GROWTH-RATE METHOD FOR DETERMINING FERTILIZER REQUIREMENTS OF SUGARCANE

By J. L. DU TOIT.

Chemical analyses of both plants and soils to investigate problems of soil fertility have been practised with success for a long time. The technique of soil analysis has been greatly improved, but there is not, and there probably never will be, a method which gives the total nutrients available to the plant throughout its life. In plant analysis the emphasis is shifted to the plant itself, but here again there are complications and, although many can be eliminated and, with standardisation, the method can be made a most useful tool in investigating soil fertility, it is the growth of the plant itself which has the greatest appeal and which in the end must supply proof of the diagnosis based on soil and plant analytical methods.

A number of pot experimental techniques have been developed whereby either the actual growth (usually weight) of the plant itself, or more often some indicator plant, serves as a measure of response to a particular fertilizer, or the chemical composition of the plant or some visual symptom may be used to show deficiencies. Here again objections may be raised. The artificial conditions in the pot are one. Indicator crops may react differently to the actual crop under investigation. All these methods have their drawbacks, but that is no reason why they should not be used very intensively, for their advantages far outweigh their disadvantages and, if more than one method is used, exceedingly valuable information can be gained. The normal fertilizer field-plot experiments take a long time and are expensive. This is particularly so with a crop such as sugarcane, which takes, in this country, about two years before the crop is harvested. For reliable results to be obtained several cuttings are desirable, as climatic conditions during the long period of two years may often be so abnormal that the results obtained from a single crop may not be a guide at all for subsequent years. Nevertheless the properly conducted field-experiment, and of course success in the commercial large-scale plantations, must be regarded as the final test of these diagnostic procedures, because here the actual crop under investigation is used under field conditions.

A method which appears to have many of the advantages of pot tests, in so far as quick results and flexibility are concerned, and share with field trials the great advantage of being conducted on the more or less undisturbed soil under field conditions and on the crop which is under investigation, was described by Evans.[1] Here the total increase in length of sticks is taken as a measure of the growth of a cane-stool over a given period. Fertilizers are applied to individual stools and responses arrived at by comparing the increased elongations of treated with control stools. The method depends on the fact, which has been reaffirmed here, that a correlation of a very high order exists between the growth of sugarcane stools during one month and the following month. Evans selected 25 stools (5 rows of 5 alternate stools) so as to enable him to impose a latin square design. These stools were measured during the period of active growth and the measurement repeated a month later to ascertain the growth for that period. The following treatments were then applied: O, N, P, K and NPK. The method of fertilizer application was by removing some soil so as to expose a dense matting of roots in a circle of about a foot radius around the cane-stool and then making holes 6 to 8 inches deep with a small crow-bar and applying the fertilizer in the holes and as a broadcast over the partly exposed roots and then covering up. After another month all the sticks in stools, including newly formed tillers, are measured again and the difference between the two increments statistically analysed.

This method of testing out responses to fertilizers in the field during the short period of two months seemed to have such possibilities in a general programme of research on soil fertility that it was tried out at the Experiment Station.

Preliminary Experiments.

The first experiments were necessarily exploratory, for it was not known what quantities of fertilizers had to be applied to individual stools of cane to get the best responses, neither was it known how early these experiments could be started or how late they could be continued with a reasonable chance of success. Thus in the first experiments carried out on a wind-blown sand at Bellamonte near Umhloti no responses were indicated on a 5 by 5 latin square design when fertilizers were applied at the rate of 300 lbs. ammonium sulphate, 300 lbs. superphosphate and 150 lbs. potassium chloride per acre. It was then realised that, although the dressings were quite normal in field trials, and were in fact those used by Evans, except that he used 300 lbs. precipitated calcium phosphate instead of super, they may not be adequate to force individual stools sufficiently, because cane adjacent to the fertilizer stools will share in the applications.

