POTASH : A NEGLECTED FERTILIZER ?

By J. L. DU TOIT

Introduction.

South African soils are notoriously deficient in available phosphates, and the soil of the sugar belt is no exception. Some of the first experiments put down after the establishment of the South African Sugar Association's Experiment Station gave spectacular increases in yield of sugarcane after the application of phosphatic fertilizers and particularly superphosphate[3, 4, 5]. Responses to inorganic nitrogen and to potassic fertilizers were in some cases not so apparent and it is therefore not altogether surprising that phosphatic fertilizers became, to the near exclusion of potash, the most common artificial added to the soil.

Although nitrogenous fertilizers were somewhat overshadowed by superphosphate at first, their importance was soon demonstrated, and some excellent papers were written on the subject.[2, 6] To-day the value of this most important plant food is well realised in the industry, although many plantations are still showing signs of inadequate applications of nitrogen.

Potash, however, still remains the Cinderella fertilizer of the Natal sugar industry. The value of potash was apparently realised quite early on. In fact some of the first experiments carried out in the industry and published in 1912[20] showed that phosphate was the most urgently needed plant food, but that the best results were obtained by using phosphates and potash together. It was stated "little benefit is derived from renewed applications [of phosphate] when given alone and without potash. Such applications only serve to enhance the exhaustion of soil potash and may in the circumstances do more harm than good. The lesson derivable from these plots and those receiving superphosphate and potash, is that *superphosphate is the most suitable and profitable form of phosphatic manure, but that repeated application without potash is to be avoided.*"

The need for potash was later reaffirmed by fertilizer experiments carried out by the German Potash Syndicate[12].

In some of the first experiments carried out by the Experiment Station[5] the effect of potassic dressings on the plant cane crop harvested in 1928 was rather disappointing, and only increased the yields from 19.69 tons cane per acre to 20.62 and 22.80 tons in the case of potassium chloride and potassium sulphate dressings respectively. The first ratoons received a dressing of superphosphate and sulphate of ammonia on all plots and the potash dressings were repeated. The results described as "evidently a real response to potash" were as follows:—

	Control	KCl	K_2SO_4
Tons cane per acre	30.58	35.96	35.40

And yet in 1942 Dodds[7] stated: "While we have found occasionally a response to potash, such cases have been relatively few, and satisfactory yields were obtained in practically every case without potassic fertilizer. It would appear to be unnecessary under present conditions, therefore, to apply potash, which is fortunate in view of the position of the supply of such fertilizers." A year later the same author[8] reaffirmed this statement: "There are very few cases where any response [to potash] is indicated, and none where any highly important differences are found." Later, Sherrard[21] found that out of twenty-six trials examined only four gave positive significant responses to potash and seven a doubtful response. He concluded: "The position with regard to the use of potash on cane is obscure, and until further investigations are carried out it would seem advisable to leave this manure out of the fertilizer scheme on the cane farm."

Further investigation on the potash problem is certainly most essential as there are many important aspects that need elucidation; but to leave potash out of a general fertilizer programme, as is being done at present, may be dangerous and costly, particularly so in view of the continuous depletion of soil potash by the cane crop and where war conditions as referred to by Dodds might again interfere with the supply position.

Potash Depletion of Soils.

Sugarcane is known to absorb very large quantities of potash from the soil, and whereas the phosphate taken up by the sugarcane plant is very largely returned to the land as filter cake, nearly all the potash is lost in the molasses and to a lesser degree in bagasse ash. If we assume the following general averages:—

Molasses on cane	3 per cent.
Ash on molasses	11 per cent.
Potash (K_2O) on ash	35 per cent.

then potash as K_2O per cent. molasses is 3.85 and potash as K_2O in cane is 0.1155 per cent. It follows, therefore, that on an average the loss of potash in molasses alone in a 30 tons per acre crop is about 70 lbs. K_2O, and the total amount of potash removed in molasses on a 5,700,000 ton cane crop is no less than 6,583 tons K_2O, or equivalent to nearly 11,000 tons of high grade muriate of potash. Add to this the loss of potash removed in bagasse, and it will be seen that the soil of the sugar belt is annually deprived of a colossal quantity of potash, and to replace it would cost the industry at present prices about £250,000.

