NOTES ON SOME FERTILIZER EXPERIMENTS HARVESTED DURING THE 1934 SEASON.

By H. H. DODDS, M.Sc., A.I.C.

It may be noted that there have been very few papers on the results of fertilizer experiments or on the use of fertilizers read at our conferences for the past two or three years.

The reasons for this are by no means that no fertilizer experiments have been harvested, or that the importance of the subject of fertilizers for sugar cane is not recognised. Probably one of the principal reasons for the lack of published information or opinion is the difficulty of adequately interpreting the very diverse and conflicting experimental data recorded.

The sheet-anchor of all early attempts to explain field experiments with fertilizer was to call attention to the undeniable marked response to phosphatic materials of almost any kind in practically all South African soils and crops.

This has led to a widespread use of phosphatic fertilizer, principally superphosphates, but also to some extent, basic slag, bonemeal, rock phosphate, ammonium phosphates, or other forms of phosphoric acid, often to the more or less complete exclusion of all other fertilizer elements.

Yet the sugar cane crop does not take such large quantities of phosphorus out of the soil, but takes out much more considerable quantities of other elements.

Thus Hedley and Beater[1] showed that a sugar cane crop of 30 to 40 tons per acre removed in the cane stalks 13 to 36 lbs. of phosphate as P_2O_5, corresponding to a loss of 65 to 180 lbs. of superphosphate, 20% P_2O_5, per acre. This was much less than the loss of nitrogen, 38 to 56 lbs. per acre, corresponding to 190 to 280 lbs. of ammonium sulphate; and still less than the loss in potash, 82 to 259 lbs. of K_2O per acre, corresponding to 137 to 432 lbs. of potassium chloride per acre.

Many similar analyses have been done in other countries with very varying results depending on variations in the character and composition of the soil and other diverse factors.

The first information of this kind seems to have been recorded by Stubbs[2] in 1900, who stated that a 30 ton crop of cane in Louisiana removed 102 lbs. of nitrogen, 45 lbs. of phosphate, and 65 lbs. of potash per acre, corresponding to 225 lbs. of superphosphate, 510 lbs. of ammonium sulphate, and 108 lbs. of potassium chloride. Browne and Blouin[3] in 1907 also did pioneer work in Louisiana on this subject.

More recently work on these lines has been done by Honig[4] in Java, Ayres[5] and Stewart[6] in Hawaii, Deomana[7] in the Philippines, Saint[8] in Barbados, Coates, Fieger and Salazar[9] in Louisiana, and Bonazzi[10] in Cuba.

A summary of the mass of data already accumulated in this subject up to 1921 is given by Noël Deerr[11] and shows average values for phosphoric acid 30 lbs., nitrogen 30 lbs., and potash 90 lbs. withdrawn from the soil by a 30 ton crop of cane. These correspond to 150 lbs. each of superphosphate, ammonium sulphate and potassium chloride.

The general consensus of opinion appears to be that the analysis of the mineral contents of a plant is not a reliable indication of the sufficiency or otherwise in the soil of the elements concerned in form available for the plant.

The content of sugar cane juice in phosphorus or potassium, however, may be a useful indication of any deficiency in those elements in the soil, as shown by Walker[12] and later workers in this field in Hawaii, and according to Moir[13] many plantations in that country for several years have found in this way valuable information concerning phosphatic and potassic fertilizer requirements.

Work in South Africa on these lines by McRae[14] showed that similar relations existed, for phosphorus at least; but subsequent experience has proved that the method is liable to too many exceptions and pitfalls to be of much material help in this country. A large amount of routine analytical data are still being collected at the Experiment Station, however, on the phosphate and potash contents of cane juices of many different varieties grown under different conditions, from which it is hoped that at some time some general conclusions may be drawn.

At all events the mineral composition of the cane as distinct from the juice appears to tell us very little concerning the status of the soil. We know that our soils require much more phosphatic and much less potassic fertilizer than the analysis of the cane would indicate, and that the response to nitrogen seems to be influenced by various factors connected with the physical and bio-chemical condition of the soil more than its total nitrogen content.