On increasing the applications to 1,088 lbs. ammonium sulphate, 461 lbs. superphosphate and 273 lbs. potassium chloride per acre a significant response to N and NPK was obtained on a similarly designed experiment in the same field. The latin square design was, however, difficult to arrange on stools not originally planted for this purpose and there was the possibility of biased results. This would necessitate the analysis of the results by the co-variance method involving long and complicated calculations for a rapid and simple method and leaving us with adjusted totals which are not so readily understood. It was then decided to arrange experiments in randomised blocks, each block consisting of stools of rather similar growth-rates. This procedure made it advisable to ascertain the growth-rate of a number of additional stools, so as to leave a better selection, but it simplified the calculation a great deal and in addition the experiment could now be applied to any shape or size of plot or field. An experiment of this lay-out at Bellamonte again gave significant results, N being better than NPK and both better than O, P and K. When this last experiment was later repeated on an adjacent plot and the fertilizers applied in April no response was found, the reason probably being that the cane had passed its active growing period, with a consequent drop in sensitivity of the method and a lower fertilizer demand by the cane plant.

Attempts to simplify the work by measuring only five sticks in each stool, or five adjacent sticks in a row, failed because the total response to fertilizers is often largely the result of increased tillering which will not be accounted for in these shortcuts. As stated before, a high positive correlation was found between one month's growth and the succeeding month's growth, but a simple arrangement in blocks based on the size of stools instead of growth-rates, thereby eliminating one measurement, also proved unsuccessful.

Method.

The method finally decided on was to measure 30 to 40 stools and to repeat the measurement after about one month's growth during the best growing period and then to arrange in blocks according to the determined growth-rate. The necessary treatments, e.g. O, N, P, K and NPK properly randomised and replicated, say, five times, are now applied. The final measurement is taken after about a further month and the results analysed on the actual increment in growth after the fertilizer application.

The following example will illustrate the procedure for a test carried out on a field at the Experiment Station which was shown by leaf analyses to be extraordinarily low in nitrogen :—

	Monthly growth increment in inches before treatment.					Monthly growth increment in inches after treatment.				
Block...	C.	N.	P.	K.	NPK.	C.	N.	P.	K.	NPK
A ...	19	18	17	18	20	31	81	24	39	96
B ...	16	15	15	15	16	25	84	23	23	89
C ...	12	14	12	14	13	35	79	24	33	61
D ...	10	10	12	12	9	30	59	19	25	68
E ...	9	8	9	8	7	22	64	18	21	45
Average ...	13.2	13.0	13.0	13.4	13.0	28.6	73.4	21.6	28.2	71.8

Significant diffeernces at P= .05 is 12.4.
at P= .01 is 17.1.

It will be seen therefore that N and NPK gave highly significant increases in the rate of growth over all other treatments.

The amount of fertilizers applied in this case, as in all experiments since the beginning of 1949, were equivalent to: ammonium sulphate 1,088 lbs., superphosphate 922 lbs. and potassium chloride 546 lbs. per acre.

The measurements were taken from the top of a grid resting on a fixed iron peg next to the stool to the last dew-lap of each cane stick. The grid is fitted with two spirit levels. Measurements are done by means of a steel measuring tape and the readings taken to the nearest ¼ inch, but the totals per stool rounded off to the nearest inch.

Results.

From the time that growth measurements have been started at the Experiment Station some 30 tests have been completed, including the trials already described at Bellamonte. A further experiment some distance away and on a slightly heavier sandy soil gave a significant response to NPK only.

A test at the Experiment Station in field M, consisting of a heavy black loam, was planted to conform to 6 by 6 latin square design and the following treatments applied : O, N, P, K and NPK as top dressings and an additional P as a basal dressing. Here an analysis by the co-variance method gave a significant response to N and NPK only.

At Doornkop, Sprinz section, an experiment on rather old plant cane was carried out with the following treatments : O, N, P, K, NPK, lime and molasses. No significant results were obtained. Young cane on the same section planted on two adjacent plots, one of which received no lime and the other 4 tons of slaked lime per acre about three months before planting, was tested out for responses to N, P, K and NPK, but in neither case had these any significant effects. This Doornkop area is part of the mist-belt soils. A test on old ratoons on a mist-belt soil at Inanda gave a significant response to N and NPK, while K was found significantly better than P.

