# SOME FERTILISER TRIALS ON SUGAR CANE

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Were the soil a passive medium, the amount of work already done in connection with soil problems would probably have yielded a great deal more concrete data than is actually available. Instead, we are dealing with a hypersensitive, extremely active medium, constantly undergoing changes governed by internal and external agencies.

Man's interference with the soil can be disastrous in the extreme, but with careful thought and good management he may derive great benefits from it and can develop the various branches of agricultural industry.

Throughout it must be remembered that " Man's lot in earning his livelihood, is largely that of an intruder whose permanent success depends often on his ability to co-operate intelligently with Nature and sometimes by rebelling against her dictates. . . . However, Nature always maintains her course, even if at times men think they have deflected her from it. In the long run success attends those who keep in step with the purposeful old Dame. Aware that she is ruthless in annihilating species who ignore adjustment to her, man nevertheless must wrest his livelihood from her. . . . Her pattern for design is part of her, must not be interfered with so far as essentials are concerned. And since her pattern is designed on soil, her foremost decree is, that the soil must in no way be impaired. But here, as elsewhere, she showers her favours on those who assist her. Encouragement is to be derived from the knowledge that for thousands of years some civilisations have cultivated their land to their permanent advantage. On the other hand, the pages of history are strewn with the records of those civilisations who, having rendered their land derelict, have vanished. The reasons for her apparent benevolence and malevolence can only be understood when the nature of the soil is appreciated."[1]

There is therefore every good reason to take infinite trouble over the study of the soil processes and requirements.

In the case of the Sugar Industry, in particular, we are continually extending the areas of cane varieties possessing inherent properties for high production, thus increasing the necessity to guard against soil depletion. It is possible that a change of variety on any given soil will have at any rate a partial effect of crop rotation. Temporarily, therefore, a new variety might appear to do well on a soil which is perhaps below standard for that particular variety. It will not take long, however, before the real truth will become apparent, and it will then be useless jumping to sudden conclusions and blaming the variety or soil.

It is often far from easy to know just how to treat the soil which we know varies enormously over sometimes incredibly small areas.

It is the purpose of this paper to report the results of three experiments, which are a small part of an extensive plan to investigate the reactions of the released varieties of sugar cane to soil type and fertiliser treatment, as well as various possible interactions which may exist.

The first was established at Tongaat. The total area under the experiment is 3.63 acres in open rolling country. The height above sea-level is approximately 150 feet.

The geological conditions of the area are a sand of recent origin and the soil is sandy.

The area is not drained, but there is no danger of flooding. It is not possible to irrigate the area.

Available data regarding the history of the field reveals the following information:—

1917: Under second ratoon Uba cane, which yielded 15.1 tons per acre. Followed, it is assumed, by a two-year bare fallow.

1919: The area was replanted to Uba.

1921: The plant cane harvested yielded 24.5 tons per acre.

1923: First ratoon gave 20 tons per acre.

1925: Second ratoon gave 15.6 tons per acre.

The crop was then ploughed out and replanted.

1928: Plant cane harvested gave 26.1 tons per acre.

1930: First ratoon gave 23.7 tons per acre.

1932: Second ratoon gave 17.4 tons per acre.

The area was not treated with artificial fertilisers at all, but received, if not regular applications, at least periodical dressings of filter press cake. In all probability at the very least every plant cane crop was dressed. The rate of application did not exceed ten tons per acre. Precise data in this connection, however, is not available; but it is of interest to note the gradual rise in the yield of cane per acre from comparable cuts illustrated in Fig. 1.

TONGAAT. NATAL ESTATES.

Cane received successive application of Filter Press Cake at the rate of 10 tons per acre per application.

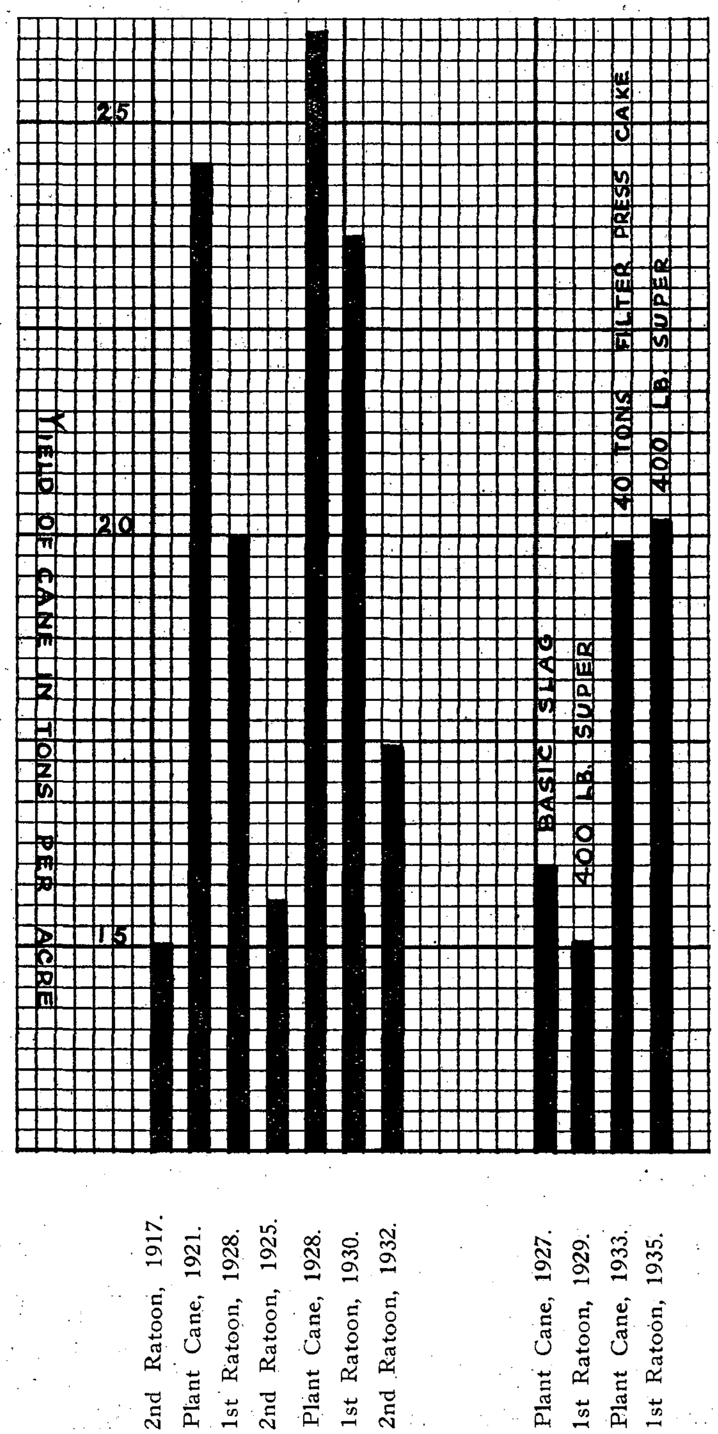


**FIGURE 1.**

FIG. 1.—Showing increase in yields following probable rise in $P_2O_5$ and CaO content of the soil due to applications of filter press cake.

An examination of the profiles of pits dug at random over the experimental area gave the following information —

$A_0$: Burnt off.