Neither does the chemical analysis of the soil by any of the conventional methods seem to help us very much in determining the fertilizer requirements. The results of a chemical analysis of a given soil may be of interest and value in conjunction with a knowledge of its physical nature and topography, and of its depth, and the character of the subsoil. The history of its previous cultivation and results thereof need also to be taken into account, and if possible the results of field experiments in that type of soil, if a correct interpretation of the chemical analysis is to be reasonably assured.

Without such local knowledge of the soil, a chemical analysis is of little value, or may even be misleading.

The determination of the so-called "available" phosphate and potash in the soil by extraction with dilute citric acid, or other dilute acids, is of value in many cases, but here also the proportion of exceptions to the rule is very great.

Pot experiments of the Mitscherlich type with a plant like sugar cane need to be inconveniently large, requiring a large greenhouse and bulky equipment, making them difficult and expensive to handle; while pot experiments such as Neubauer's using indicator plants of a conveniently small size instead of sugar cane are as yet of unproven applicability to sugar cane agriculture. The same may be said of Winogradsky's azotobacter soil plaque test. (See Moir's paper "Hawaiian Soils and Fertilizer Research" [13] and discussion thereon at the International Sugar Technologists' Conference in Puerto Rico).

All that remains, therefore, is the direct empirical appeal to the soil by methods resembling actual field practice as closely as possible, that is, by field experiment.

This also is open to many difficulties and objections. The time taken to bring the matter to completion is very long, especially in a country such as this where the crop is normally harvested only in alternate years and where several ratoon crops are taken. So that by the time the results are obtained the original problem has perhaps assumed a different angle, and one would have planned the experiment somewhat differently.

The experimental error is apt to be great, both from causes that might have been foreseen and from those that could not—especially the latter. These may occur, for example, from variations in soil composition or texture, or in depth and drainage conditions. Every experiment station appears now to have learned that at least five or six replications of each treatment is necessary, and it is the usual practice to calculate the mean probable error by some recognised mathematical procedure, so as to assess if possible the significance of the results.

Last, but not least, field experiment is expensive because of the extra labour and skilled supervision required above ordinary field practice, although at least the ordinary crop profit (if any) may be expected in most cases to return some slight set-off to the cost of the experiment.

Compared with the number of experiments done annually by most other agricultural experiment stations, and in view of the great lack of technical information in the South African cane-growing industry and urgent need for it, we are only yet at the beginning of things in this country.

However, a beginning has been made, and during the past season more sugar cane field experiments have been harvested in this country than ever before, 24 in all, of which 13 were fertilizer experiments, four at the Experiment Station and nine at co-operative field stations.

The results of only a selection of these can be quoted here, taking those which have any bearing on any general provisional conclusions that may now be made.

The phosphatic fertilizer experiments planted at the Experiment Station in 1926, of which the first two crop results were described in 1928[15] and 1931[16], respectively, have now been harvested as third ratoons.

This experiment continues to show a response to all the six forms of phosphatic fertilizer used, although the only application was with the plant cane eight years ago.

Following is an outline of the results at the fourth cutting:—

Treatment	Tons cane per acre	Sucrose per cent	Purity of juice	Tons corrected sucrose per acre*	Ratio to controls (= 100)	Standard Deviation	Standard Exp. Error
Control—no phosphate	22.70	12.92	92.5	3.05	100.0	0.095	0.047
Superphosphate— 500 lbs. per acre	28.83	13.10	92.5	3.93	128.7	0.269	0.134
Rhenania phosphate— 320 lbs. per acre	27.54	12.73	91.7	3.63	118.9	0.171	0.085
Basic slag—470 lbs. per acre	28.68	12.38	90.8	3.62	118.5	0.62	0.31
Super and rock phosphate— (1 : 1), 375 lbs. per acre	27.17	12.83	91.8	3.58	117.3	0.267	0.133
Bonemeal—410 lbs. per acre	26.59	12.87	92.4	3.56	116.6	0.287	0.144
Rock phosphate alone— 300 lbs. per acre	26.97	12.69	91.2	3.51	114.9	0.171	0.085

* Adjusted for purity bonus according to Fahey Scale.