The following experiment was carried out on a red recent sand on the farm of D. Ackerman, Gingindhlovu :—

Treatment:	C.	N.	P.	K.	NP.	NK.	NPK
Mean increment in inches	51.6	87.4	51.2	52.4	88.4	76.8	65.8

The spectacular increases due to nitrogen and nitrogen combinations are evident. N, NP and NK are significantly better than C, P and K. The treatment NPK fails in significance due to poor growth and damage to two stools.

At Chaka's Kraal Experimental Farm six growth measurement tests were carried out. Four of these tests were done where a field trial had shown significant nitrogen responses. In all four cases the growth-rate method gave similar responses. In one of these tests different levels of nitrogen were applied and the results were as follows :—

Nitrogen as lbs. ammonium sulphate per acre ...	0	544	1,088	1,632
Mean increment in inches	150.0	182.4	215.2	229.0

All the differences between treatments are significant.

The other two tests were done as a result of leaf analyses. It was found that nitrogen in leaves was high in one case and low in the other. Growth measurements showed no responses in the first test and a response to nitrogen as a top dressing in the second case. At Powerscourt no response was obtained from nitrogen in a rapid test and a field experiment also failed to show such a response.

Growth measurement tests therefore agree very well with field experiments and also with leaf analyses as far as nitrogen is concerned.

Tests were carried out in three areas where phosphate field trials were in progress and where phosphate responses were obtained. At both Gingindhlovu and Powerscourt the growth rate method gave increases due to the application of P and more so to NPK; but none of these results was significant. The results of the Gingindhlovu tests were :—

Treatment:	C.	N.	P.	NP.	NPK.
Mean increment in inches	49.0	52.0	61.2	66.2	78.2

Some interesting growth tests were done at the third centre, Compensation, on cane that was about a year old. Different levels of superphosphate were tried out, but there was no significant difference between the control and any of the levels. The results were as follows :—

Lbs. Superphosphate per acre	0	461	922	1,844
Mean increment in inches	48.8	48.3	50.2	52.4

In a trial consisting of the following treatments, O, N, P, K and NPK, however, the NPK dressing gave a highly significant response and was the only treatment that resulted in a real increased growth. It may be mentioned that phosphate concentration was very low in the leaves and that the nitrogen per cent. leaf was also low. These percentages were somewhat increased by phsophate and nitrogen dressings, but not nearly to the extent as when the NPK treatment was applied. The following combinations were then tried out, O, NP, NK, PK and NPK, and the results were as follows :—

Treatment:	O.	NP.	NK.	PK.	NPK.
Mean increment in inches	42.8	64.6	49.8	43.6	61.2

Significant differences: 13.28 at P=.01 and 9.64 at P=.05.

Now, both NPK and NP were significantly better than any other treatment. In this experiment under the then existing conditions it is clear that a top-dressing of superphosphate, or ammonium sulphate or potassium chloride by itself gave no responses, but either NP or NPK gave significant responses.

After this field was cut and the whole experiment top-dressed with 200 lbs. of ammonium sulphate, a growth test was again done. The cane was then about six months' first ratoon. In this test N, P and K and all their possible combinations were tried out as well as precipitated calcium phosphate, which was originally used by Evans. The same amount of precipitated calcium phosphate (922 lbs. per acre) as superphosphate was used. The results of the experiment were as follows :—

Treatment:	C.	N.	P.	Px.	K.	NP.	NK.	PK.	NPK
Mean increment in inches.	44.8	50.2	68.6	69.4	43.4	78.2	41.4	72.4	91.8

Significant differences: 22.8 at P=.05 and 30.7 at P=.01.

The effects of P and its combinations are clearly shown. It can also be seen that there is no difference in the experiment between results obtained from superphosphate and precipitated calcium phosphate, headed Px.

When the field trial was cut a significant response to a top-dressing of superphosphate was also found; but it seems very doubtful whether this result would have been obtained had the dressing of ammonium sulphate not been given.