A certain amount of potash is now recovered from dunder, but the sugar industry as a whole uses only a very small quantity of potash annually and that mostly in the form of mixtures and Karroo manure.

The analysis of the coastal soils is by no means high in available potash, and in some cases they are exceptionally low. It seems most unlikely that this drain on potash can be afforded by the industry for very much longer, in fact potash deficiency symptoms have become more common in recent years. Whether this is the result of closer observation or that these deficiencies are rapidly increasing, is difficult to say. The danger is, however, that some soils, deprived of so much available potash that starvation symptoms become apparent, might require far more potash fertilizer to satisfy their own powers of fixation and the requirements of the plant, than the quantities calculated above. This important aspect of the problem has already been referred to by Lintner[13] who pointed out that "no reserves are inexhaustible."

Potash Deficiency Symptoms.

Potash deficiency symptoms have been described by the last named author, and excellent descriptions were given by Hart[10] and by Martin[19] of deficiency symptoms developed by sugarcane grown in culture solutions. Potash deficiency symptoms are fairly easily recognisable in the field. One of the most outstanding features is the reddish discolouration on the upper surface of the midribs. This is associated with numerous tiny red-brown spots on the laminae of the blades and a firing of the edges where the leaves seem to die back from the tips and along the edges. These symptoms are more common and better developed in the older leaves which assume a yellowish-green colour. It is often claimed that the plants assume a fanlike appearance and that the leaf tips after dying seem to curl more than normal. These latter symptoms have been noticed in some fields, but the spots mentioned on the leaves and midribs are more easily recognisable and characteristic. Only in very severe cases of potash deficiency are the symptoms apparent on the younger leaves. Potash deficiency symptoms are well established and a great help in identifying very deficient areas; but with the periodic droughts along our coast leaves often die prematurely because of lack of moisture, and red markings on the midribs may appear as a result of insect injury or red rot in the midribs. It is therefore necessary to get some leaves analysed wherever any doubt exists. Potash deficiency is of course revealed by an abnormally low concentration of potassium in the leaf, but with sugarcane in Natal this seems also to be invariably associated with an abnormal accumulation of magnesium and sometimes calcium. Potassium/calcium antagonism is of course quite common in other crops, but with us potassium/magnesium antagonism seems to be the rule.

Growth-Rate Measurement Experiments.

When areas are found which seem either abnormally low in potash content of the leaves or actually show potash deficiency symptoms and further proof is still required, then growth-rate experiments as described last year[9] can be conducted. In fact this was done in some localities. Thus at Kearsney, where stunted growth, deficiency symptoms and leaf analyses all pointed to a shortage of potash in the soil, the following results were obtained rather late in the season when conditions for conducting this type of experiment were far from optimum :—

Treatment	O.	N.	P.	K.	NPK.
Mean increment in inches ...	36.2	43.8	35.6	46.6	56.4

Significant difference 8.46 at P=0.05.

Another experiment in the same area suffered as a result of rat damage but yielded the following results:

Treatment	O.	N.	P.	K.	NPK.
Mean increment in inches ...	31.8	44.4	28.0	43.4	58.2

Significant difference 19.8 at P=0.05.

The error, as a result of the damage to some stools, was abnormally high, but, although not statistically significant, the effect of the potash dressing was obvious, and the NPK dressing significantly better than control or phosphate treatment.

Similarly, potash responses were obtained using this method on certain plots at the Experiment Station and also in the Inanda area. It is rather interesting that the leaves from the plots on the Experiment Station were very low in potash but there were no deficiency symptoms. The variety Co.281 was then ploughed out and after a green manure crop Co.301 was planted. Leaves from the plant cane crop were again low in potash, but the deficiency symptoms only became apparent in the first ratoon crop this year. Apparently, therefore, the cane in these plots suffered from insufficient potash for quite a time before the actual symptoms appeared. Deficiency symptoms are really starvation symptoms as pointed out by Spurway,[22] and it seems certain that for every field showing deficiency symptoms there must be a number of others not showing the symptoms but suffering from a lack of fertilizer.