$A_1$: 0"—6" fairly fine, light grey-brown sand.

B: 6"—10" a very dark area, almost black material, giving the appearance of an accumulation of organic material at that level.

C: 10"—48" fairly uniform, slightly red sand.

There is a total absence of stones. The region of main root development is from ¼" or ½" to 30". Average soil samples collected from each level were analysed and the following are the results:—

| | 0"—6" horizon. | 6"—10" horizon. | 10"—48" horizon. |
|---|---|---|---|
| Loss on ignition .. | 1.8% | 1.6% | 1.4% |
| Total nitrogen .. | 0.06% | 0.05% | 0.04% |
| Ammonia ($NH^4$) .. | 24 p.p.m. | 13 p.p.m. | 10 p.p.m. |
| Nitric ($NO_3$) .. | 2 p.p.m. | 1.6 p.p.m. | 1.6 p.p.m. |
| Available $P_2O_5$* .. | 0.062% | 0.057% | 0.009% |
| Available CaO .. | 0.18% | 0.17% | 0.08% |
| Available $K_2O$ .. | 0.005% | 0.003% | 0.004% |
| Exchangeable $K_2O$ | 0.069% | 0.065% | 0.053% |
| Mgr. equivalents .. | 1.5 | 1.4 | 1.2 |
| Hydrogen ion concentration (pH) . | 5.9 | 6.2 | 5.8 |

* Available $P_2O_5$, etc.: Amount extracted by shaking with $N/_5\ HNO_3$.

Further samples taken from the three levels were sent to the Pretoria University for bacterial analysis. The information gathered from the investigation was as follows:—

1. Test for Azotobacter by the crumb plate method.

   $A_1$—1.00 colonies per gram of soil (dry).

   B —0.25 colonies per gram of soil (dry).

   C —1.25 colonies per gram of soil (dry).

2. Total number of micro-organisms (plate method).

| | |
|---|---|
| $A_1$ .. .. .. .. .. .. .. .. .. .. .. | 853,200 |
| B .. .. .. .. .. .. .. .. .. .. .. | 182,400 |
| C .. .. .. .. .. .. .. .. .. .. .. | 171,200 |

The plate method for determining the numbers of micro-organisms consists in diluting the soil with water making a series of dilutions so that 1 ml. of the final dilution when plated out with nutrient agar or gelatin will allow 40 to 200 colonies to develop on the plate. This method is convenient, but its chief limitation is the fact that it allows the development of only the heterotrophic aerobic bacteria of certain yeasts, moulds and actinomyces.[2] Actually nutrient agar was used in the above determination according to Curie's method.[3] The medium used consists of 15 grams of agar, 20 grams of mannite, plus 2 grams of a stock salt mixture per litre. The stock salt consists of:—

| | |
|---|---|
| Dipotassium phosphate .. .. .. .. .. | 100 parts. |
| Magnesium sulphate .. .. .. .. .. .. | 60 ,, |
| Sodium chloride .. .. .. .. .. .. .. | 60 ,, |
| Ferric sulphate .. .. .. .. .. .. .. | 1 ,, |
| Manganese sulphate .. .. .. .. .. .. | 1 ,, |
| Calcium carbonate .. .. .. .. .. .. | 178 ,, |

Into each 25 cm. Petri dish, 100 cc. of the medium are poured and allowed to set. It is then "seeded" with the equivalent in moist soil of 1 gram of the dry soil. To secure uniform distribution of the inoculum, the soil is first passed through a 20-mesh and a 40-mesh sieve. In this manner fairly uniform soil particles are obtained.[4]

Eight plates for each sample were found to keep the probable error within 5 per cent. This number was consequently used for the above investigation. The samples were incubated for four days at 30°C. and then counted.

The total rainfall over the whole period of the experiment was 99.59 inches, with the following distribution:—

| | 1933. | 1934. | 1935. |
|---|---|---|---|
| January .. .. .. .. .. | — | 5.61 | 5.58 |
| February .. .. .. .. .. | — | 4.22 | 3.33 |
| March.. .. .. .. .. .. | — | 4.44 | 4.80 |
| April .. .. .. .. .. .. | — | 3.33 | 1.49 |
| May .. .. .. .. .. .. | — | 2.72 | 7.85 |
| June .. .. .. .. .. .. | — | 1.39 | 16.79 |
| July .. .. .. .. .. .. | — | 2.15 | 0.86 |
| August .. .. .. .. .. | — | 3.14 | 3.35 |
| September (from 23rd) .. | 0.23 | 0.71 | 0.88 |
| October .. .. .. .. .. | 2.36 | 1.15 | 2.60 |
| November (to 18th, 1935) | 5.80 | 2.15 | 0.94 |
| December .. .. .. .. .. | 5.50 | 6.22 | — |

The plots in this trial were 1/40th acre in extent, with five replications of each treatment. Filter press cake was used in this experiment, and where given was applied in the furrows and mixed with the soil on the 27th September, about a week before the rest of the fertiliser was applied.

The cane was planted on the 2nd October, 1933, double and continuous in the row, the setts used being on an average 18 inches with six buds. The rows are 4.5 feet apart and the variety of cane Uba.