Unfortunately, due to the long distances involved, it was not possible to conduct such a detailed investigation on the Powerscourt and Gingindhlovu experiments; but it has been demonstrated how useful such tests can be. Phosphate responses can certainly be obtained by this method and the fact that initial tests failed, even with very high dressings of superphosphate, shows that responses could not be obtained at that stage because of a lack of something other than phosphate—in this case nitrogen. The growth measurement tests have therefore complemented the field trial and rendered information which the latter in its present form could not provide.

In a burning-trashing-fertilizer field trial in field G2 at the Experiment Station it was noticed that some of the burnt plots were exceedingly poor. Leaf analyses gave a strong indication of potash deficiency amongst other things, but there were no potash deficiency symptoms. Growth tests were then conducted on two such plots (plots 16 and 23) and on a third trashed plot, No. 20, where potash was high and the growth excellent. In the latter plot no potash response was found, but a highly significant response to N and NPK. In a similar experiment in plot 23 there were responses to N, K and NPK. In the third test in plot 16, different levels of potash were tried out with the following results :—

Potassium chloride lbs. per acre	0	150	300	450
Mean increment in inches	35.0	30.0	41.2	50.2

Significant difference : 15.29 at $P=.01$ and 11.06 at $P=.05$.

The potash deficiency might have been created artificially by removing the tops of the cut cane from the burnt plots.

Areas in which potash deficiency is obvious are not common in the sugar belt and, when such a field was found at Mtunzini, where visual symptoms and leaf analyses pointed to a deficient supply of potash, a field trial was put down and a growth test done on some adjacent cane rows. The field trial showed a highly significant response to potash. The growth-rate experiment, however, gave no such response, but a highly significant increased growth-rate was obtained from a dressing of ammonium sulphate. The effect of nitrogen was not tested out in the field trial; but the potash results appear at first sight contradictory and a response was expected in both cases, although there happened to be no deficiency symptoms in the cane used for the growth test. The leaves of all plots in the field trial and the different treatments in the growth trial were analysed and this provided a full explanation of the responses obtained. The analysis of the growth-test samples revealed the cane to be very low in nitrogen and the potash content high in comparison to most control plots in the field trial. In fact the control plots in the field trial became more normal in potash content the nearer they were to the growth trial; and this was also reflected in the yields. Further investigation has therefore completely explained an apparent contradiction.

A growth experiment was put down in the Kearsney area, where potash deficiency was again apparent. Here stools showing actual deficiency symptoms were used and, although the experiment was carried out very late in the season, a significant response was obtained from the potash application and, although it was no longer the most active growing period, the symptoms in the younger leaves disappeared soon after the K dressing was applied. The whole field was then treated with molasses ash and when last seen looked really well.

A number of experiment results have been given in detail and others have just been referred to. The detailed results of tests not yet recorded in full are given in the following table. The results given under the treatments are the mean actual increments in inches per stool of cane after fertilizer application; or in a few cases the mean adjusted increments. † and * signify significance over control at $P=.01$ and $P=.05$ respectively. The fertilizers used were equivalent to :—

A: Ammonium sulphate 300, superphosphate 300 and potassium chloride 150 lbs. per acre.

B: Ammonium sulphate 1,088, superphosphate 461 and potassium chloride 273 lbs. per acre.

C: Ammonium sulphate 1,088, superphosphate 922 and potassium chloride 546 lbs. per acre.

TABLE OF RESPONSES.

