RESULTS OF A FERTILIZER TRIAL ON VERY SHALLOW SOIL

By John Lintner

Introduction

At the 1958 Annual Congress of this Association a paper was presented entitled "Random Block and Quasi-Latin Square Designs used to Determine Fertilizer Requirements of Sugar Cane". In this paper an experiment at "Nelthorpe", Gingindhlovu was recorded.

The soil of the present experiment is similar to that at "Nelthorpe" and the reason for this duplication was to have a comparison of areas far apart.

The Site Soil and Rainfall

The site was rather hard to find and was selected because of the uniformity of the weed growth over the area which was lying fallow at the time. Soil analyses were not done to test uniformity.

The experiment is situated on the left of the main South Coast Road on the property of Reynolds Bros., Maryvale section.

The field is 400 feet above sea level in open undulating country. The rainfall at the Sezela Mill which in a straight line is very close, is given below, since it is probably not dissimilar to the rainfall on the experimental site.

An examination of the soil profile revealed that root development was discernible from 0″–20.8″. 0″–12.4″ grey sandy loam compact with no crumb structure; below 12.4″ yellowish red shale intermixed with crumbly shale and sandstone.

Sezela Mill Annual Rainfall in inches—

1st January to the 31st May

1952–53	*1953–54*	*1954–55*	*1955–56*	*1956–57*
37.08	40.91	50.35	41.08	49.30

Thus the average for these years was 43.74 inches with the minimum at 37.08 inches and maximum at 50.35 inches.

Green Crops and Fertilizer Practice

This soil which has been under cultivation for about thirty years had only one green manure crop grown on it, and that was just prior to planting the experiment.

Sunn Hemp Crotolaria juncea was used and did not give a great bulk of green material to be ploughed in.

The fertilizer practice was confined to an application of approximately 20 tons of filterpress cake broadcast and ploughed in before planting about every eight years. The fertilizer applied was about 350 lbs.—450 lbs. of a mixture with an analysis of 3.15.3.

The lack of uniformity in the distribution of filter cake makes the selection of sites for fertility trials in this area very difficult.

Profile samples were drawn from this soil on the 29th April, 1953. The area of root development was very variable over the test pits examined, being anything from 8 inches to 28 inches. The average depth of soil is 12.83 inches composed of a grey sandy loam which is compact with no crumb structure at all. Below there is a reddish yellow shale which is hard and impervious.

The design of the experiment selected was a Quasi-Latin Square and the four factors tested were nitrogen, phosphate, potash and variety.

The varieties involved were N:Co.310, N:Co.293 and N:Co.339.

The total fertilizer levels were in lbs. per acre.

N_0 0 N
N_1 125 N
N_2 250 N
} from ammonium sulphate

P_0 0 P_2O_5
P_1 100 P_2O_5
P_2 200 P_2O_5
} from superphosphate

K_0 0 K_2O
K_1 150 K_2O
K_2 300 K_2O
} from potassium chloride

The cane was planted on 21st October, 1953 and the following amounts of fertilizer were put into the furrow at the same time in lbs. per acre:

N_0 0 N
N_1 25 N
N_2 50 N
} from ammonium sulphate

P_0 0 P_2O_5
P_1 100 P_2O_5
P_2 200 P_2O_5
} from superphosphate

K_0 0 K_2O
K_1 50 K_2O
K_2 100 K_2O
} from potassium chloride

On the 7th October, 1954 the following amounts of fertilizer were applied per acre:

N_0 0 N
N_1 100 N
N_2 200 N

P_0	0 P_2O_5	K_0	0 K_2O
P_1	0 P_2O_5	K_1	100 K_2O
P_2	0 P_2O_5	K_2	200 K_2O

At the very beginning the cane came away very well indeed but the initial vigorousness of growth diminished later and even after the top-dressings had been applied there was nothing spectacular

Field notes made during the growth period up to the first cutting indicated that one could expect a nitrogen effect on the yield of cane but not much more. The N:Co.293 flowered profusely and the N:Co.310 appeared to lag behind the other two varieties but no measurements were taken.

Leaf samples were collected on two or three occasions but due possibly to an uneven distribution of press cake there was no significance and this angle of the investigation was abandoned.

The experiment was harvested on the 13th September, 1955.

The three-way table showed that the two highest yields were 61.12 tons of cane per acre with $N_2P_0K_2$ and 59.13 tons of cane per acre with $N_2P_1K_0$. There were no interactions which were significant.

The only significant figures obtained were as follows:

Varieties

N:Co.310	*N:Co.339*	*N:Co.293*	*Sig. Diff. as T/Ac.*	
50.18	54.58	51.74	P=.05	2.07
			P=.01	2.80
			P=.001	3.74

N:Co.339>N:Co.310 at P=.001 with 4.40 tons of cane and > N:Co.293 at P=.01 with 2.84 tons of cane. N:Co.293 was not significantly better than N:Co.310.