The growth-rate method has confirmed certain suspicions of potash deficiency and revealed others, but it must be pointed out that in the majority of cases no potash response was found.

Field Experiments.

Much the same can be said about field experiments carried out by the Experiment Station over the last twenty to twenty-five years. The analyses by Sherrard[21] has already been referred to and also the comments by Dodds.[7, 8] A further examination of the trials dealt with by Sherrard and a few additional and some new ones, reaffirms the conclusion that in the majority of instances no significant responses were recorded. The total number of doubtful and statistical significant responses is about equal to the number of no responses or unlikely responses. There were some relatively high increases in yield but these were by no means numerous, and on the average for the thirty-one experiments examined, potash application gave an increase in yield of about 5 to 7 per cent. There were five experiments in which the potash treatment gave a slightly lower yield than the no-potash treatment, one was practically identical and twenty-five gave some sort of an increase. The average amount of potash used in these experiments is not high and amounted to the equivalent of about 115 lbs. muriate of potash per acre, and in a large number of instances the quantity of potassium chloride used was no more than 80 lbs. per acre. In fact, the lack of significance might have been due in some cases to too low an application of this fertilizer. The averages of yield increase and fertilizer used must necessarily be somewhat approximate, because in some of the older experiments the data is somewhat incomplete. It is often, for example, difficult to know whether ratoons have been fertilized or not, and residual effects have not been included in the results given here. Sucrose determinations for all different treatments are not always available either, and therefore a cane basis, instead of the more satisfactory sucrose per acre basis, is used.

It should be pointed out that the significant responses and strong indication of responses were by no means confined to one or two soil types but were in fact obtained on recent sands, soils derived from dolerites, Table Mountain sandstone, Ecca shales, granites, and, in one case, a doubtful result was even obtained on alluvial soil.

It will be agreed that the average increase due to potash application is not very spectacular, but it does amount to an extra 1½ to 2 tons of cane on a 30 ton crop, and it does not compare so very unfavourably with the average increases due to nitrogen and phosphates given by Dodds[8] for experiments conducted during the years 1933-1942. The results from all these experiments are given as follows:—

For Nitrogen :

Number of experiments	56
Cane yield per acre with no nitrogen	37.26
Cane yield per acre with nitrogen	41.69

Increase due to nitrogen about 12 per cent.

For Phosphates :

Total number of experiments	60
Cane yield per acre with no phosphates	35.39
Cane yield per acre with phosphates	38.17

Increase due to phosphate about 8 per cent.

Lintner,[13, 14, 15, 16, 17, 18] who has carried out quite a number of experiments, found significant potash responses on recent sands, an alluvial soil and a red dolerite soil. In all, eight experiments done by this author were examined and potash gave responses in five of them, had no noticeable effect in two, and a significant depression in one experiment was caused by the heavier dressing of potash. On the average the potash-treated plots augmented the yield by about 16 per cent., and about 160 lbs. of K_2O, or equivalent to 250 lbs. of muriate of potash per acre, were used to bring about this result. In some trials an appreciable residual effect from potash application was also demonstrated. A few of the results obtained on a red dolerite soil at Kearsney may be of interest:—

	lbs. K_2O per acre.		Yield in tons cane per acre.		
	K_1	K_2	NP	NPK_1	NPK_2
Plant cane	109	218	42.63	46.42	50.09
1st Ratoon (residual)...	0	0	26.30	29.82	31.42
2nd Ratoon...	100	200	19.19	26.69	28.69

Watson[24] gave the results of four experiments in which the effect of potash was measured. In three of these experiments potash had little or no effect on the yield, but in the fourth a significant increase in yield was obtained. The results were as follows:—

	lbs. K_2O per acre.		Treatments.		
	K_1	K_2	NP	NPK_1	NPK_2
Yield in tons cane per acre	195	345	35.23	39.01	42.44

A Potash Experiment at Mtunzini.