The fertiliser treatments were as follows, in lbs. (per acre):—

| FORMULA. | TREATMENT. | N | | $P_2O_5$ | | $K_2O$ | |
|---|---|---|---|---|---|---|---|
| | | — | TOTAL | — | TOTAL | — | TOTAL |
| O | No Fertiliser | — | | — | | — | |
| P | 200 Super 19.1% | — | | 38.2 w.s. | | — | |
| NP | 200 Super 19.1% | — | | 38.2 w.s. | | — | |
| | 84.5 Sulphate of Ammonia | 17.41 | 34.73 | — | 48.25 | — | |
| | 165 Whale Guano No. 1 | 17.32 | | 45.2 c.s. | | — | |
| NPK | 200 Super 19.1% | — | | 38.2 w.s. | | — | |
| | 84.5 Sulphate of Ammonia | 17.41 | 34.73 | — | 48.25 | — | |
| | 165 Whale Guano No. 1 | 17.32 | | 45.2 c.s. | | — | |
| | 100 Muriate of Potash 60% | — | | — | | 60.1 | 120.22 |
| | 124 Sulphate of Potash | — | | — | | 60.12 | |
| FPNPK | 200 Super 19.1% | — | | 38.2 w.s. | | — | |
| | 84.5 Sulphate of Ammonia | 17.41 | | — | | — | |
| | 165 Whale Guano No. 1 | 17.32 | | 45.2 c.s. | 688.25 | — | |
| | 100 Muriate of Potash | — | 342.73 | — | | 60.1 | 120.22 |
| | 124 Sulphate of Potash | — | | — | | 60.12 | |
| | 20 tons Filter Press Cake | 308.00 | | 640.00 | | — | |
| $FP_2NPK$ | 200 Super 19.1% | — | | 38.2 w.s. | | — | |
| | 84.5 Sulphate of Ammonia | 17.41 | | — | | — | |
| | 165 Whale Guano No. 1 | 17.32 | | 45.2 c.s. | 1328.25 | — | |
| | 100 Muriate of Potash 60% | — | 650.73 | — | | 60.1 | 120.22 |
| | 124 Sulphate of Potash | — | | — | | 60.12 | |
| | 40 tons Filter Press Cake | 616.00 | | 1280.00 | | — | |
| $N_2PK$ | 200 Super 19.1% | — | | 2.83 w.s. | | — | |
| | 179 Sulphate of Ammonia | 36.87 | 71.51 | — | 56.5 | — | |
| | 330 Whale Guano No. 1 | 34.64 | | 51.8 c.s. | | — | |
| | 100 Muriate of Potash | — | | — | | 60.1 | 120.22 |
| | 124 Sulphate of Potash | — | | — | | 60.12 | |
| $NP_2K$ | 400 Super 19.1% | — | | 76.4 w.s. | | — | |
| | 84.5 Sulphate of Ammonia | 17.41 | 34.73 | — | 88.25 | — | |
| | 165 Whale Guano No. 1 | 17.32 | | 83.8 c.s. | | — | |
| | 100 Muriate of Potash | — | | — | | 60.1 | 120.22 |
| | 124 Sulphate of Potash | — | | — | | 60.12 | |
| $NPK_2$ | 200 Super 19.1% | — | | 38.2 w.s. | | — | |
| | 84.5 Sulphate of Ammonia | 17.41 | 34.73 | — | 48.25 | — | |
| | 165 Whale Guano No. 1 | 17.32 | | 45.2 c.s. | | — | |
| | 200 Muriate of Potash | — | | — | | 120.2 | 240.48 |
| | 248 Sulphate of Potash | — | | — | | 120.28 | |
| $N_2P_2K_2$ | 400 Super 19.1% | — | | 76.4 w.s. | | — | |
| | 179 Sulphate of Ammonia | 36.87 | 75.51 | — | 96.5 | — | |
| | 330 Whale Guano No. 1 | 34.64 | | 90.4 c.s. | | — | |
| | 200 Muriate of Potash | — | | — | | 120.2 | 240.48 |
| | 248 Sulphate of Potash | — | | — | | 120.28 | |
| FP $N_2P_2K_2$ | 400 Super 19.1% | — | | 76.4 w.s. | | — | |
| | 179 Sulphate of Ammonia | 36.87 | | — | | — | |
| | 330 Whale Guano No. 1 | 34.64 | | 90.4 c.s. | 736.5 | — | |
| | 200 Muriate of Potash | — | 379.51 | — | | 120.2 | 240.48 |
| | 248 Sulphate of Potash | — | | — | | 120.28 | |
| | 20 tons Filter Press Cake | 308.00 | | 640.00 | | — | |
| $FP_2N_2P_2K_2$ | 400 Super 19.1% | — | | 76.4 w.s. | | — | |
| | 179 Sulphate of Ammonia | 36.87 | | — | | — | |
| | 330 Whale Guano No. 1 | 34.64 | | 90.4 c.s. | 1376.5 | — | |
| | 200 Muriate of Potash | — | 687.51 | — | | 120.2 | 240.48 |
| | 248 Sulphate of Potash | — | | — | | 120.28 | |
| | 40 tons Filter Press Cake | 616.00 | | 1280.00 | | — | |
| $N_3P_2K_2$ | 400 Super 19.1% | — | | 76.4 w.s. | | — | |
| | 179 Sulphate of Ammonia | 36.87 | | — | 96.5 | — | |
| | 330 Whale Guano No. 1 | 34.64 | 95.51 | 90.4 c.s. | | — | |
| | 150 Nitrate of Soda | 24.00 | | — | | — | |
| | 200 Muriate of Potash | — | | — | | 120.2 | 240.48 |
| | 248 Sulphate of Potash | — | | — | | 120.28 | |
| $N_2P_3K_2$ | 600 Super 19.1% | — | | 114.6 w.s. | | — | |
| | 179 Sulphate of Ammonia | 36.87 | 71.51 | — | 136.5 | — | |
| | 330 Whale Guano No. 1 | 34.64 | | 129.0 c.s. | | — | |
| | 200 Muriate of Potash | — | | — | | 120.2 | 240.48 |
| | 248 Sulphate of Potash | — | | — | | 120.28 | |
| $N_2P_2K_3$ | 400 Super 19.1% | — | | 76.4 w.s. | | — | |
| | 179 Sulphate of Ammonia | 36.87 | 71.51 | — | 96.5 | — | |
| | 330 Whale Guano No. 1 | 34.64 | | 90.4 c.s. | | — | |
| | 334 Muriate of Potash | — | | — | | 200.0 | 400.0 |
| | 412.5 Sulphate of Potash | — | | — | | 200.0 | |
| $N_3P_3K_3$ | 600 Super 19.1% | — | | 114.6 w.s. | | — | |
| | 179 Sulphate of Ammonia | 36.87 | | — | 136.5 | — | |
| | 330 Whale Guano No. 1 | 34.64 | 95.51 | 129.0 c.s. | | — | |
| | 150 Nitrate of Soda | 24.00 | | — | | — | |
| | 334 Muriate of Potash | — | | — | | 200.0 | 400.0 |
| | 412.5 Sulphate of Potash | — | | — | | 200.0 | |
| FP $N_3P_3K_3$ | 600 Super 19.1% | — | | 114.6 w.s. | | — | |
| | 179 Sulphate of Ammonia | 36.87 | | — | | — | |
| | 330 Whale Guano No. 1 | 34.64 | | 129.0 c.s. | | — | |
| | 150 Nitrate of Soda | 24.00 | 403.51 | — | 776.5 | — | |
| | 334 Muriate of Potash | — | | — | | 200.0 | 400.0 |
| | 412.5 Sulphate of Potash | — | | — | | 200.0 | |
| | 20 tons Filter Press Cake | 308.00 | | 640.00 | | — | |
| $FP_2N_3P_3K_3$ | 600 Super 19.1% | — | | 114.6 w.s. | | — | |
| | 179 Sulphate of Ammonia | 36.87 | | — | | — | |
| | 330 Whale Guano No. 1 | 34.64 | | 129.0 c.s. | | — | |
| | 150 Nitrate of Soda | 24.00 | 711.51 | — | 1416.5 | — | |
| | 334 Muriate of Potash | — | | — | | 200.0 | 400.0 |
| | 412.5 Sulphate of Potash | — | | — | | 200.0 | |
| | 40 tons Filter Press Cake | 616.00 | | 1280.00 | | — | |

The analysis of the filter press cake used was as follows:—

| | % |
|---|---|
| Loss on ignition | 24.33 |
| Silica | 50.99 |
| $Fe_2O_3/Al_2O_3$ | 4.30 |
| CaO | 9.23 |
| $P_2O_5$ | 1.60 |
| $K_2O$ | Nil. |
| $N_2$ | 0.77 |
| Moisture | 32.4 |
| $SO_4$ | 1.169 |
| $SO_2$ | 6.1 |
| Carbon | 48.14 |
| $CaCO_3$ | 9.66 |

It was further decided that some useful data might be acquired by investigating whether the fertiliser treatment had any effect on the germination of the cane.