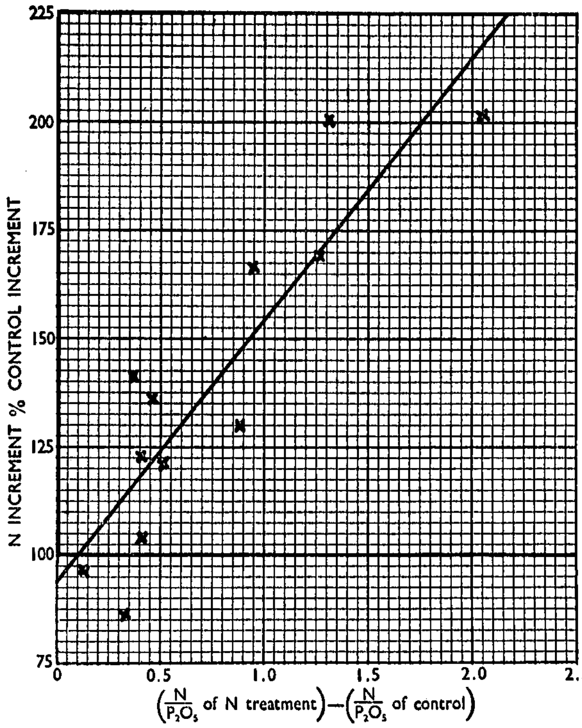
Locality.	Soil or formation.	Amount of fertilizer	Approx. age of cane.	C.	N.	P.	K.	NPK.
Bellamonte, Umhloti	Recent sands	A	12 P	34.8	36.2	38.4	29.4	41.0
,, ,, ...	,, ,, ...	A	13 P	65.2	47.4	42.0	40.8	78.2
,, ,, ...	,, ,, ...	B	14 P	42.4	56.7*	40.2	41.9	62.7†
,, ,, ...	,, ,, ...	B	14 P	61.0	117.6*	66.6	65.0	97.8*
,, ,, ...	,, ,, ...	B	15 P	91.5	109.6	99.0	90.2	122.7*
Experiment Station M_1...	Black clay loam ...	B	5 P	317.6	359.0*	350.0	318.3	373.8*
,, ,, G_2, Plot 20 ...	Black dolerite ...	B	3 R	109.0	142.1†	114.4	102.1	156.0†
,, ,, G_3, Plot 23 ...	,, ,, ...	B	3 R	31.8	63.6†	46.2	55.0*	79.2†
Chakaskraal Experimental Farm	Dwyka loam... ...	B	6 R	143.8	203.0*	145.4	139.6	229.6*
,, ,, ,, ,, ...	,, ,, ...	B	6 R	35.2	151.2†	24.8	46.2	126.2†
,, ,, ,, ,, ...	,, ,, ...	B	6 R	141.4	186.4†	153.6	121.8	213.4†
Compensation	Recent sands	B	13 P	42.6	45.8	45.0	43.8	78.4†
Powerscourt	Mist-belt soil	B	15 R	29.4	25.7	32.6	32.6	38.1
Doornkop	,, ,, ...	B	16 P	44.6	48.2	45.6	42.8	49.0
Doornkop—limed	,, ,, ...	C	7 P	245.0	210.6	219.9	260.0	231.4
Doornkop—not limed	,, ,, ...	C	7 P	214.4	208.4	225.4	188.8	202.2
Inanda	,, ,, ...	C	8 R	47.2	58.0*	41.6	54.8	58.6*
Chakaskraal Experiment Farm ...	Dwyka loam... ...	C	7 R	29.2	48.8†	27.2	29.2	45.4†
,, ,, ,, ,, ...	,, ,, ...	C	8 R	65.2	68.8	61.8	59.4	73.2
Mtunzini	Recent sands	C	8 R	33.6	68.0†	27.6	32.4	72.6†
Kearsney	T.M.S. ... ..., ...	C	6 P	36.2	43.8	35.6	46.6*	56.4†

The age of the cane is given in months, P stands for plant cane and R for ratoon.

Leaf Analyses and Growth-rate Tests.

This paper does not deal with leaf analysis as such, but it has been referred to, and has often offered an explanation of the results obtained. Unfortunately leaf analyses have not been done systematically for some of the earlier experiments. Leaf analyses have been done on composite samples of the various treatments in 15 growth-measurement tests. Phosphate and potash responses have not been found often enough to attempt correlations. Nitrogen responses have been more common, but of course the experimental material, cane, varied in age and variety and the samples were not all taken during the same months or seasons. All these factors affect leaf composition. It is therefore somewhat surprising that, in spite of these causes of variability, a highly significant correlation coefficient, $r = -0.6651$, is obtained for the 15 comparisons between per cent. leaf nitrogen of the control stools, on the one hand, and the growth-increment of the nitrogen-treated stools expressed as a percentage of the corresponding growth-increment of the control stools on the other. If we exclude the two tests where phosphate deficiency apparently prevented the nitrogen dressing to take full effect, the correlation coefficient rises to -0.7326. It is, however, not necessarily only the nitrogen content of the leaves that controls the response to nitrogen, but often the nitrogen/phosphate ratio, and it is possible that this ratio is less sensitive to age and perhaps variety and may tend to a constant with well-balanced nutrition. The correlation coefficient between percentage nitrogen response and the nitrogen/phosphate ratio of N treatments, less the nitrogen/phosphate ratio of controls (excluding 3 negative values), is 0.8902 for 12 comparisons and is highly significant. The regression equation becomes: $E = 93.7 + 60.558X$, where E=increment of N stools per cent. increment of C stool; X= (nitrogen/phosphate ratio of N)—(nitrogen/phosphate ratio of C.)