During 1948, third-leaf samples were brought in for analysis from the farm of Mr. I. Garland, of Mtunzini. The Co.301 was stunted, and what appeared to be potash deficiency symptoms were evident in places. The analysis of the leaf samples showed that potash deficiency existed on the farm and it was decided to put down a potash top-dressing experiment on the ratoon cane crop. The design of the experiment was a Latin square with the following treatments:—

N = 400 lbs. per acre ammonium sulphate.
NK_1 = N+335 lbs. muriate of potash per acre.
NK_2 = N+400 lbs. potassium sulphate per acre.
NK_3 = N+670 lbs. molasses ash (30% K_2O) per acre.
NP = N+500 lbs. superphosphate.
NPK_1 = N+P+K_1.

The top dressings amounting in the case of potash to 200 lbs. K_2O per acre, were applied in September, 1948, to the young ratoon cane.

The soil is a reddish recent sand and gave the following analysis:—

Total nitrogen (N)	=	0.064 per cent.
Total phosphates (P_2O_5)	=	0.02 per cent.
Total potash (K_2O)	=	0.02 per cent.
Available phosphates (P_2O_3)	=	0.001 per cent.
Available potash (K_2O)	=	0.001 per cent.
pH		5.5

During May, 1949, third leaf samples were taken from all plots. Total nitrogen was determined on the dried third leaf samples and potash and phosphates after dry ashing. The nitrogen in the leaves showed no significant difference between treatments, but the concentration of potash and phosphates were significantly affected. All the potash treatments increased the potash content of the leaves and there was no significant difference between the different potash treatments.

Treatment	N.	NP.	NK_1	NK_2	NK_3	NPK.
Per cent. K_2O...	0.83	0.91	1.42	1.45	1.54	1.38

Significant difference : 0.22 at P=0.05.
0.30 at P=0.01.

The NP treatment affected the phosphate concentration very significantly in the leaf and the NK_3 treatment also had a significant effect:—

Treatment	N.	NP.	NK_1	NK_2	NK_3	NPK.
Per cent. P_2O_5...	0.312	0.335	0.318	0.310	0.330	0.315

Significant difference : 0.015 at P=0.05.
0.020 at P=0.01.

The cane was harvested in December, 1949, and gave the following results:—

	Tons sucrose per acre.	Tons cane per acre.
N	2.82	20.71
NP	2.87	20.90
NK_1	4.06	28.03
NK_2	4.26	29.20
NK_3	3.89	25.99
NPK	3.97	27.09
Significant difference : P=0.05=	0.51	3.02
P=0.01=	0.69	4.11

All the potash treatments therefore increased the yield of sucrose per acre very significantly, but there was no difference among the potash treatments themselves or among the non-potash treatments—a conclusion which is identical to the effect of treatments on potash concentration in the leaf. This experiment gave a very spectacular increase in yield as a result of potash application. On an average the yield of sucrose per acre was increased by 42.2 per cent.

In this experiment both the yield of cane and the sucrose per cent. cane were significantly affected by potash treatments. The effect of the treatments on sucrose per cent. cane was as follows:—

	Sucrose per cent. Cane
N	13.53
NP	13.55
NK_1.	14.47
NK_2.	14.60
NK_3.	14.92
NPK	14.65

Significant difference : 0.80 at P=0.05.
1.09 at P=0.01.

It has, of course, often been claimed that potash increases the sucrose per cent. cane and improves the juice quality; but this is the first experiment in South Africa of which the writer is aware where this effect has been clearly demonstrated.