Counts of the shoots were made on the 19th December, 1933, with the following results:—

| | |
|---|---|
| O | 277.6 |
| P | 239.6 |
| NP | 250.6 |
| NPK | 244.2 |
| FPNPK | 416.8 |
| $FP_2NPK$ | 497.2 |
| $N_2PK$ | 271.4 |
| $NP_2K$ | 258.8 |
| $NPK_2$ | 261.6 |
| $N_2P_2K_2$ | 293.6 |
| FP $N_2P_2K_2$ | 379.6 |
| $FP_2N_2P_2K_2$ | 488.8 |
| $N_3P_2K_2$ | 317.8 |
| $N_2P_3K_2$ | 275.2 |
| $N_2P_2K_3$ | 305.2 |
| $N_3P_3K_3$ | 317.6 |
| FP $N_3P_3K_3$ | 420.4 |
| $FP_2N_3P_3K_3$ | 504.4 |

On the 11th January, 1934, counts were made of the number of stools per plot, and the intensity of streak recorded:—

| | Average stools per plot. | Streak infected stools per plot. | % streak infected stools per plot. |
|---|---|---|---|
| O | 112 | 17.4 | 15.54 |
| P | 112 | 16.0 | 14.26 |
| NP | 111 | 20.2 | 18.42 |
| NPK | 113 | 14.6 | 13.06 |
| FPNPK | 118 | 20.2 | 17.22 |
| $FP_2NPK$ | 118 | 22.6 | 19.10 |
| $N_2PK$ | 116 | 19.2 | 16.62 |
| $NP_2K$ | 111 | 15.6 | 13.50 |
| $NPK_2$ | 111 | 16.2 | 14.96 |
| $N_2P_2K_2$ | 115 | 21.0 | 16.64 |
| FP $N_2P_2K_2$ | 117 | 23.2 | 19.88 |
| $FP_2N_2P_2K_2$ | 116 | 25.4 | 19.58 |
| $N_3P_2K_2$ | 116 | 20.6 | 17.70 |
| $N_2P_3K_2$ | 118 | 18.6 | 15.76 |
| $N_2P_2K_3$ | 118 | 14.2 | 11.96 |
| $N_3P_3K_3$ | 117 | 23.2 | 19.80 |
| FP $N_3P_3K_3$ | 117 | 20.4 | 18.48 |
| $FP_2N_3P_3K_3$ | 120 | 22.8 | 18.98 |

It was intended to carry out a complete series of periodical growth measurements; unfortunately, however, unforeseen circumstances prevented more than one measurement being taken. The first measurements gave the following figures:—

| | Average height in inches per plot up to topmost visible collar. |
|---|---|
| O | 8.75 |
| P | 9.787 |
| NP | 10.75 |
| NPK | 9.962 |
| FP NPK | 14.76 |
| $FP_2NPK$ | 12.0375 |
| $N_2PK$ | 10.962 |
| $NP_2K$ | 10.85 |
| $NPK_2$ | 10.0125 |
| $N_2P_2K_2$ | 9.725 |
| FP $N_2P_2K_2$ | 12.75 |
| $FP_2N_2P_2K_2$ | 17.85 |
| $N_3P_2K_2$ | 8.275 |
| $N_2P_3K_2$ | 12.337 |
| $N_2P_2K_3$ | 12.462 |
| $N_3P_3K_3$ | 11.5 |
| FP $N_3P_3K_3$ | 12.25 |
| $FP_2N_3P_3K_3$ | 17.412 |

Periodical visits of inspection revealed that in the early stages, the cane had rather a yellow appearance on the single fertiliser series, with the exception of the NPK, which did look a little better. Of the fertiliser only plots, the $N_2P_3K_2$ and $N_2P_2K_3$ certainly had a better appearance than any of the others right from the commencement of growth.

The most outstanding feature of the whole experiment from the very outset was the remarkable growth of the plots which had received dressings of filter press cake in addition to the fertiliser. It was possible from the start to pick out these plots from the others, and, what was more, to distinguish between the twenty- and forty-ton application.

The experiment escaped damage from locusts, and, apart from streak, was free from disease. No damage from any other pests was observed.

The experiment was harvested on the 18th November, 1935, and samples sent from each plot to the Maidstone Mill for sucrose determination. The juice was not tested for either $K_2O$ or $P_2O_5$.

The effects obtained from the fertiliser dressings were as follows (46% bullshoots):—

| | O | P | NP | NPK | FP NPK | $FP_2NPK$ | $N_2PK$ | $NP_2K$ | $NPK_2$ |
|---|---|---|---|---|---|---|---|---|---|
| Tons cane per acre | 17.77 | 17.89 | 19.74 | 28.87 | 35.61 | 36.04 | 23.86 | 22.25 | 20.49 |
| Increase or decrease over controls | — | 0.12 | 1.97 | 11.10 | 17.84 | 18.27 | 6.09 | 4.48 | 2.72 |
| % increase or decrease over controls | — | 0.67 | 1.11 | 62.40 | 100.30 | 102.80 | 34.20 | 25.20 | 15.30 |
| Sucrose % cane | 15.61 | 15.91 | 16.44 | 16.29 | 15.86 | 15.61 | 16.02 | 16.26 | 15.98 |
| Tons sucrose per acre | 2.77 | 2.84 | 3.22 | 4.68 | 5.62 | 5.61 | 3.80 | 3.73 | 3.29 |
| Increase or decrease over controls | — | 0.07 | 0.45 | 1.91 | 2.85 | 2.84 | 1.03 | 0.96 | 0.52 |
| % increase or decrease over controls | — | 2.59 | 16.29 | 68.70 | 102.88 | 102.45 | 37.05 | 34.53 | 18.88 |
| Juice; Brix | 21.59 | 21.86 | 21.59 | 21.34 | 21.26 | 21.56 | 21.54 | 21.80 | 21.80 |
| Java Ratio | 81.65 | 83.65 | 82.26 | 82.51 | 80.20 | 81.94 | 83.25 | 82.49 | 81.49 |
| Purity | 90.28 | 88.04 | 90.42 | 90.98 | 90.00 | 89.88 | 90.36 | 90.68 | 90.80 |
| Fibre % cane | 13.69 | 13.83 | 13.85 | 13.74 | 13.47 | 13.05 | 13.32 | 13.35 | 13.43 |
| Value (total) of sucrose per acre at £4.59689 per ton | £12 14 8 | £13 1 1 | £14 16 0 | £21 10 3 | £25 6 8 | £25 15 9 | £17 9 4 | £17 2 11 | £15 2 6 |
| Value of increase or decrease over controls | — | 0 6 5 | 2 1 4 | 8 15 7 | 13 2 0 | 13 1 1 | 4 14 8 | 4 8 3 | 2 7 10 |
| Cost of fertiliser treatment* | — | 0 6 1 | 1 3 3 | 2 6 3 | 5 14 3 | 8 14 3 | 3 4 2 | 2 12 5 | 3 9 4 |
| Nett gain over controls | — | 0 0 4 | 0 18 1 | 6 9 4 | 7 7 9 | 4 6 10 | 1 10 6 | 1 15 10 | −1 1 6 |
| Standard error in tons between treatment at 19 : 1 odds | 0.52 | 0.52 | 0.52 | 0.52 | 0.52 | 0.52 | 0.52 | 0.52 | 0.52 |
| % standard error between treatments | 11.48 | 11.48 | 11.48 | 11.48 | 11.48 | 11.48 | 11.48 | 11.48 | 11.48 |
| Value of standard error between treatments | £2 7 10 | £2 7 10 | £2 7 10 | £2 7 10 | £2 7 10 | £2 7 10 | £2 7 10 | £2 7 10 | £2 7 10 |
| General mean in tons sucrose | 4.54 | 4.54 | 4.54 | 4.54 | 4.54 | 4.54 | 4.54 | 4.54 | 4.54 |
| % of yield in tons sucrose on general mean of sucrose per acre | 61.10 | 62.68 | 71.05 | 103.08 | 123.96 | 123.70 | 83.74 | 82.20 | 72.64 |

