MANURIAL EXPERIMENTS FOR PLANTERS.

As a plantation is not a scientific institute, but a commercial enterprise, the planter cannot be expected to carry out experimental work, with the view of promoting scientific knowledge in general. It must be left, therefore, to the experiment station to carry out the research work necessary to solve the new problems which continually arise.

With regard to fertilizer problems, it is not necessary for the planter to undertake any research work to find out the general requirements of the plant. Experiment stations showed long ago that every plant requires certain amounts of nitrogen, phosphorus and potash, and that fertilizers which contain these elements must be supplied, if they are not already present in the soil in sufficient and available quantities.

What the experiment station cannot do, however, is to adapt the general results of its investigations to the specific conditions of different planations. This problem can only be solved by the planter himself. Within this restricted sphere, therefore, he cannot avoid some small amount of scientific work, if he wishes to apply the results of science to his own endeavours, a proceeding which is becoming more and more necessary if good results are to be obtained.

If the planter wishes to carry out practical manurial experiments, the following two conditions must be carefully observed, namely:—

(*a*) The experiment must be simple, to ensure that it be carried out in a proper manner under the difficult conditions of actual practice.

(*b*) The experiment must be laid out in such a way that the results can be relied upon, i.e., that any increase in the yield must be due to the manuring, and not to any casual outside factors.

To comply with the first condition, it is essential that the planter restrict himself when laying out the scheme of his experiment, and that he does not aspire to solve too many questions at one time. It is best to attempt to answer only one question at a time. If, for example, a planter wants information as to the elements required by his soil, he should lay out the experiment with the sole object of solving this question.

Scientific research work in, and practical experience of, more advanced countries have shown that the best dressing is one which returns to the soil all the chief elements, which are taken out of the soil by the crop; and these are nitrogen, phosphorus, potassium and possibly also calcium. If, therefore, a planter wishes to know whether it will pay him to make use of artificial fertilizers, he should lay out an experiment which will enable him to compare two plots, one of which is a check plot, receiving no manure, and the other a plot receiving a complete manure. The two plots must be equal in every respect, size, situation, aspect, composition and condition of the soil, humidity, previous treatment and manuring. The only difference between these plots ought to be that one has been fertilized. In Table 1, plot 1 remains unmanured as a check plot; plot NPK receives a complete dressing with artificial fertilizers.

TABLE 1.—PLAN OF FERTILIZER EXPERIMENT.

Plot. 1	Plot 2
	N.P.K.
Unmanured	Full dressing with nitrogen, phosphoric acid and potash

To calculate the profit from this manuring, the planter has only to weigh the yield from each plot and so obtain the increase due to the complete dressing. By deducting the cost of the manure applied from the value of the increased yield, he will arrive at the net profit to be gained by manuring.

The next question to be solved is, which particular plant foods are especially wanted. Such an experiment should be laid out according to Table 2. Here, to the plots 1 and 2 are added three plots, on each of which in turn one element of plant food has been omitted. Thus plot 3 receives the same amounts of nitrogen and phosphoric acid as plot 2, potash, however, being omitted. It must be here emphasized, that the dressing with nitrogen and phosphoric acid should be exactly the same on both plots. If, for example, nitrogen be given on one plot in the form of nitrate of soda, it must be given in the same form to the other plot; not in the form of nitrate of soda on one plot and in the form of

TABLE 2.—WAGNER SCHEME FOR FERTILIZER EXPERIMENTS.

Plot 1	Plot 2	Plot 3
	NPK	NP
Unmanured	Full dressing with nitrogen, phosphoric acid and potash	One-sided dressing with nitrogen and phosphoric acid without potash

Plot 4	Plot 5
PK	NK
One-sided dressing with phosphoric acid and potash without nitrogen	One-sided dressing with nitrogen potash without phosphoric acid

sulphate of ammonia on the other. In the latter case one would not be able to say exactly whether any difference in the results of the two plots was to be attributed to the different forms in which the nitrogen was given, or to the additional potash given to the one.

Only when this dressing of potash is the sole difference between the two plots, can one conclude that the difference in results is a consequence of the potash dressing. The same applies to plots 4 and 5, a comparison between plot 2 and 4 showing the effect of nitrogen and a comparison between plots 2 and 5 showing the effect of phosphoric acid.

As the use of nitrogen and phosphoric acid is already well and widely known, the planter will in most cases be already well informed about their necessity. The problem which remains for him to solve will be whether a complete manuring which provides also potash is more advantageous than the one-sided manuring perhaps formerly in vogue.

Such an experiment could be laid in the simplified manner of Table 3, where a comparison between O and NPK will show the effect of a complete manuring and a comparison of NPK and NP the effect due to potash alone.