The effect of the treatments on some juice qualities was as follows:—

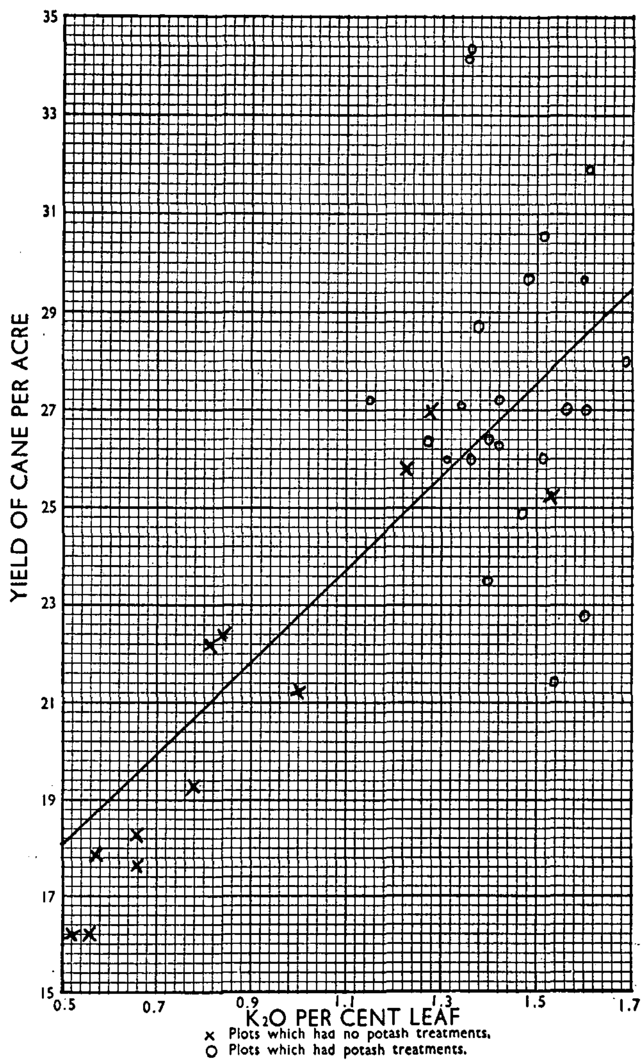
Treatment.	Purity.	Reducing Sugar per cent.	Reducing Sugar Ratio.	Brix of Juice
N	88.4	0.79	4.70	19.5
NP	88.6	0.76	4.54	20.0
NK_1	91.0	0.47	2.57	20.0
NK_2	90.2	0.49	2.68	20.2
NK_3	91.1	0.44	2.33	20.6
NPK...	91.8	0.49	2.64	20.2

After the crop was harvested, a high degree of correlation was found to exist between final yield in tons cane per acre and the percentage K_2O in the dried, third cane leaf sample. The correlation coefficient for the 36 pairs of observations was 0.7437, which is, of course, highly significant, and the linear regression equation was:—

$$E = 13.30+9.5967X.$$

Where E = expected yield in tons cane per acre.
X = K_2O per cent. dried leaf.

The following graph illustrates the relationship between yield and leaf analysis:—



It will be seen that there was evidently a wide variation in the potash-supplying power of the control plots. There were several plots with an extremely low concentration of potash in the leaf, and yields of less than 19 tons per acre were quite common. On the other hand, three plots with no potash treatment yielded between 25 and 27 tons cane per acre, but as will be seen, they were evidently on plots appreciably higher in available potash.

After harvesting, nitrogen, phosphates and potash were also determined on all juice and bagasse samples, and by combining the known proportions of juice and bagasse, the percentage of N, P_2O_5 and K_2O on millable cane could be calculated. Thus the average percentage composition for the various treatments on millable cane was as follows:—

	N.	P_2O_5	K_2O
N	0.074	0.036	0.053
NP	0.067	0.049	0.070
NK_1.	0.064	0.037	0.129
NK_2.	0.062	0.032	0.126
NK_3.	0.058	0.043	0.139
NPK	0.063	0.041	0.166

The percentage composition of the third leaves was as follows:—

	N.	P_2O_5	K_2O
N	1.44	0.312	0.83
NP	1.37	0.335	0.91
NK_1.	1.41	0.318	1.42
NK_2.	1.38	0.310	1.45
NK_3.	1.34	0.330	1.54
NPK	1.37	0.315	1.38

It will be seen that the agreement between leaf analysis and cane composition, particularly of potash and phosphate, is very good, and the leaf analysis therefore gives an excellent indication of the relative amounts of these plant foods available to the plant and being taken up by the plant in an experiment of this nature.