| | $N_2P_2K_2$ | FP $N_2P_2K_2$ | $FP_2N_2P_2K_2$ | $N_3P_2K_2$ | $N_2P_3K_2$ | $N_2P_2K_3$ | $N_3P_3K_3$ | FP $N_3P_3K_3$ | $FP_2N_3P_3K_3$ |
|---|---|---|---|---|---|---|---|---|---|
| Tons cane per acre | 24.92 | 35.57 | 39.36 | 23.76 | 30.64 | 30.51 | 26.62 | 35.88 | 43.98 |
| Increase or decrease over controls | 7.15 | 17.80 | 21.59 | 5.99 | 12.87 | 12.74 | 8.85 | 18.11 | 26.21 |
| % increase or decrease over controls | 40.20 | 100.10 | 121.40 | 33.70 | 72.40 | 71.60 | 49.80 | 101.90 | 147.40 |
| Sucrose % cane | 15.96 | 15.90 | 15.24 | 16.16 | 16.48 | 16.12 | 16.16 | 15.90 | 15.08 |
| Tons sucrose per acre | 3.97 | 5.66 | 6.04 | 3.86 | 5.01 | 5.00 | 4.33 | 5.69 | 6.61 |
| Increase or decrease over controls | 1.20 | 2.89 | 3.27 | 1.09 | 2.24 | 2.23 | 1.56 | 2.92 | 3.84 |
| % increase or decrease over controls | 43.40 | 104.18 | 117.88 | 39.36 | 80.67 | 80.38 | 56.38 | 105.33 | 138.28 |
| Juice; Brix | 21.83 | 21.20 | 21.25 | 21.94 | 21.57 | 21.80 | 21.86 | 21.38 | 20.46 |
| Java Ratio | 83.67 | 82.73 | 82.74 | 81.32 | 80.47 | 83.77 | 81.55 | 81.18 | 83.12 |
| Purity | 89.50 | 89.66 | 88.74 | 90.30 | 91.56 | 90.86 | 90.30 | 89.96 | 88.86 |
| Fibre % cane | 13.38 | 13.71 | 13.44 | 14.25 | 13.89 | 13.73 | 13.69 | 13.40 | 13.83 |
| Value (total) of sucrose per acre at £4.59689 per ton | £18 5 0 | £26 0 4 | £27 15 4 | £17 14 10 | £23 0 7 | £22 19 8 | £19 18 11 | £26 3 1 | £30 7 8 |
| Value of increase or decrease over controls | 5 10 4 | 13 5 8 | 15 0 8 | 5 0 2 | 10 5 11 | 10 5 0 | 7 4 3 | 13 8 5 | 17 13 0 |
| Cost of fertiliser treatment | 4 13 5 | 8 1 5 | 11 1 5 | 5 6 7 | 4 19 6 | 6 4 2 | 7 3 5 | 10 11 5 | 13 11 5 |
| Nett gain over controls | 0 16 11 | 5 4 3 | 3 19 3 | 0 6 5 | 5 6 5 | 4 0 10 | 0 0 10 | 2 17 0 | 4 1 7 |
| Standard error in tons between treatment at 19 : 1 odds | 0.52 | 0.52 | 0.52 | 0.52 | 0.52 | 0.52 | 0.52 | 0.52 | 0.52 |
| % standard error between treatments | 11.48 | 11.48 | 11.48 | 11.48 | 11.48 | 11.48 | 11.48 | 11.48 | 11.48 |
| Value of standard error between treatments | £2 7 10 | £2 7 10 | £2 7 10 | £2 7 10 | £2 7 10 | £2 7 10 | £2 7 10 | £2 7 10 | £2 7 10 |
| General mean in tons sucrose | 4.54 | 4.54 | 4.54 | 4.54 | 4.54 | 4.54 | 4.54 | 4.54 | 4.54 |
| % of yield in tons sucrose on general mean of sucrose per acre | 87.62 | 124.75 | 133.12 | 85.15 | 110.39 | 110.22 | 95.55 | 125.46 | 145.59 |

* Filter press cake at 3/- per ton, 8/- applied.

The second experiment was laid down at Burnside, Natal Estates.

The total area under the experiment was 4.05 acres in open rolling country at a height of about 130 to 140 feet above sea-level.

The geological conditions of the area are the same as for the experiment at Tongaat, a sand of recent origin and the soil is sandy.

The area is not drained, but there is no danger of flooding. It is not possible to irrigate this area. There is a slope across the site from west to east.

Data regarding the previous history of the field gives the following information.

The soil has had both tobacco and sweet potatoes on it in the past; the exact dates are not available. In 1924 Uba as plant cane was fertilised with basic slag, the quantities per acre being unknown. Harvested in 1927, the yield was 16.0 tons per acre. The first ratoon was fertilised with 400 lb. of 17.1% w.s. superphosphate and cut in 1929, and yielded 15.05 tons of cane per acre. The field was then long fallowed and a crop of cowpeas ploughed in. In 1931 approximately 40 tons of filter press cake per acre were broadcast over the field and ploughed in, after which the cane was planted. Harvested in 1933, the yield was 19.9 tons per acre. Treated again with 400 lb. of superphosphate per acre, the first ratoon yielded 20.16 tons per acre in 1935.

A comparable rise in yield to that noticed in the history of the Tongaat field is observed at Natal Estates and also recorded in Fig. 1.

An examination of the soil profile carried out with pits dug at random over the experimental site, gave the following information:—

$A_0$: Burnt off.

$A_1$: 0″—6″ light red, fairly fine wind-blown sand.

B: 6″—10″ a zone of darker colouring, identical to that occurring on the experimental site at Tongaat.

C: 10″—48″ extremely uniform light red sand.

There is a total absence of stones. The region of main root development extends from about ½″ to 24″, there not being the same evidence of root development there as on the Tongaat site.

Soil samples collected from the three levels and analysed gave the following results:—

| | 0″—6″ horizon. | 6″—10″ horizon. | 10″—48″ horizon. |
|---|---|---|---|
| Total N .. .. .. | 0.046% | 0.043% | 0.02% |
| Ammonia N ($NH^4$) | 17 p.p.m. | 14 p.p.m. | 15 p.p.m. |
| Nitric N ($NO_3$) .. | 2 p.p.m. | 2.6 p.p.m. | 2.5 p.p.m. |
| Available $P_2O_5$* .. | 0.061% | 0.057% | 0.003% |
| Available $K_2O$ .. | 0.004 | 0.004 | 0.003 |
| Available CaO .. | 0.24 | 0.23 | 0.07 |
| Exchangeable $K_2O$ | — | — | — |
| Total iron and alumina ($Fe_2O_3$) and ($Al_2O_3$) | 2.6 | 2.2 | 2.8 |
| Available $Fe_2O_3$ and $Al_2O_3$ .. .. .. | 0.18 | 0.20 | 0.12 |
| Loss on ignition .. | 1.2 | 1.3 | 0.7 |
| pH .. .. .. .. | 7.2 | 7.0 | 7.1 |

* Available $P_2O_5$, etc.: Amount extracted by shaking with $N/_5$ $HNO_3$ (ammonium chloride used for exchangeable $K_2O$).