For fertilizer treatments the following were the significant figures obtained:

N_0	N_1	N_2	*Sig. Diff. as T/Ac.*	
49.33	52.23	54.94	P=.05	2.07
			P=.01	2.80
			P=.001	3.74

N_1>N_0 at P=.01 with 2.91 tons of cane per acre and N_2>N_0 at P=.001 with 5.61 tons of cane per acre.

The only other effect which was anywhere near significant was K_1 but even this is rather remote at this stage.

For sucrose per cent cane the following was obtained:

N:Co.310	*N:Co.339*	*N:Co.293*	*Sig. Diff. as Suc. %*	
16.24	14.59	15.56	P=.05	0.67
			P=.01	0.91
			P=.001	1.21

N:Co.310>N:Co.293 and > N:Co.339 by 0.68 per cent P=.05 and by 1.65 per cent at P=.001. N:Co.293>N:Co.339 by 0.97 per cent at P=.01.

This great difference in the percentage of sucrose eliminated any significance between the varieties for tons sucrose per acre.

For P the per cent sucrose was:

P_0	P_1	P_2	*Sig. Diff. as Suc. %*	
15.16	15.80	15.44	P=.05	.067
			P=.01	0.91
			P=.001	1.21

This table is recorded because with 0.64 per cent for P this figure is very near significance.

For tons sucrose per acre the following are the relevant figures:

N_0	N_1	N_2	*Sig. Diff. as T/acre*	
7.69	8.03	8.41	P=.05	0.51
			P=.01	0.68
			P=.001	0.91

N_2>N_0 at P=.01 with 0.72 tons sucrose. The varietal effect was not significant.

The general means for the experiment were:

Tons cane	52.16
Tons Sucrose	8.05
Sucrose per cent ...	15.47

In January 1958 the cane was pre-trashed and the total fertilizer dressings applied. The cane was then cut, being the 1st ratoon crop.

The two highest yields were again $N_2P_0K_2$ with 60.16 and $N_2P_1K_0$ with 57.66 tons of cane per acre.

For tons cane per acre the following are the relevant figures:

N_0	N_1	N_2	*Sig. Diff. as T/ac.*	
43.80	45.61	51.79	P=.05	3.90
			P=.01	5.26
			P=.001	7.02

N_2>N_0 at P=.001 with 7.99 tons of cane per acre and > N_1 at P=.01 with 6.18 tons of cane per acre.

The varietal yields were:

N:Co.3a0	*N:Co.339*	*N:Co.293*	*Sig. Diff. as T/ac.*	
49.81	48.90	42.49	P=.05	3.90
			P=.01	5.26
			P=.001	7.02

N:Co.310 was not significantly better than N:Co.339 but > N:Co.293 at P=.001 with 7.32 tons of cane and N:Co.339>N:Co.293 at P=.01 with 6.41 tons of cane per acre.

There were no other significant effects and K_1, which in the plant cane came within a reasonable distance of significance, was quite negative.

The next figures examined were for the effects found in connection with tons sucrose per acre which yielded the following significant figures:

N:Co.310	*N:Co.339*	*N:Co.293*	*Sig. Diff. as T/ac.*	
6.18	5.81	4.61	P=.05	.45
			P=.01	.61
			P=.001	.81

There is no significant difference between N:Co.310 and N:Co.339 but N:Co.319>N:Co.293 at P=.001 with 1.57 tons sucrose per acre and N:Co.339> N:Co.293 at P=.001 with 1.20 tons sucrose per acre.

For the nitrogen levels—

N_0	N_1	N_2	*Sig. Diff. as T/ac.*	
5.16	5.33	6.12	P=.05	.45
			P=.01	.61
			P=.001	.81

N_1 was not significantly better than N_0 but N_2 is significantly better than N_0 at P=.001 with .96 tons of sucrose and > N_1 at P=.01 with .79 tons of sucrose.

There was only one significant level for the sucrose per cent cane and that was for variety.

N:Co.310	*N:Co.339*	*N:Co.293*	*Sig. Diff. as Suc. %*	
12.53	11.89	10.92	P=.05	0.30
			P=.01	0.41
			P=.001	0.54

N:Co.310>N:Co.339 at P=.001 with .64 per cent and > N:Co.293 at P=.001 with 1.61 per cent. N:Co.339>N:Co.293 at P=.001 with .97 per cent.

There were no other significant figures.