The percentage increase in yield of cane over the controls for each successive cutting is as follows:—

Treatment.	1.	2.	3.	4.	Average.
Superphosphate . . .	22.4	21.4	34.6	27.0	26.3
Basic slag	22.9	15.2	25.5	26.3	22.5
Rhenania phosphate	15.1	19.6	25.8	21.3	20.4
Bonemeal	17.0	20.5	20.0	17.1	18.6
Rock phosphate . . .	12.5	16.1	14.5	16.8	15.5
Super and rock phosphate	7.9	6.4	14.5	19.6	12.4

The following table shows the amounts of phosphate (P_2O_5) removed in the successive crops, expressed in pounds per acre:—

Probably the soil was originally of considerable natural fertility but it has been under cane almost continually for the past 50 years, and has evidently been periodically subject to erosion since it was denuded of its original natural covering of dense East Coast bush.

To guard against the possibility of nitrogen or potassium becoming the limiting factor, the whole field, controls and phosphate plots alike, were treated with 200 lbs. of sodium nitrate after the plant cane crop had been cut, and again with 250 lbs. of sodium nitrate per acre after the first ratoon crop. After the second ratoon crop a mixture of 120 lbs. of sodium nitrate and 60 lbs. of potassium chloride per acre was applied, but none later.

Treatment.	1928.	1930.	1932.	1934.	Total.
Control—no phosphate	11.6	17.2	12.6	9.4	50.8
Superphosphate.	15.1	22.4	17.4	14.0	68.8
Rhenania phosphate	15.1	24.5	15.3	13.9	68.8
Basic slag	15.7	21.0	15.2	13.9	65.8
Bonemeal	15.2	23.7	15.1	11.7	65.7
Rock phosphate.	15.6	21.9	15.0	11.9	64.4
Super and rock phosphate	14.8	20.4	15.1	14.0	64.3

Since the total quantity of phosphate applied in every case was 90 lbs. of P_2O_5 there is still a surplus presumably left in the soil, which will account for the continued response to the fertilizer.

The soil is a brown loam of moderate depth; immediately below this is a layer of several inches of gravel or small pebbles and under this the subsoil gradually merges into a very stiff clay.

The loss on ignition is from 4 to 7 per cent in different parts of the field, nitrogen content 0.10 to 0.16 per cent and carbon: nitrogen ratio 12. The pH value is 5.8 and the total lime as CaO only 0.14 per cent.

There is the characteristic deficiency of phosphorus, the total P_2O_5 being only 0.02 per cent, and the available P_2O_5 (soluble in one per cent citric acid after 24 hours agitation) 0.002 per cent.

The soil is only slightly better supplied with total potassium, the total K_2O being 0.04 per cent, and the available P_2O_5 0.013 to 0.015 per cent.

There are four similar replicated plots of each treatment, each of 0.05 acre. The cane is Uba, planted in rows 5 feet apart; there is one cane row without fertilizer between each two plots as a dividing line.

In view of the poverty of the soil as shown by chemical analysis, and the unsatisfactory nature of the subsoil, leading to pronounced conditions of moisture deficiency or excess according to season, it is surprising that an average crop can be obtained with only small applications of fertilizer at long intervals.

The phosphate analyses of the cane juices showed a large increase (36 to 177 per cent) at the first cutting between the control plots without phosphate and the phosphate-treated plots. This increase was still large (27 to 111 per cent) but had diminished somewhat at the first ratoon crop, and at the third cutting there was still a slightly greater content (6 to 15 per cent) of phosphate in the juice from the phosphate-treated plot than from the controls.

A theoretically possible means of determining whether the soil is adequately fertilized with phosphate is evidently indicated. But the difficult problem remains of determining a standard value for phosphate content of juice that reflects an adequate content of phosphorus in the soil; or rather a set of such standards, since the phosphate content of the juice from a given content of phosphorus in the soil varies greatly with many factors in ways still to be understood.

Certainly the phosphate content of the cane juice in this particular experiment has been, for some reason, consistently relatively low throughout, although showing the relations just mentioned. Whether this means that the plant is particularly economical in its demand for phosphatic nutrient in these soil conditions is not known; but at all events there is still a marked response from each of these plots receiving no more than the equivalent of 90 lbs. of phosphoric oxide eight years ago, since when four crops have been taken off of an average yield of 30 tons of cane each.