The following figure illustrates this relationship. Similarly a highly significant correlation co-efficient of 0.8116 for 10 comparisons is obtained between increment of NPK treatments per cent. C increment and the N/P_2O_5 ratio of NPK less N/P_2O_5 ratio of C. Here again negative results, which probably indicate phosphate responses, are excluded, as are also tests where significant K responses were obtained.



Conclusions.

The growth-rate method is quite simple, but it does entail a considerable amount of work. It is, however, a relatively rapid method of ascertaining possible deficiencies in a field and the responses to fertilizers. The tests are generally, and can always be, carried out on young cane and the results obtained can be applied to the field to improve the crop. If these tests are of practical use in showing responses so soon that corrective measures can be applied in the field to benefit the crop, it is of even greater importance in a general programme of soil fertility research. It can be used in conjunction with field trials, as has been shown, and, together with leaf analyses, which it must often follow, it becomes a most useful tool in elucidating points of interest.

It is carried out during the best growing season, not only because the quick growth reduces the relative error in measurement, but also because the cane is then most sensitive to plant-food shortages. The result is that large responses are often found which tend to overcome the rather high experimental error of the method.

Summary.

The growth-rate method of determining fertilizer reponses in sugarcane which was proposed by Evans has been tested out at the Experiment Station. After preliminary experiments the method was altered and standardised to suit our conditions. The quantities of fertilizer used have been increased and the randomised block design based on initial increments is now used. The results are obtained by a statistical analysis of the increments in growth after fertilizer application.

About 30 experiments have been completed. In general there was good agreement between field trials and this rapid technique where such comparisons were made. Apparent contradictions could be explained after further investigation.

Leaf analyses done on some of these tests proved instructive. Certain correlations found between nitrogen per cent. leaf as well as the nitrogen/phosphate ratio and nitrogen response are given.

The method is considered a useful tool in research and the results can also be applied directly in the field.

Acknowledgments.

The writer wishes to acknowledge the co-operation of farmers and managers of the estates where the tests were done. Special thanks are also due to Mr. W. O. Christianson, who pioneered these tests at the Experiment Station, and to Mr. K. E. F. Alexander, who was very largely responsible for carrying out the later experiments.

REFERENCES.

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Experiment Station,
South African Sugar Association,
Mount Edgecombe.
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The PRESIDENT said that this was a very attractive method of determining fertilizer requirements of sugarcane, of direct appeal to growers, and it had been worked on for a long time.

When the Experiment Station first considered carrying out experiments of this kind, letters were written to various parts of the world in an endeavour to obtain information as to what work had been done on these lines. At first very little help was forthcoming, and even the Department of Agriculture in Washington could give no suggestions for carrying out the necessary measurements. Fortunately Dr. Evans, of the British Colonial Service, formerly of Mauritius and now of Trinidad, who had done a great deal of work of this kind, paid us a visit, and as a result of his help we were able to go ahead with experiments in this matter.

Mr. PHIPSON enquired if there were any standards by which one could tell if a cane was being sufficiently nourished.

Mr. DU TOIT replied that such standards had not been established in this country. Except for knowledge obtained from Mauritius and Hawaii, where they had certain standards, we had no information to go on. However now, with this knowledge, and with the help of growth rate experiments, we had been able to get closer to establishing standards by which to judge the results of leaf analysis here. At this stage he could give no definite rules, but at least low values, indicating cases where responses could be expected, could be found. Results depended on the leaf taken for the test. In the tests mentioned the third youngest leaf was used.