The rainfall over the whole period under observation from planting to cutting was 51.84″, with the following distribution:—

| | 1935. | 1936. |
|---|---|---|
| January .. .. .. .. .. .. | — | 6.17 |
| February .. .. .. .. .. .. | — | 8.33 |
| March .. .. .. .. .. .. .. | — | 6.02 |
| April .. .. .. .. .. .. .. | — | 1.02 |
| May .. .. .. .. .. .. .. | — | 8.10 |
| June .. .. .. .. .. .. .. | — | 0.35 |
| July .. .. .. .. .. .. .. | — | 0.82 |
| August .. .. .. .. .. .. .. | — | 0.12 |
| September .. .. .. .. .. .. | — | 1.98 |
| October (from 25th) .. .. .. .. | 0.49 | 3.26 |
| November .. .. .. .. .. .. | 3.02 | 9.88 |
| December (to the 8th, 1936) .. .. | 2.03 | 0.25 |

The experiment was planted on 25th October, 1935, with Co.290, double and continuous in the furrows, 4 feet 6 inches apart. The old Uba crop was not ploughed out. Furrows were drawn in between the lines and the new crop planted. The old crop was treated as weed growth when it started growing and hoed out. The old crop never appeared to affect the Co.290 at all.

All the fertiliser was applied in the furrow just prior to the cane being planted and mixed with the soil.

The fertiliser treatments were as follows (in lbs. per acre):—

| FORMULA | TREATMENT | N | $P_2O_5$ | $K_2O$ |
|---|---|---|---|---|
| **O** .. .. | No fertiliser .. .. .. .. .. | — | — | — |
| **P** .. .. | 600 Super 19.1% .. .. .. .. | — | 114.6 w.s. | — |
| **NP** .. .. | 600 Super 19.1% .. .. .. ..<br>113 Sulphate of ammonia 21.1% .. .. | —<br>24 | 114.6 w.s.<br>— | —<br>— |
| **PK** .. .. | 600 Super 19.1% .. .. .. ..<br>100 Muriate of potash 60% .. .. .. | —<br>— | 114.6 w.s.<br>— | —<br>60 |
| $PK_2$ .. .. | 600 Super 19.1% .. .. .. ..<br>150 Muriate of potash 60% .. .. .. | —<br>— | 114.6 w.s.<br>— | —<br>90 |
| **NPK** .. .. | 600 Super 19.1% .. .. .. ..<br>113 Sulphate of ammonia 21.1% .. ..<br>100 Muriate of potash 60% .. .. .. | —<br>24<br>— | 114.6 w.s.<br>—<br>— | —<br>—<br>60 |
| $NPK_2$ .. | 600 Super 19.1% .. .. .. ..<br>113 Sulphate of ammonia 21.1% .. ..<br>150 Muriate of potash 60% .. .. .. | —<br>24<br>— | 114.6 w.s.<br>—<br>— | —<br>—<br>90 |
| $N_2P$ .. .. | 600 Super 19.1% .. .. .. ..<br>400 Whale guano No. 1.. .. .. .. | —<br>44 | 114.6 w.s.<br>— | —<br>— |
| $N_2PK$ .. | 600 Super 19.1% .. .. .. ..<br>400 Whale guano No. 1.. .. .. ..<br>100 Muriate of potash 60% .. .. .. | —<br>44<br>— | 114.6 w.s.<br>—<br>— | —<br>—<br>60 |
| $N_2PK_2$ .. | 600 Super 19.1% .. .. .. ..<br>400 Whale guano No. 1.. .. .. ..<br>150 Muriate of potash 60% .. .. .. | —<br>44<br>— | 114.6 w.s.<br>—<br>— | —<br>—<br>90 |
| $N_3P$ .. .. | 600 Super 19.1% .. .. .. ..<br>400 Whale guano No. 1.. .. .. ..<br>113 Sulphate of ammonia 21.1% .. .. | —<br>68 {44<br>24 | 114.6 w.s.<br>—<br>— | —<br>—<br>— |
| $N_3PK$ .. | 600 Super 19.1% .. .. .. ..<br>400 Whale guano No. 1.. .. .. ..<br>113 Sulphate of ammonia 21.1% .. ..<br>100 Muriate of potash 60% .. .. .. | —<br>68 {44<br>24<br>— | 114.6 w.s.<br>—<br>—<br>— | —<br>—<br>—<br>60 |
| $N_3PK_2$ .. | 600 Super 19.1% .. .. .. ..<br>400 Whale guano No. 1.. .. .. ..<br>113 Sulphate of ammonia 21.1% .. ..<br>150 Muriate of potash 60% .. .. .. | —<br>68 {44<br>24<br>— | 114.6 w.s.<br>—<br>—<br>— | —<br>—<br>—<br>90 |

It was originally intended to test the organic and inorganic forms of N against each other and then the double quantity together. It was found, however, that the whale guano supplied actually contained more nitrogen than that which it had originally been intended to use, which accounts for the lack of possible comparisons.

The dimensions of the plots were $^1/_{20}$th of an acre, with five replications of each treatment.

There was a certain amount of damage done by white ants, borers and buck. At one period a serious setback occurred due to damage caused by locusts. Almost from the start considerable differences were observed in appearance between the plots which had received nitrogen and those which had received none. The general growth of the cane was entirely unsatisfactory. After having come away well in the initial stages, the cane appeared to lose all vigour after a few months, barely putting on any more growth right up until it was cut.

It was decided to cut the cane after 14 months had elapsed, since it was making no further progress at all. A sample was taken from each plot and sent down to the Field Research Laboratories, Mount Edgecombe, where the sucrose, etc., was determined.