The amounts of plant foods in lbs. per acre removed in this experiment are as follows:—

Treatment	N.	P_2O_5	K_2O
N	31	15	22
NP	28	21	32
NK_1.	36	21	73
NK_2.	36	19	73
NK_3.	30	23	73
NPK	34	22	63

It will be seen that only $^1/_5$ to $\frac{1}{4}$ of the heavy dressing of potash applied was removed in the first crop. Leaf analyses on the subsequent ratoon crop show, however, that there is still a large residual effect.

To get an indication as to whether using plant material really deficient in potash can effect germination and growth, setts from both potash-treated plots and plots without potash treatment were planted in a pot experiment. It was found that out of 100 setts of each:—

Cane from plots treated with potash germinated 90 setts;

Cane from plots not treated with potash germinated 64 setts.

The setts from the plots without potash treatment were also poorer in growth. Germinated setts were transplanted (care being taken to select plants of about equal size) into Mitscherlich pots filled with untreated soil from the experiment and potash applied at the rate of 0, 100 lbs. K_2O, and 200 lbs. K_2O per acre. There were six replications. For some reason the plants having had no potash grew quite well and the potash-treated ones were apparently not much superior. At harvesting the following results were, however, obtained as grams cane weight per pot:—

	Amount of K_2O per acre 0	100	200
Setts from plots with potash treatment	316.0	346.8	346.2
Setts from plots without potash treatment	282.7	318.2	318.8

The results of this pot experiment are not given as definite proof of inferior germination and poorer growth of cane from potash-deficient plant material, but the indications are definitely in that direction, and it is felt that further experiments and field trials along these lines are very necessary.

Discussion.

Enormous quantities of potassium salts are being removed from the sugarcane belt annually and the return to the soil as potassic fertilizers is almost negligible. This last season, the loss of potash in molasses and bagasse probably well exceeded 7,000 tons of K_2O, and in return the industry applied only 10 tons of muriate of potash as a straight fertilizer. It is true, however, about 30,000 tons of mixed fertilizers were used, but it is exceedingly doubtful whether the potash in them amounted to as much as 900 tons K_2O. To this must be added the potash introduced in the relatively small quantities of Karroo manure and organic mixtures. South Africa is to-day justly concerned about soil erosion, a problem which is fortunately not so acute in this industry, but can the sugar industry afford the amount of fertility "erosion" in the form of potash lost annually ?

In many instances potash experiments have yielded disappointing results, which is the more surprising because this potash drain has been going on for such a long time, but taking into account the past experiments it does seem that it pays to apply a reasonable amount of potash.

This paper is not, however, written to induce planters to apply potash indiscriminately or to show that potash responses will now suddenly become quite general, but rather to draw attention to the undesirable present tendency of gradually exhausting the soil of potash. Potash deficiency symptoms have been seen in a number of localities and on different soil types. Leaf analyses have shown that in many cases the concentration of potash seems to be inadequate and, at least in some instances, big increases have been obtained from potash applications. There is no doubt that in cases of real potash deficiency the sucrose per cent. cane is also improved by such an application and it seems possible that germination and subsequent cane growth may be adversely affected by potash deficiency in the plant material.

It seems, therefore, quite clear that we should concentrate on potash in our programme of fertilizer experiments.

South Africa is by no means the only sugar growing country where potash has been somewhat neglected and is assuming greater importance to-day. In Trinidad[1] unbalanced fertilizer practice has apparently led to the gradual depletion of soil potash reserves, and the correction of this deficiency now leads to large increases. In Jamaica[11] it is now believed that potash dressings should be greatly increased and excellent responses have been obtained, whereas before potash applications were small and mostly confined to mixed fertilizers containing potash. In Australia[23] there are indications that potash is replacing phosphates as the main plant food requirement.

Summary.

South African soils are notoriously deficient in phosphates and the value of phosphatic and nitrogenous fertilizers have been clearly demonstrated in many field trials in the sugar belt where the importance of these fertilizers are now realised.

Although some of the earlier experiments pointed to the importance of potash as a cane fertilizer, some later ones failed to give significant increases in yield. An examination of these latter experiments indicate, however, that on the average the increase to be expected from a reasonable application of potash is economical.