There is indeed some evidence to show that a generous application of phosphate will satisfy, to some extent at least, the requirements of the sugar cane crop for several years, and cuttings, and even after replanting.

For example, in a field adjoining the foregoing, in a similar kind of soil, an experiment was laid down to test the effect on yield and composition of cane of large, small and excessive applications respectively of potassium chloride.

While there was no response to the potash, not a very unusual result, there was also, for almost the first time in our experiments, no response to superphosphate, 600 lbs. per acre, either in a plant cane crop or first ratoons of Co.290 cane. The reason for this is possibly that sufficient phosphatic fertilizer had already been applied with previous crops. When this field first came under experiment it was treated with 900 lbs. of raw rock phosphate and 60 lbs. of potassium sulphate broadcast with a green manure crop in January, 1926. It was planted with cane in November of that year, when 250 lbs. per acre of superphosphote were applied. Two years later, after the plant cane crop averaging 20 tons per acre had been removed, a further 250 lbs. of superphosphate and 100 lbs. of ammonium sulphate per acre were applied. The first ratoon crop was harvested in June, 1930, averaging 26 tons of cane per acre after which the field was ploughed out, and planted with Co.290 cane, as stated, the following season.

In the light of after-events, it would appear likely that the 900 lbs. of rock phosphate and 500 lbs. of superphosphate, equivalent to 360 lbs. of total P_2O_5, per acre applied to this field during 1926 and 1928 with a debit account only of the phosphorus removed in 46 tons of cane was sufficient for the needs of several more crops, so that the lack of response to subsequent application of superphosphate is to be explained.

It is difficult to say what is now the element of plant food most lacking. It is evidently not phosphorus or potash. The wide fluctuations in rate of growth and appearance of the cane through our very variable weather conditions go to show that water is the limiting factor, and it seems probable that if subsequent drought conditions could be avoided by irrigation the application of nitrogenous fertilizer should be profitable. In any case, the response to nitrogen is obviously the next step for study in this experiment.

The general thesis indicated is that a basic dressing of phosphatic fertilizer, from 600 lbs. to 1,000 lbs. per acre of superphosphate according to soil, or its equivalent in other forms of phosphate, is necessary with nearly all our phosphorus-deficient soils to make them fertile; and that once applied this is sufficient for several crops, except perhaps for small dressings of superphosphate in the furrows at time of planting cane to help to give it the required " kick-off."

This idea is supported by certain evidence from some of our co-operative field stations.

Thus an experiment was planted in a rich chocolate loam on Wilton Park Estate, Empangeni, in 1927, to compare the effects of different forms of phosphatic fertilizer, in each case applying the equivalent of 90 lbs. per acre of phosphoric oxide, P_2O_5, without any other fertilizer. These experiments have now been harvested three times and the results of the plant cane crop[17] and residual effects on first and second ratoons[18] recorded.

Basic slag was slightly the best over the three crops with superphosphate a close second; this means that superphosphate is the most profitable in view of its lower price per unit. The response to every form of phosphate was well maintained into the third crop, although the results of other experiments in similar soil on the same estate show that the quantity of fertilizer, 90 lbs. P_2O_5 per acre, corresponding to 500 lbs. of superphosphate, apparently is not the best quantity to apply.

The latter experiments first planted in 1930, and harvested in 1932, and again in 1934[19], compare the effects of nil, 250 lbs., 500 lbs., 750 lbs., and 1,000 lbs. per acre respectively of superphosphate. In both cases the 750 lbs. treatment gave slightly the best results, winning by only an insignificant margin over the 1,000 lbs. application. The results of later ratoon and following crops will be noted with interest.

Other experiments at Empangeni serve incidentally to demonstrate the marked residual effect from generous applications of superphosphate or other phosphatic fertilizer.