The following were the results obtained from the fertiliser dressings:—

| | O | P | NP | PK | $PK_2$ | NPK | $NPK_2$ |
|---|---|---|---|---|---|---|---|
| Tons cane per acre .. .. .. .. .. .. | 5.59 | 4.82 | 8.30 | 5.38 | 6.11 | 10.34 | 11.66 |
| Increase or decrease over controls .. .. .. | — | 0.77* | 2.71 | 0.21* | 0.52 | 4.75 | 6.07 |
| % increase or decrease over controls .. .. | — | 13.74* | 48.48 | 3.76* | 9.30 | 84.97 | 108.59 |
| Sucrose % cane .. .. .. .. .. .. | 12.95 | 13.21 | 12.73 | 12.78 | 13.24 | 13.40 | 13.35 |
| Tons sucrose per acre .. .. .. .. .. .. | 0.73 | 0.64 | 1.05 | 0.69 | 0.81 | 1.39 | 1.56 |
| Increase or decrease over controls .. .. .. | — | 0.09* | 0.32 | 0.04* | 0.08 | 0.66 | 0.83 |
| % increase or decrease over controls .. .. | — | 12.33* | 43.83 | 5.48* | 10.96 | 90.41 | 113.69 |
| Juice; Brix .. .. .. .. .. .. .. | 18.32 | 18.79 | 18.24 | 18.30 | 18.55 | 18.80 | 18.62 |
| Purity .. .. .. .. .. .. .. | 88.70 | 88.14 | 87.21 | 87.44 | 89.50 | 89.46 | 89.96 |
| Value (total) of sucrose per acre at £5.76923 per ton | £4 4 3 | £3 13 10 | £6 1 2 | £3 19 7 | £4 13 5 | £8 0 5 | £9 0 0 |
| Value of increase or decrease over controls.. .. | — | 0 10 5* | 1 16 11 | 0 4 8* | 0 9 2 | 3 16 2 | 4 15 9 |
| Cost of fertiliser treatment .. .. .. .. .. | — | 0 18 4 | 1 7 5 | 1 8 5 | 1 13 5 | 1 17 6 | 2 2 6 |
| Nett gain or loss over controls .. .. .. | — | 1 8 9* | 0 9 6 | 1 13 1* | 1 4 3* | 1 18 8 | 2 13 3 |
| Standard error in tons between treatments at 19 : 1 odds .. .. .. .. .. .. | 0.266 | 0.266 | 0.266 | 0.266 | 0.266 | 0.266 | 0.266 |
| % standard error between treatments .. .. | 19.30 | 19.30 | 19.30 | 19.30 | 19.30 | 19.30 | 19.30 |
| Value of standard error between treatments .. | £1 10 8 | £1 10 8 | £1 10 8 | £1 10 8 | £1 10 8 | £1 10 8 | £1 10 8 |
| General mean in tons sucrose .. .. .. | 1.38 | 1.38 | 1.38 | 1.38 | 1.38 | 1.38 | 1.38 |
| % of yield in tons sucrose on general mean of sucrose per acre .. .. .. .. .. .. | 52.89 | 46.37 | 76.08 | 50.00 | 58.69 | 100.72 | 113.04 |

| | $N_2P$ | $N_2PK$ | $N_2PK_2$ | $N_3P$ | $N_3PK$ | $N_3PK_2$ |
|---|---|---|---|---|---|---|
| Tons cane per acre .. .. .. .. .. .. | 11.59 | 13.58 | 15.38 | 14.90 | 15.15 | 13.79 |
| Increase or decrease over controls .. .. .. | 6.00 | 7.99 | 9.79 | 9.31 | 9.56 | 8.20 |
| % increase or decrease over controls .. .. | 107.33 | 142.93 | 175.13 | 166.54 | 171.01 | 146.69 |
| Sucrose % cane .. .. .. .. .. .. | 12.56 | 13.38 | 13.15 | 13.27 | 13.38 | 13.19 |
| Tons sucrose per acre .. .. .. .. .. .. | 1.48 | 1.81 | 2.02 | 1.94 | 1.97 | 1.81 |
| Increase or decrease over controls .. .. .. | 0.75 | 1.08 | 1.29 | 1.21 | 1.24 | 1.08 |
| % increase or decrease over controls .. .. | 102.73 | 147.94 | 176.71 | 165.75 | 169.86 | 147.94 |
| Juice: Brix .. .. .. .. .. .. .. | 18.02 | 18.76 | 18.54 | 18.67 | 18.68 | 18.55 |
| Purity .. .. .. .. .. .. .. | 87.44 | 89.54 | 89.04 | 89.10 | 89.76 | 89.22 |
| Value (total) of sucrose per acre at £5.76923 per ton | £8 10 9 | £10 8 10 | £11 13 1 | £11 3 10 | £11 7 4 | £10 8 10 |
| Value of increase or decrease over controls.. .. | 4 6 6 | 6 4 7 | 7 8 10 | 6 19 7 | 7 3 1 | 6 4 7 |
| Cost of fertiliser treatment .. .. .. .. .. | 2 4 0 | 2 14 1 | 2 19 1 | 2 13 1 | 3 3 2 | 3 8 2 |
| Nett gain or loss over controls .. .. .. | 2 2 6 | 3 10 6 | 4 9 9 | 4 6 6 | 3 19 11 | 2 16 5 |
| Standard error in tons between treatments at 19 : 1 odds .. .. .. .. .. .. | 0.266 | 0.266 | 0.266 | 0.266 | 0.266 | 0.266 |
| % standard error between treatments .. .. | 19.30 | 19.30 | 19.30 | 19.30 | 19.30 | 19.30 |
| Value of standard error between treatments .. | £1 10 8 | £1 10 8 | £1 10 8 | £1 10 8 | £1 10 8 | £1 10 8 |
| General mean in tons sucrose .. .. .. | 1.38 | 1.38 | 1.38 | 1.38 | 1.38 | 1.38 |
| % of yield in tons sucrose on general mean of sucrose per acre .. .. .. .. .. .. | 107.25 | 131.09 | 146.38 | 140.58 | 142.75 | 131.46 |

* Signifies a minus value.

The third experiment has already been the subject of a paper read before this Association in 1935, entitled "A few Preliminary Observations on a Fertiliser Experiment on Sugar Cane."[5] For purposes of comparison, the following essentials may be mentioned again.

The experimental site is situated about 1,550 feet above sea-level. The field is inclined towards the south, although so slightly as to be hardly noticeable.

The soil is a red clay of doleritic origin, which has been under cultivation for about 15 years or more, and prior to the planting of cane was under wattles.

The region of main root development extends to about 20 inches below the surface. There is a total absence of stones.

The soil analysis was as follows:—

| | A horizon. % | B horizon. % | C horizon. % |
|---|---|---|---|
| Carbon .. .. .. .. .. | 4.363 | 3.362 | 0.641 |
| Nitrogen ($N_2$) .. .. .. .. | 0.273 | 0.168 | 0.054 |
| C: N ratio .. .. .. .. | 16.000 | 20.100 | 11.600 |
| Available potash ($K_2O$) .. | 0.012 | 0.009 | 0.005 |
| Available $P_2O_5$ .. .. .. | 0.002 | 0.001 | 0.0002 |
| Total $K_2O$ .. .. .. .. | 0.090 | 0.063 | 0.055 |
| Total $P_2O_5$ .. .. .. .. | 0.082 | 0.052 | 0.059 |
| Loss on ignition .. .. .. | 19.840 | 18.790 | 14.530 |
| Hygroscopic moisture .. | 6.610 | 6.310 | 4.310 |
| Hydrogen ion concentration (pH) .. .. .. .. | 4.750 | 4.640 | 5.270 |
| Nitrate $NO_3$, p.p.m. .. | 1.640 | 2.410 | 2.340 |
| Silica ($SiO_2$) .. .. .. .. | 39.150 | 36.800 | 40.260 |
| Iron ($Fe_2O_3$) .. .. .. .. | 14.200 | 15.800 | 16.920 |
| CaO .. .. .. .. .. .. | 0.350 | 0.275 | 0.251 |
| MgO .. .. .. .. .. .. | 0.121 | 0.060 | 0.069 |
| Alumina, etc. ($Al_2O_3$, $TiO_2$, $Mn_3O_4$) .. .. .. .. | 26.930 | 27.090 | 28.640 |

The total rainfall over the period October, 1932, when the cane was planted, to November, 1934, when it was harvested, was 101.74 inches. The distribution was mentioned in the Proceedings of the Ninth Annual Congress of this Association.