The PRESIDENT remarked that with application of large quantities of nutrients to sugarcane and plants in general, one found what was known as luxury intake. Not unlike human beings, for instance, if a plant found more food than it required available to it, it would take in more food.

Mr. DU TOIT agreed that to a certain extent luxury intake might take place in sugarcane. As far as nitrogen was concerned however, it was not certain that the plant would keep on absorbing it and the leaf rise in percentage indefinitely. In the paper he had quoted one case of potash deficiency where the leaf of the young plant shewed abnormal potash and nitrogen contents, so that what appeared to be luxury consumption of one element might well be symptomatic of a deficiency in another.

The PRESIDENT asked if the author would comment on the rather large quantity of fertilizer required for these tests, as compared with the ordinary field dressing.

Mr. DU TOIT pointed out that the first experiments carried out with small dressings did not give the expected response, although Dr. Evans had successfully used similar quantities. We were looking for a method which would give results, and if possible, spectacular results. This was a diagnostic method, and not a means of finding the correct amounts to use as field dressings. The quantities used in the tests were applied to small areas and not over the whole field, so that it was not certain that all the roots of a particular stool could get at the fertilizer. There was also competition from adjoining cane, adjacent stools shewing obvious benefit from the dressings applied to the stool tested. Another reason for adopting the heavy dressings was that no depressing effect was found.

The PRESIDENT believed that experiments in Hawaii showed that benefit from the fertilizer treatment applied to one plot extended to the adjoining three rows in the next plots. In a field experiment carried out at Chaka's Kraal it was found that, at pre-war prices, 600 lbs. of ammonium sulphate per acre gave the maximum profit, but later, when the price increased, 400 lbs. became the most profitable dressing. 800 lbs. gave the maximum yield, but a still heavier dressing showed a definitely depressed yield. Similarly, dressings of more than 1,200 lbs. of superphosphate showed a depressing effect, particularly in certain phosphatic soils, but not so regularly as in the case of ammonium sulphate.

Mr. DU TOIT said it was realised that, while the concept of diminishing returns operated and one could even get depressing effects, there was generally a large latitude. The law of the minimum had also to be considered, as was illustrated in the one experiment where no response to phosphate was obtained until nitrogen had been supplied.

Mr. PEARCE enquired of the President the period over which the field experiment with ammonium sulphate was carried on, and if this period included drought years. It was possible during a drought that the concentration of salts in the soil could reach such a density that the root system of the plant was precluded from taking up other nutrients besides nitrogen, and that this caused the depressing effect.

The PRESIDENT replied that the experiment was started during the early part of the war and finally ploughed out in 1946. At least two crops showed the results he had mentioned. One of these grew during a drought period, but he did not think this applied particularly in the case of the other crop. The results were recorded in our 1946 Proceedings.

He thought the depressing effect might be due to the acidity resulting from the use of ammonium sulphate. While it had been found that repeated dressings of 1,200 lbs. had not been able to affect the acidity of that particular soil very much, later tests had shown that the use of heavy applications of ammonium sulphate did begin to affect the acidity, and this would have to be taken into consideration when further experiments of this nature were carried out.

Mr. DU TOIT said that Mr. Pearce had brought up a very important factor, and that was moisture. A drawback to the field experiment run over two years was that, while the whole period was not dry, part of it might be too dry. Moisture, of course, also came under the law of the minimum.

Mr. PEARCE described a rough experiment in which applications of 600, 800 and 1,000 lbs. of ammonium sulphate were made to plant cane. The treatments were given some months ago and since then there had been a considerable amount of rain. Now there was definitely much greater growth shewn by the 1,000 lb. treatment.

Mr. CHRISTIANSON drew attention to the fact that the discussion had veered away from the heavy applications used in the growth-rate experiments to heavy field dressings. It should be remembered, as the author had pointed out, that these growth-rate experiments were qualitative tests and were not designed to determine economic field dressings. One would not expect to find a depressing effect in these tests, because they were carried out in the summer period when there was usually plenty of rain, and when maximum growth took place.