Further evidence that a heavy, but not unlimited, application of phosphatic fertilizer is almost invariably profitable whether any response is noted to other elements or not, is shown by the co-operative field experiments in alluvial soil with Hulett's at Felixton[20]. Thus 500 or 750 lbs. of superphosphate per acre gave a profitable response that was not increased by the addition of 200 lbs. of ammonium sulphate or 75 lbs. of potassium chloride, or both.

An equal or even greater response was shown by the application of 10 tons per acre of filter cake, a response that was not increased, however, by applying both filter cake and superphosphate.

This is probably accounted for by the phosphate content of the filter cake; this was ordinary sulphitation cake and probably contained at least 1 per cent of phosphorus as P_2O_5, which means that the 10 tons of filter cake applied would supply as much phosphorus as 1,000 lbs. of superphosphate. Consequently, provided that the soil could readily assimilate the insoluble form of phosphate that exists in filter cake, which apparently was the case, the application of both superphosphate and filter cake in the quantities used was probably unnecessary.

Under very different conditions at Umhlali[20], a very coarse wind-blown sandy soil, but very productive, overlaying cretaceous strata, the response to phosphatic fertilizer was even greater, the application of 640 lbs. per acre of superphosphate increasing the yield of sucrose per acre by as much as 36 per cent. The residual effects in this soil still remain to be traced.

The foregoing considerations, mainly concerning phosphorus, have already made this a sufficiently long and tedious paper, without considering the other principal elements of plant food, or the other fertilizer experiments harvested during the past season.

Briefly stated our conclusions regarding potash are that although relatively large quantities of this element are removed by the crop, there are many soils in which the response to potassic fertilizer is not at all evident. In coarse, sandy soils, however, as in Table Mountain sandstone at Chaka's Kraal[21] or wind-blown beach sands at Umhlali[20] we have found some response to potash as an addition to superphosphate.

Even though the demands of the plant for potassium may be great, most soils, even those most deficient in this wide spread element, contain ample reserves of potash to supply crop requirements for many years.

Only a relatively small proportion, however, is at any given time present in a form available for the plant, and this is one of the most important factors in soil fertility.

This so-called "available" fraction may be increased in many ways besides the rapid but expensive one of applying potassium salts. It is increased by green manuring and in some cases by liming, and by cultivation generally. In this respect, especially, the words of Jethro Tull "tillage is manure" are just as true to-day as when they were first uttered, 200 years ago.

When we come to nitrogen supply the local aspects of the problem are still more complex. We have had very few cases in our experiments of definite response to ammonium sulphate, the fertilizer par excellence for sugar cane in almost all other sugar growing countries.

Sodium nitrate has proved little better, though there has been a response to this fertilizer in some of our experiments at the Experiment Station[16].

With both these inorganic forms of nitrogen, the lack of response appears to be bound up in some way with the recurrent lack of moisture, and with the lack of organic matter in most of our soils.

Organic nitrogen, as in whale meal and the like appears to be a valuable source of nitrogen under our conditions and a response to it, over and above that due to the small proportion of phosphorus it contains, seems to be assured. In some cases the response is very great, as in sandy soils already mentioned[20, 21]. In view of the scarcity locally of supplies of organic nitrogenous fertiilizers, the possibilities of various other sources need to be carefully studied.

Sufficient work has been done to indicate that our fertilizer problems are very different from those of other sugar-growing countries, and to show what a large scope for agricultural research exists to learn how to get the best out of our characteristic soils and agronomic conditions, in which South Africa is unique.

SUMMARY AND ACKNOWLEDGMENTS.

1. It is shown that the relative quantities of the three principal plant-foods removed from the soil by sugar cane is no guide to the fertilizer requirements of the soil or crop.

2. The only valid method yet examined for estimating fertilizer requirements is the empirical one of field experiment with the crop and type of soil for which the information is desired.

3. The great response of our almost universally phosphorus-deficient soils to phosphatic fertilizer is discussed, and the thesis advanced that a basic dressing of 600 lbs. to 1,000 lbs. per acre of superphosphate, or the equivalent in other forms of phosphatic fertilizer is necessary to make such soils properly fertile; and that such an application is sufficient for several crops, except possibly for small quantities of superphosphate at time of planting.