Now it may be argued, that the scheme suggested here is unnecessarily complicated and that the problem could be solved in the much simpler way, unmanured against potash, i.e. by comparing a check plot receiving no fertiliser with one receiving only a potash dressing.

If we look through the literature we find many records of manurial experiments where this incorrect method has been adopted. In other cases we find experiments where planters, who were accustomed to a dressing of nitrogen alone, tried to solve the phosphoric acid and potash questions by such a scheme as comparing nitrogen with nitrogen and phosphoric acid, or nitrogen with nitrogen and potash respectively. Such trials are in no way reliable, because they ignore Liebig's law of minimum by which the development and growth of the plant is governed. Liebig proved that the development of the plant is limited by that plant food of which, in relation to the demand of the plant, the least quantity is available in the soil.

If in a certain soil, nitrogen is the weakest link, then an addition of phosphoric acid and potash, that is a strengthening of the other links, can have no effect, because growth is limited by the nitrogen which is in the minimum. In such a case a dressing of potash alone would have no effect and a trial according to one of the aforesaid schemes would lead to the wrong conclusion that potash on such a soil had no effect at all. That this is so, would be proved if we laid out an experiment according to the scheme of Table 3.

TABLE 3.—CORRECT PLAN OF A POTASH EXPERIMENT.

Plot 1	Plot 2	Plot 3
	NPK	NP
Unmanured	Full dressing with nitrogen phosphoric acid and potash	One-sided dressing with nitrogen and phosphoric acid without potash

In that method, the soil has a sufficiency of nitrogen and phosphoric acid so that the potash is enabled to show its full effect, and to show whether it be possible to augment the crop more by adding potash than is possible by one-sided manuring with nitrogen and phosphoric acid alone.

A similar mistake would be made by comparing a nitrogen plot with another plot receiving nitrogen and potash. (Table 4.) If in this case phosphoric acid be a limiting factor, allowing the combination of nitrogen and potash to act only to a certain degree, it is evident that the dressing of potash can show no effect at all. Only when a complete manure is given, i.e. one containing nitrogen, phosphoric acid and potash, can reliable and conclusive results be obtained.

TABLE 4.—FAULTY PLANS OF POTASH EXPERIMENT.

Plot 1 Unmanured	Plot 2 One-sided dressing with potash
Plot 1 Nitrogen alone	Plot 2 Nitrogen and potash

Another method of experiment which in some cases has been tried is to give to one plot say 2 cwt. of a nitrogenous manure, and 2 cwt. of a phosphatic manure; whereas to another plot is given only 1 cwt. of a nitrogenous manure, 1 cwt. of a phosphatic manure and in addition 2 cwts. of a potassic manure, presuming that the potash can replace part of the nitrogen and phosphoric acid. This idea is wrong, because each element plays a different part in the life of the plant and cannot be substituted by any other element. These elementary experiments will not only give the planter an indication as to what elements are necessary, but will also give him an idea of the quantities and in what forms they are required.

The form in which an element should be given is best determined by a special experiment. If the planter wants to know whether sulphate of ammonia or nitrate of soda be more suitable for his crop, he should compare two plots one of which has received in addition to phosphoric acid and potash, nitrogen in the form of sulphate of ammonia, whereas the other one has received the same amount of nitrogen in the form of nitrate of soda. Another point, which must be kept in mind, is that in such experiments the planter should employ only manures which have been proved by science and practice to be free of noxious substances. Sulphate of potash is to be recommended for experimental work, since this salt has no bad effect even on such very sensitive plants as tobacco and sugar cane.

Muriate of potash is also a very pure salt and may be employed for many crops. Because of its high chlorine content, however, its use is not to be recommended for sugar cane or tobacco; and even for tea or cocoa, preference should be given to the sulphate. A practice not to be recommended either, is the use of impure potash manures, e.g. crude salts, tobacco ash or sugar cane ash, because these contain accessory substances, the effect of which on tropical plants is not yet fully known but is probably harmful. In laying out manurial experiments, these impure salts should be avoided, as they may give inconclusive and misleading results.

The main source of error in manurial experiments, however, is to be found in the inequalities of the soil over the experimental area, even though one may try to choose as uniform an area as possible. To find a sufficiently large area free from these soil inequalities is impossible, so it may happen that the plot receiving a dressing of potash may be poorer than that receiving no potash and consequently, although the potash has in fact had an effect, this improvement will not be shown. In order to correct these differences and to obviate their influence on the results a certain number of control plots should be laid out which, as in a chess-board, should be evenly distributed over the whole field. If this be not possible, at least one control plot should be allowed.