For purity the effects were for—

N:Co.310	*N:Co.339*	*N:Co.293*	*Sig.Diff. as °Purity*	
89.52	88.52	87.39	P=.05	.81
			P=.01	1.11
			P=.001	1.47

N:Co.310>N:Co.339 at P=.05 with 1 degree and > N:Co.293 at P=.001 with 2.13 degrees. N:Co.339 >N:Co.293 at P=.01 with 1.13 degrees.

There were some significant interactions the principle of which was KV.

N:Co.310	*N:Co.339*	*N:Co.293*	*Sig.Diff. as °Purity*	
K_0	—	—	P=.05	0.47
K_1	—	—	P=.01	0.64
K_2	—	—	P=.001	0.85

The differences are well over the figure given for P=.001.

The 1st ratoon means were as follows:

Tons cane per acre ...	47.06
Tons sucrose per acre	5.53
Sucrose per cent ...	11.78%
Purity...	88.48

Comments

Comparing the results of this experiment with the one on the North Coast it is interesting to note the absence of response to P and K. It will be remembered that there was some indication of a positive effect from K in the plant cane but this disappeared completely in the first ratoon.

The soil under test is a more difficult one even than that at Gingindhlovu and probably the only chance of obtaining satisfactory results is to maintain a thick mulch.

Although this experiment is being continued the site is a poor one due to slope. There is a possibility that with very heavy rain the water may flow on top of the hard pan. With twenty-seven hidden replications however one has a sufficient number to provide a high degree of security of variation.

Summary

A fertilizer cum variety trial was conducted on a shallow soil on the Maryvale section of Reynolds Bros. on the South Coast of Natal.

The salient features of the experiment were the differences between the varieties, the beneficial effect of nitrogen and the interaction between variety and treatment on purity.

Mr. du Toit (in the chair) said this paper was valuable because it included not only fertilizer treatments but also varieties. Unfortunately this experiment did not shew up fertilizer responses so well and only to some extent differences between varieties.

Mr. Deenik said that tremendous progress had been made in the study of the effects of fertilizer on cane, especially since the war. He was of the opinion that for optimum economic returns from fertilizers, a fertilizer programme should be a balanced one, and he thought that the time had arrived that in the planning of a fertilizer programme one should think of the application of nitrogen, phosphates, potash and even magnesium in a definite ratio. He asked Mr. Lintner whether he could suggest a N.P.K. ratio as far as the main varieties of cane were concerned. He included magnesium with the major elements because of its importance, particularly, under conditions of high potash usage. In this connection he referred to the deciduous fruit industry of the Western Province where of recent years increased potash usage had induced magnesium deficiency and the application of magnesium with potash either in the form of potash-magnesia or as straight magnesium sulphate had become an accepted practice.

Mr. Lintner said that he had some figures to illustrate the point raised about ratios.

SOIL TYPE	Highest Yield Tons Cane per acre	Tons Sucrose	NPK Ratio
Mist Belt T.M.S.			
Plant Cane (Powers Court)	58.19	7.77	1 : 1 : 1
1st ratoon	47.72	6.77	1 : 1 : 0
Shallow Ecca Shale with hard-pan (Gingindhlovo)			
Plant Cane	49.95	7.79	1 : 0 : 1
1st ratoon	51.93	6.66	1 : 0.5 : 0
Ecca Sand	76.20	—	1 : 0.36:2.6
Plant Cane	—	11.09	1 : 0.36:1
Sand of recent origin			
Plant Cane	55.34	8.49	1 : 3 : 2
1st ratoon	61.00	9.30	1 : 2 : 2
2nd ratoon	46.64	6.64	1 : 0 : 4
Very Shallow Ecca Shale ...	60.16	7.24	1 : 0 : 1
Shallow Ecca Shale			
Plant Cane	59.58	10.04	0 : 1 : 0.5
1st ratoon	45.70	6.04	1 : 1 : 1
2nd ratoon	45.31	6.75	1 : 1 : 1
3rd ratoon	64.41	7.79	1 : 1 : 1

These figures were taken from the three-way tables and were not significant within the experiments concerned. They merely express in each instance the NPK ratio of the highest yield.

The Chairman said that, as in the Western Province we were now attaching more importance to magnesium, here also we were very interested in the correct balance. Correct balance was one of the most important aspects of fertilization which should be investigated, but unfortunately any ratio may not be best, for one might strike areas where one element only was deficient. To find the best ratio we would have to have more levels with higher quantities of fertilizer. Experiments were now being carried out with nitrogen, potash and magnesium with potash to try and determine such a ratio. For the whole industry he would say roughly the ratio should be 1 to 0.6 to 1.3; something like 10-6-13.