4. The response to potassic fertilizer is much less assured, notwithstanding the relatively large proportions of potassium removed from the soil by the sugar cane crop; but a response to potash appears generally to be found in sandy soils. In view of the large reserves of potassium in all soils, the aim should be to increase the so-called "available" fraction by cultivation or otherwise.

5. Organic nitrogenous fertilizer is usually of decided benefit, especially in the lighter soils. The response to inorganic forms of nitrogen appears to depend largely on the moisture supply and moisture-holding capacity of our soils.

6. It is pointed out that we are only at the beginning of solving the complex, but very important problem of the most economic and efficient methods of fertilizing the soil, a problem that has in South Africa aspects that make it unique.

The writer wishes to express thanks to those who have so heartily co-operated in field experiment work, including Wilton Park Estate (F. V. Ebsworth, manager); E. J. Smith, Umzinto; Sir J. L. Hulett & Sons, Ltd., especially G. C. Dymond and the chemical laboratory staff of Darnall factory; G. P. Ladlau, Umhlali; and the Umfolozi Co-operative Sugar Planters, Ltd., especially E. S. Murphy. Also the field staff of the Experiment Station for their willing and efficient assistance, B. E. Beater for much of the chemical analytical work, and P. Hanbury-King for help in the large amount of clerical work involved in this and other papers for this conference.

REFERENCES.

[1] E. P. Hedley and B. E. Beater, Proc. Sth. Afr. Sugar Tech. Assoc., 1933, p. 37.

[2] W. C. Stubbs, Cultivation of Sugar Cane, U.S.A., 1900.

[3] C. A. Browne and R. E. Blouin, Louisiana Bull. No. 91, 1907.

[4] P. Honig, De Aschbestanddeelen van Suikerriet, Arch. Suikerind. Nederlandsch-Indie, 1934, 10, p. 435.

[5] A. Ayres, Hawaiian Planters' Record, 1933, 37, 4, p. 197.

[6] G. R. Stewart, Repts. Assoc. of Hawaiian Sugar Tech., 1929, p. 199.

[7] F. V. Deomano, Philippine Agriculturist, XX., p. 139.

[8] S. J. Saint, Rept. Dept. Sci. Agr., Barbados, 1929/30, p. 76.

[9] C. E. Coates, E. A. Fieger and L. G. Salazar, Louisana Planter, 1928, 80, 22, p. 421.

[10] A. Bonazzi, Tropical Agriculture, 1927, 4, p. 196.

[11] Noël Deerr, Cane Sugar, Norman Rodger, London, 1921, p. 99.

[12] H. Walker, Jl. of Ind. & Eng. Chem., 1923, 15, 2, p. 164.

[13] W. W. G. Moir, Hawaiian Soils and Fertilizer Research, Fourth Cong. Intern. Soc. Sugar Cane Tech., Puerto Rico, 1932.

[14] D. McRae, Proc. S. African Sug. Tech. Assoc., 1929, p. 54.

[15] H. H. Dodds, P. Fowlie and D. McRae, Sth. Afric. Sug. Jnl., 12, 11, Nov., 1928, p. 697.

[16] H. H. Dodds and P. Fowlie, Proc. S. Afric. Sug. Tech. Assoc., 1931, p. 141.

[17] Ibid, p. 73.

[18] Experiment Station Notes, S. Afric. Sug. Jnl., 17, 8th Aug., 1933, p. 413.

[19] Ibid, 19, 1 Jan., 1935, p. 19.

[20] Ibid, 18, 11 Nov., 1934, p. 657.

[21] H. H. Dodds and P. Fowlie, Proc. S. Afric. Sug. Tech. Assoc., 1931, p. 80.

Experiment Station,
South African Sugar Association,
Mount Edgecombe,
Natal.

April, 1935.

CHAIRMAN: Gentlemen, this paper is now open for discussion. As there are several planters here this morning, no doubt they will like to say something about it.