TABLE 5.—EXPERIMENT WITH CONTROL PLOTS.

Plot 1 Unmanured	Plot 2 Complete manure
Plot 3 Complete manure	Plot 4 Unmanured

If the results of the unmanured plots are uniform, whereas the results of the manured plots show a variation, then with every probability this difference may be attributed to the effect of the various manurings. The greater number of control plots, however, the surer will the results be.

The experimental stations of Java, where excellent scientific work is done, even go so far as to lay out ten or twelve control plots. For practical purposes this number would be excessive, because the laying out of experiments would then be far too difficult and complicated for the planter. For practical purposes three control plots are deemed sufficient.

An exact potash experiment could therefore be laid out after the manner shown in Table 6.

TABLE 6.—POTASH EXPERIMENT WITH THREE CONTROL PLOTS.

1 O	2 NP	3 NPK
4 NPK	5 O	6 NP
7 NP	8 NPK	9 O

For field crops each plot should be about 1/40 acre (= 121 sq. yards). Then from the results of the equally manured plots, the increases resulting from the various other manurings can be calculated. If the variations between the control plots are not great, the average results of the other plots will permit of reliable conclusions. In any case, one should calculate the average yield of every kind of manuring from yields of the various control plots. For example, if plots 2, 6 and 7 gave yields of 1,000 lb., 1,020 lb. and 1,061 lb., the average of these plots (NP) would be (1,000 + 1,020 + 1,061) ÷ 3 = 1,027 lb., the differences between the average and the several different yields are respectively — 27, — 7 and + 34 lb. If we then find that plots 3, 4 and 8 had respective yields 1,179 lb., 1,201 lb. and 1,160 lb., corresponding to an average of 1,180 lb., the variations of the single plots in comparison to the average yield are 1, 21 and 20 lb. The difference between the two average yields of NP and NPK then is calculated as 153 lb. In view of the irregular distribution of the different control plots throughout the field, this difference should be put down to the potash, as it cannot be due to the variations in soil, because the variations between equally manured plots are far smaller.

For scientific purposes, another and more exact calculation of the average variation based, on the law of probability, is generally adopted, but for practical purposes our method, which is much less complicated, is sufficient.

In dealing with permanent crops, the inequalities of the soil can be eliminated by another method. In the year previous to the experiment, the plots are laid out, the soil if left unmanured and the average yields of the various plots are determined and recorded. The variation between these plots will not be very great, if care has been taken to choose a field where the soil is as even as possible all over.

In the second year, the trials of the various manures may be commenced and their effects on the yields noted. In comparing the results of the second year, the difference between the plots, as found in the first year, should be taken in account. By such a method, a truer estimate of the effect of a certain manuring may be obtained. The disadvantage is that one must wait an extra year before any results are known, and further, that the influence of the weather cannot be eliminated in this way.

Manurial experiments very often require much patience, because perennial crops do not as a rule show any beneficial results in the first year of treatment. For example, the effect of potash may be diminished by the fact that the soil in its hunger for potash may absorb the first application so greedily, that the plant benefits little. Furthermore, in contrast to nitrogen, phosphoric acid and potash will in the first year only have the effect of promoting the vigour of the plant and the growth of wood, so that only later will these elements show their effects directly upon the yield. If only for these reasons, then it is to be recommended that potash manurial experiments should always be extended over a number of years, because even where negative results are shown in the first year, planters may be sure that at the end of several years potash will prove itself a great and valuable ally in the production of the production of remunerative crops.

In spite of all the care and precautions which are taken to obtain conclusive results, it is not always possible to get precise experimental data on special questions. In such cases, the planter finds himself in a dilemma; he must either spend money on a fertilizer without being assured that his soil requires it, or he must omit some plant-food without the satisfaction of knowing that his soil does not need it. Generally the latter choice will be the more dangerous, because he then loses any chance of obtaining a crop increase which a fertilizer dressing might eventually have yielded him.

This uncertainty of experimental work has its explanation in the fact, that the planter is not dealing with a dead mechanism, but with a living organism subjected to all the incalculable influences of nature, and one which cannot be expected to react so promptly to the experimental factors, as would be the case with an experiment in the laboratory.

Experimental work in the plantation, therefore, must always be left to the personal judgment of the planter upon whose knowledge and energy depends the success of the plantation.

The planter, who is well acquainted with the nature of the soil, and the requirements of his plantation, is in a position to learn very much more from the results of experiments, even though they are not quite conclusive, than the other who lacks this knowledge and who relies only upon the figures themselves.—[*Rewritten from a pamphlet by Jacob and Coyle. R.C.H.*]