Mr. A. C. Barnes said magnesium was a most important element since in the plant which builds up sugar, in the chain of reactions from carbon dioxide and water to the sugars, magnesium is essential. This did not mean that heavy dressings of magnesium compounds were going to increase the sucrose per cent cane. Some records showed that yields had been depressed by magnesium. This might have been due to absence of other fertilizer elements which would interact with it. In light shallow soils with hard impervious sub-soils, the possibility of using explosives for sub-soiling could be investigated. It appears that no work of this description has been done in the sugarcane belt in Natal, although perhaps it might be considered. African Explosives would no doubt co-operate.

Dr. Dodds said that the paper was interesting notwithstanding the rather unfavourable soil site. Attention had been drawn in the paper to the interaction of various soil nutrients such as phosphorus and nitrogen. In sugarcane experiments in Rhodesia on soil which had not previously been cultivated, the control gave almost negligible growth of cane, the soil being very deficient in phosphorus and nitrogen. In the case of nitrogen only, it was no better than the control. Phosphorus gave a slight increase but there was no real improvement until the two were applied together, and the effect was then remarkable. He thought that in the past the need for a balanced fertilizer was not properly appreciated. Many years ago at Chaka's Kraal, various amounts of ammonium sulphate were applied to a nitrogenous fertilizer experiment with sugarcane, from nil to 1,000 lbs. per acre, but he now suspected the amounts of super-phosphate and potash added were probably not really as high as they should have been in some cases, to get the most effect from heavy applications of nitrogen. Generous amounts of these elements were given to each experiment, but no more was added when the nitrogen had been increased. Excellent responses to ammonium sulphate were gained when it was about 1,000 to 1,200 lbs. over a cycle of crops, but the most payable amount was 600 to 800 lbs. per acre, according to the cost of the fertilizer and the price paid for the cane. Possibly a better response could have been obtained from nitrogen if the phosphate and potash had been increased. Referring to the use of explosives for breaking up sub-soil, this was done many many years ago in Natal—apparently it had a good effect. However, these experiments did not arouse much interest at the time so the experiments were not continued. They would be worthwhile taking up again.

Mr. Pearson said that one point which interested him was that in the plant cane the highest yield was in the N_2K_2 plot. In 1st ratoons for the $N_2P_0K_2$ plot there was only a very small drop in tons per acre, the drop being from 52 to 47. This apparently would point to a more balanced fertilization giving a better return for ratoons. We should endeavour to obtain the maximum from ratoons.

The Chairman said that cane that had been well fertilized would give longer ratooning. Cane would show when it had been adequately fertilized. In this particular experiment the increased yield was not so obvious. Although the experiment did not show it, Mr. Pearson's point was correct, although it was very dangerous to generalise on the results of one or two treatments only. In the past the amount of fertilizer applied was not evenly balanced. In the experiment mentioned by Dr. Dodds the amounts of potash and phosphate applied were nearly adequate.

Dr. McMartin said that as far as the ratio of various plant foods was concerned, he had discussed the matter with overseas representatives of a fertilizer firm and he was told that the world-wide tendency

towards consumption of N.P.K. was in the ratio of 1-1-1. One could analyze the plant and find out how much N.P.K. was removed from the soil. If the soil was very deficient, say, in phosphate and by the addition of phosphate in experiments one obtained an increased yield, the use of phosphate could be soundly recommended. One knew from analytical data that sugarcane was taking out considerable quantities of potash, but if by applying potash one got no increased yield, then it was adequate in the soil. In the past tremendous quantities of potash had been removed, but none had been applied until recently, and he wondered if we should have waited until now, or should have applied potash all along.

The Chairman said that it was not an uncommon experience in many countries to start first of all with phosphate then discover the need for nitrogen and finally potash. It appeared that this was the case in more primitive countries, but in the more progressive countries it looked as though the ratio used approximated 1-1-1. As far as applying potash where one got no response was concerned, he thought that one should not use it if one did not get a response. One should be guided by fertilizer experiments and the applications made only when they were economical, but we had waited too long in the industry in the application of potash.

Mr. Lintner said it was a moot point as to whether one could be guided entirely by a chemical analysis of the soil. Soils are capable of fixing potassium and a negative response to a potash application need not necessarily indicate that it was not required and was in a sufficient available quantity for maximum growth. Also when leaf analyses were done a "luxury" uptake of potassium was not necessarily an indication of the soil's capacity to supply more than enough potassium to secure a maximum yield, but rather an indication of an insufficiency of calcium and magnesium.

Dr. Dodds said in the early days it would not have been advisable to tell planters to use fertilizers unless an immediate response could be expected.

The Chairman said that the price of cane was lower in the past and planters would not have been able to apply more fertilizer, whereas now the increased price of cane enabled planters to be in a position to buy more fertilizer.