Mr. PALAIRET: Mr. Dodds has given us a very useful summary. It confirms all his previous experiments. There is one thing I would like to touch on. We are beginning to realise that many of our so-called plant foods are really something more than that, and this applies more to phosphorus than any other. We are liable to forget that plants cannot grow in sterile soil, but need the aid of soil bacteria. I know that recent bio-chemical experience suggests that the main use of phosphorus in the soil is to feed micro-organisms. Now, as Mr. Dodds never lets us forget, our principle trouble is lack of humus, and I am wondering whether the co-relation between soil organic content and the effect of the various phosphates is not very much closer than we realise. Perhaps the majority of the phosphate is used by micro-organisms, and is used over and over again. This would help to explain a carry over in soils rich in bacterial activity. I feel that real progress, in the sense of really accurate understanding of the results of our experiments, are going to be arrived at when we have a greater knowledge of the organic life in the soil. We shall need to know, not only the average bacterial count of the soil, but also the proportion of the different types of organism, and probably also the stage in the plants' growth when each is in the ascendancy. I do not know if Mr. Dodds can tell us what hopes we have of finding some means of getting some of this information with our experiments?

Mr. DODDS: Mr. Chairman, there is no doubt a great deal in what Mr. Palairet says. One should regard phosphorus not entirely as a necessity for the direct nutrition of the plant—although it is so necessary to a certain extent. The chief need for phosphorus, I think, is to supply the deficiency of the soil in that element, and once the concentration of phosphate in the soil solution has been brought up to the required standard of fertility, whatever that concentration may be, it looks as though the plant could get along well for quite a while with only small dressings of phosphatic fertiliser. The exact functions of the phosphate in the soil are difficult to define. In a paper to be read to you tomorrow by Mr. Lintner, you will find some attempt has been made to study the population of the soil in micro-organisms, which will eventually be followed up, I believe, and will throw a good deal of light on our fertiliser problem. At present we are very much in the dark in that particular sphere, and will be until a proper bio-chemical study of the soil is made.

Mr. BERÈNGER: Experiments made in Mauritius on our estate comparing organic manures with mineral fertilisers have always shown that in the juice from cane treated with organic manure much more phosphoric acid occurs than in the juice treated only with mineral phosphorus. Manure was applied about 25 tons per acre, and contained a fair amount of P_2O_5, I should say roughly contained 0.35% of P_2O_5. In all cases with heavy dressings of phosphatic manure, we found the cane juices from fields so treated always contained much more phosphoric acid than those from fields that had received little or no phosphatic fertiliser.

Mr. DODDS: That certainly is very interesting. I cannot say that we have yet been able to trace in this country the relation Mr. Berènger mentions, but we do find that the phosphate content of the juice from soils well supplied with organic matter is much greater than from soils which are deficient in organic matter, and probably the lack of phosphate content in the cane from the particular experiment I was describing to you just now is associated with this low organic content. That, of course, points to some co-relation with the organic activity of the soil as Mr. Palairet suggests.

Mr. OWEN JOHNSON: I have listened with very great interest to this paper. But all this to me works down to one point—£ s. d. Where the planters are concerned, it is very difficult to analyse the soil to find what we have to use to grow crops. We have seen that a certain kind of phosphate is necessary, and you have succeeded in showing us that 750 lbs. of superphosphate may be as advantageous as 1.000 lbs. As a practical planter, I want to know whether if I lay out so much money in fertiliser, what is going to be the return? That is the way every planter looks at it. If we spend £3. we want to make a profit of another pound, so that we get some return for the money. We are not tied down to exactly what we shall spend. If you can advise us that mixtures of sulphate of ammonia, or something else besides superphosphate is going to be advantageous to the crops, well and good. It seems to me that we are not getting very far ahead with manuring crops. That is my difficulty. We are certainly a step further ahead than what we were when we started the Experiment Station. I think what is being done there is excellent. But I do not think we are getting on as far as we expected. Farmers in the Old Country had no scientific training, but they grew crops. They had to use their experience. You have practically told us in your papers "You have got to go back to your farms and experiment and find out for yourselves." We have been doing that for a long time, and shall continue to do it. I did hope that you would have told us something which we could have relied on a little more definitely.