The present practice of applying negligible quantities of potash fertilizers is considered dangerous in view of the large amount of potassic salts being lost annually. Potash deficiency symptoms are in fact becoming more common and leaf analyses and growth measurement experiments have indicated that potash deficient areas do exist.

Results of a field trial where potash top dressings had an outstanding effect in increasing the yield of cane as well as the sucrose per cent. cane are given. Juice quality was appreciably improved by the potash application. Leaf analyses as well as juice and bagasse analyses correlate well with the final yield, and show large potash variations in the control plots which explain the yield variations in these plots. There were indications that germination and subsequent growth might be adversely affected by using potash-deficient plant material.

Experiment Station,
South African Sugar Association,
Mount Edgecombe.
March, 1951.

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The President said the paper provided a jumping off ground for argument and added that cases of failure were known which had defied diagnosis, but which were now thought to be due to lack of potash.

Mr. Lintner congratulated Mr. du Toit on bringing information on the subject up to date and also for putting on a sound basis work on sugar cane leaf diagnosis. This method of determining plant nutrient requirements had proved invaluable for other crops and the results obtained for cane by Mr. du Toit were most interesting. The number of experiments in which significant responses to potash were shown was not numerous, but the number of fields of cane in which the leaves showed the accepted potash deficiency symptoms probably indicated that the problem had been insufficiently investigated. The majority of experiments had not been conducted for a sufficiently long period; had the work been continued over a number of years on the same sites where the original negative results were obtained it might have been possible to obtain evidence of a more general response to potash. A French worker, de Chaminade, investigating potassium on heavy clay soil, used some 200 kgs of K_2O per hectare per annum and it was only about six years after the first application that he found an increase in potash in the drainage water, indicating that large amounts of potash had been fixed by the soil. More recent work showed that continuous wetting and drying of a soil increased considerably the unavailability of potash; the erratic climatic conditions of the Natal coast might easily create the conditions necessary for firm fixation.

The speaker felt that it was time to take stock of knowledge of the soils in the sugar belt, which was not very detailed. In the face of the success achieved through plant breeding on tonnage and sucrose content the progress made on soil work was not spectacular. Only in exceptional cases had a particular soil treatment given effects visible to the eye through crop growth. There was no reason to suppose that because of the striking increases obtained by plant breeding the soil did not remain the most important aspect of cane sugar production; the more intensively soils were cropped the more urgent soil research became, and he advocated properly designed experiments capable of furnishing data necessary to study soil developments. He referred to the effort before the 1939-45 war to establish permanent soil check points throughout the sugar belt and suggested an effort to intensify soil work to enable a proper and detailed survey to be made.

Mr. du Toit said the rapid system of soil testing was now again being applied and it was hoped to carry out the soil fertility surveys which were so essential. These could best be done in conjunction with field experiments. He referred to a case of potash deficiency which was not mentioned in the paper, where attention was directed to a field of cane reported to be dying. As plant cane and first ratoon it apparently yielded about 30 to 40 tons per acre and then suddenly seemed to be dying. Investigation showed that potash deficiency was the sole cause.

Mr. Hendry said emphasis in recent years had been on factory efficiency, but there was a school of thought which felt that some research on the soils of Natal and Zululand was desirable, especially when the objective was a large production of sugar per annum. Past research had not been conclusive on the desirability of additional potash as an essential plant food; there had been a response in a few selected areas to potash but they were isolated. Reynolds Bros. had in recent years commenced analysis of the soils as fields went out of production and were on long fallow. Results in the Esperanza area, which was noted for its high sucrose, showed a sufficiency of K_2O, but shortages of N and P_2O_5. The company was green manuring during long fallow and making heavy applications of super followed by an application of $(NH_4)_2SO_4$ when the cane was established in areas that had had no sun hemp. Overhead irrigation was to be practised in the near future in selected areas. He asked if the Experiment Station field staff had observed any potash deficiency during their tour of the South Coast. Would K_2O deficiency be observed where luxuriant green foliage followed nitrogen application ? What minimum percentage of K_2O would be expected in the dried leaves to say there was ample K_2O for the plants' requirements ? What was the view on applying boiler ash to the fields as fertiliser ?