Mr. DODDS: My idea is that we are just at the beginning of things, although a few general conclusions are beginning to appear, as Mr. Johnson says. What I have long agitated for is for field experiments in all our characteristic soils. Conditions vary so much that the results of experiment in one particular soil are by no means necessarily applicable to those in others. That is the experience of other countries also, and in any proper experiment scheme, one has to take the various typical soils into account separately and have series of field experiments in each one. This paper is only a very general outline. I have hardly touched on the economic return, but you will find that in many of these references which are set out here, the cost of the fertiliser and the value of the extra cane obtained are stated. You will find in many cases a very handsome return on the expenditure on fertiliser. It should be some encouragement to the planter to follow out the lines indicated in these experiments, as far as they may apply to his class of soil. Of course our aim is to discover the fertiliser that would give the best response in each particular class of soil, and that necessarily implies the most profitable result, because it means that you get the biggest sucrose return per acre from soil which has been properly fertilised. The economic advantages are bound to follow since it is quite evident that the increased returns that may be expected from suitably fertilised cane far outweigh the cost of purchase and application of the fertiliser. The latter, however, will be strictly scrutinised before positive general recommendations are made.

Mr. ALFRED TOWNSEND: This fertiliser paper does not mention the use of Peruvian guano. We almost always used that as a top-dressing in the early days. We had wonderful results. We never use it now. I do not know why. Has Mr. Dodds experimented with Peruvian guano with a basic dressing of superphosphate and then a top dressing of Peruvian guano about April or May just round the roots, and with what results?

Mr. DODDS: Before the days when superphosphate came into its present prominence, Peruvian guano was one of the principal fertilisers used. In those days it was obtainable in almost unlimited quantities because huge accumulations of it had been discovered in islands off the coast of Peru. That original accumulation has been very largely worked off, but there is still a large quantity of Peruvian guano becoming available every year.

Supplies are now rationed by the Peruvian Government, I believe, but Peruvian guano is still on the market. I remember at a field day two or three years ago I made a similar remark, and appeared to hint, apparently, that Peruvian guano was not of very much importancne to-day, and immediately I had letters from the Peruvian guano agents, telling me that large quantities were still in use in various parts of the world and could be obtained at any time in South Africa. I mentioned in my paper the shortage of organic nitrogen, and it seems to me that there is a possibility of Peruvian guano coming into its own again from that point of view, because it contains a certain amount of nitrogen in the organic form, if the supply of whale meal is not equal to the demand, then we may find Peruvian guano again useful. An important point about Peruvian guano is its relatively high price. Possibly that is in consequence of the limited supply, but the fact remains that the price of Peruvian guano in its various preparations and mixtures is high compared with the unit values of the fertiliser elements it contains. Nevertheless, we have in mind some experiments in that matter. We had accumulated last season a series of all the practicable alternative forms of nitrogen for a comprehensive experiment on this subject, but for various reasons we were unable to get them planted at that season. We will do so at the earliest opportunity. The experiments have been planned out and the materials are ready; we are only waiting the opportunity to plant.

Mr. DYMOND: May I ask Mr. Dodds if he has any positive knowledge, or whether he has a scheme in view for obtaining knowledge about the fixation of phosphates in Natal soil? I refer especially to those containing large quantities of iron and alumina.

Mr. DODDS: That matter is dealt with in a paper to be read to you and discussed tomorrow, but as far as we can see, the deficiency of phosphorus in our soil is so great, and the response to phosphorus so immediate, that it does not appear to matter very much in what form that phosphorus exists. We have not yet studied the effect of phosphates of alumina and iron, such as has been done in other countries. They have found in certain soils in Hawaii that were as particularly deficient in phosphorus as ours, a marked response to phosphorus, even where it was supplied actually as phosphates of iron and alumina that are generally supposed to be unavailable in the soil. If the plant urgently requires phosphate, I believe it will take it, no matter whether there is an excess of these other elements or not. But that also is a matter which requires further experiment under our own conditions.

CHAIRMAN: If there are no more questions to ask Mr. Dodds, I propose that you accord him a hearty vote of thanks for his paper and his answers and explanations to questions put to him.

Carried.

CHAIRMAN: We will now call upon Mr. le Roy to read the paper on A System of Control and Distribution of Water in Sugar Cane.