Mr. du Toit said potash deficiency had been found on the South Coast but it was not common. South Coast soils were generally high in potash. It was possible to find potash deficiency after nitrogen application when all the cane was green, as the lower leaves would probably be yellow. The potash content varied with the season, the rainfall, the age of cane and the method of analysis. In Mauritius the content was, he thought, somewhere about two per cent. and somewhat less in the West Indies. Under the methods he was using he would put the percentage when using cane six to ten months old at about 1.7. Boiler ash contained about eight per cent. potash, but it was largely potash silica and not available.

Mr. Barnes said soil was not static and the fact that potash deficiencies were not found in Natal many years ago did not mean the position was unchanged. Much the same had happened in the West Indies where opinion based on ascertained fact showed clearly that forty years ago the supply of potash was adequate. Fields existed where cane would not grow but excellent results were eventually obtained by using potash; in a few years the potash requirements were completely satisfied and nothing was gained by adding more. Cane over the years might exhaust some of the minerals in the soil and difficulties would arise unless these were replaced. On the question of nitrogen he expressed the hope that some of this might become available from new industries in Natal and said if synthetic ammonia was produced it would be possible to add liquid ammonia to the soil at less cost than applying sulphate of ammonia. It was known that cane's response to fertiliser depended largely on an adequate supply of water being available and water relationships as well as nitrogen relationships had to be taken into account, which indicated that a new outlook was required in assessing potash deficiency.

Mr. Bechard expressed the view that on the whole fertiliser experiments had been somewhat neglected in the post-war years. A fair volume of data was available but not anything like that required. He also felt it might be misleading to suggest that the application of potash increased sucrose content, quoting his own experience to indicate conditions in which wrong conclusions might be drawn. He felt the question of boiler ash should not be dismissed simply with an expression of opinion. It had been found profitable to use a large quantity of boiler ash in Mauritius but this had not been tried in Natal. Most factories burnt little coal, with the result that a clean white ash without clinkers resulted. On the other hand high boiler temperatures might have an adverse effect on potash so that experimentation was required.

Mr. du Toit gave the assurance that fertiliser experiments were being pushed forward on a large scale. He had not said that potash increased sucrose; he had said that in real cases of deficiency the sucrose content could be improved by potash. He did not think potash application increased the sucrose at all if potash were not deficient; some authorities said it depressed the sucrose.

Dr. Dodds said the paper traced certain important progressive experimental fertiliser data based on field experiments over a long period. It was of special interest to him because some of his early statements on the subject were quoted. The experiments cited from the 1928 crop were among the first done at the Experiment Station. In those days methods of field experiments were somewhat primitive; few if any replications were carried out and statistical calculations of significance were unknown. Between 1928 and 1942 a wide range of fertiliser experiments was carried out by the Experiment Station so that it became possible to make certain general statements that were valid at that time.

It was realised that although there was little or no response to potassic fertiliser in those days the position could not last indefinitely. Drs. Hedley and Beater in 1933 showed that the cane crop removed from the soil more potassium than any other fertiliser element, amounting to over 400 lbs. of potash per acre by a 30 ton crop. This, with soil analyses, made it possible to calculate how many crops of cane a given soil could produce without supplies of available potash being renewed. As Mr. du Toit had pointed out, the position had changed during the past twenty years and it was now not unusual to find indications of potash deficiency. It was evident that much study should now be given to this matter and to present fertiliser requirements generally.

Alternative experimental methods were the old established soil analysis system now carried out successfully on a large and systematic scale, for example at Tully in Queensland, on which a valuable paper was read at the previous year's annual Congress of the Queensland Society of Sugar Cane Technologists. There was also the more modern method of foliar diagnosis of cane fertiliser requirements, on which excellent papers were read at the International Conference in Queensland by P. Halais of Mauritius and Dr. Clements of Hawaii. These methods were greatly facilitated in their analytical phase by modern methods of rapid chemical analysis as applied to sugar cane agriculture, originally developed in Hawaii and modified in various other countries. There was, thirdly, the method of growth measurement successfully developed at the Experiment Station, in which he believed some interesting and valuable data might be expected before long from Mr. du Toit and his associates.