The cane was planted 3rd October, 1932. The total fertiliser applications were as follows, on Section A and Section B, which it is our purpose to study together:—

| Formulæ. | Treatment in lbs. per acre. | N. | $P_2O_5$. | $K_2O$. |
|---|---|---|---|---|
| O | No fertiliser .. .. .. | — | — | — |
| P | 400lbs. Super 17.1% .. | — | 68.4 w.s. | — |
| NP | 400lbs. Super 17 1% .. | — | 68.4 w.s. | — |
| | 125lbs. Sulphate of ammonia 20.6% .. .. | 25.62 | — | — |
| NPK | 400lbs. Super 17.1% .. | — | 68.4 w.s. | — |
| | 125lbs. Sulphate of ammonia 20.6% .. .. | 25.62 | — | — |
| | 225lbs. Sulphate of potash 48.5% .. .. .. | — | — | 109.125 |
| $NPK_2$ | 400lbs. Super 17.1% .. | — | 68.4 w.s. | — |
| | 125lbs. Sulphate of ammonia 20.6% .. .. | 25.62 | — | — |
| | 450lbs. Sulphate of potash 48.5% .. .. .. | — | — | 218.25 |
| $N_2PK_2$ | 400lbs. Super 17.1% .. | — | 68.4 w.s. | — |
| | 250lbs. Sulphate of ammonia 20.6% .. .. | 51.25 | — | — |
| | 450lbs. Sulphate of potash 48.5% .. .. .. | — | — | 218.25 |

The plant cane was remarkably good and showed extraordinary growth on the heavily fertilised plots.

The total rainfall on the first ratoon crop was 94.18 inches, with the following distribution:—

| | 1934. | 1935. | 1936. |
|---|---|---|---|
| January .. .. .. .. .. | — | 4.35 | 7.90 |
| February .. .. .. .. .. | — | 6.55 | 11.40 |
| March .. .. .. .. .. | — | 4.20 | 9.27 |
| April .. .. .. .. .. | — | 1.30 | 1.01 |
| May .. .. .. .. .. .. | — | 4.20 | 5.92 |
| June .. .. .. .. .. .. | — | 9.90 | 0.64 |
| July .. .. .. .. .. .. | — | 0.72 | 1.13 |
| August .. .. .. .. .. | — | 1.85 | 0.20 |
| September (to 14th, 1936) | — | 0.72 | 1.68 |
| October .. .. .. .. .. | — | 2.88 | — |
| November (from 17th) .. | 0.00 | 1.42 | — |
| December .. .. .. .. | 12.17 | 4.77 | — |

The first ratoon was not fertilised, the intention being to study the residual effects of the fertilisers applied. The cane came away slowly and lacked vigour, although the tillering was good. From casual observations there was a considerable increase of streak infection; the accurate percentage was not determined. The differences observed between treatments on the plant cane became more apparent still on the ratoon. The cane was harvested on the 14th September, 1936, and samples taken from each plot and sent down to the S.A. Sugar Association Experiment Station, where they were analysed for sucrose, etc.

The original crop was unfortunately not tested from a sucrose point of view, as mentioned in the previous report on this experiment. For purposes of comparison, however, the average sucrose for the whole estate of 11.6 was taken and the results worked out on that basis.

The following table gives the results of the effects of the fertiliser on the yields of both plant cane and first ratoon, separately and together.

## YEAR, 1934.

| | O | P | NP | NPK | $NPK_2$ | $N_2PK_2$ |
|---|---|---|---|---|---|---|
| Tons cane per acre .. .. .. .. .. | 37.90 | 45.04 | 42.63 | 46.42 | 50.09 | 46.74 |
| Increase or decrease over controls .. .. .. | — | 7.14 | 4.73 | 8.52 | 12.19 | 8.84 |
| % increase or decrease over controls .. .. | — | 18.84 | 12.48 | 22.48 | 32.16 | 23.32 |
| Sucrose % cane .. .. .. .. .. | For purpose of comparison taken at 11.6%, which was average for the estate. | | | | | |
| Tons sucrose per acre .. .. .. .. .. | 4.39 | 5.22 | 5.00 | 5.38 | 5.81 | 5.48 |
| Increase or decrease over controls .. .. .. | — | 0.83 | 0.61 | 0.99 | 1.42 | 1.09 |
| % increase or decrease over controls .. .. | — | 18.90 | 13.89 | 22.55 | 32.35 | 24.83 |
| Juice; Brix .. .. .. .. .. .. .. | — | — | — | — | — | — |
| Purity .. .. .. .. .. .. .. | — | — | — | — | — | — |
| Value (total) of sucrose per acre at £5.470729 per ton (1934) .. .. .. .. .. .. | *£23 11 9 | £28 11 2 | £27 7 1 | £29 8 8 | £31 15 8 | £29 19 7 |
| Value of increase or decrease over controls .. .. | — | 4 19 5 | 3 15 4 | 5 16 11 | 8 3 11 | 6 7 10 |
| Cost of fertiliser treatment .. .. .. .. | 0 8 6 | 0 14 2 | 0 19 3 | 1 11 0 | 2 2 9 | 2 7 10 |
| Nett gain or loss over controls .. .. .. | — | 4 5 3 | 2 16 1 | 4 5 11 | 6 1 2 | 4 0 0 |
| Standard error in tons between treatments at 19 : 1 odds .. .. .. .. .. .. | 0.63 | 0.63 | 0.63 | 0.63 | 0.63 | 0.63 |
| % standard error between treatments .. .. | 12.13 | 12.13 | 12.13 | 12.13 | 12.13 | 12.13 |
| Value of standard error between treatments .. | £3 8 11 | £3 8 11 | £3 8 11 | £3 8 11 | £3 8 11 | £3 8 11 |
| General mean in tons sucrose .. .. .. .. | 5.22 | 5.22 | 5.22 | 5.22 | 5.22 | 5.22 |
| % of yield in tons sucrose on general mean of sucrose per acre .. .. .. .. .. | 84.10 | 100.00 | 95.78 | 103.04 | 111.30 | 104.98 |

## YEAR, 1936.

| | O | P | NP | NPK | $NPK_2$ | $N_2PK_2$ |
|---|---|---|---|---|---|---|
| Tons cane per acre .. .. .. .. .. .. | 22.61 | 28.80 | 26.30 | 29.82 | 31.41 | 27.10 |
| Increase or decrease over controls .. .. .. | — | 6.19 | 3.69 | 7.21 | 8.80 | 4.49 |
| % increase or decrease over controls .. .. | — | 27.37 | 16.32 | 31.89 | 38.92 | 19.85 |
| Sucrose % cane .. .. .. .. .. .. | 14.56 | 14.39 | 14.33 | 14.48 | 14.46 | 14.48 |
| Tons sucrose per acre .. .. .. .. .. .. | 3.30 | 3.99 | 3.76 | 4.33 | 4.54 | 3.93 |
| Increase or decrease over controls .. .. .. | — | 0.69 | 0.46 | 1.03 | 1.24 | 0.60 |
| % increase or decrease over controls .. .. | — | 20.91 | 13.93 | 31.48 | 37.58 | 18.18 |
| Juice; Brix .. .. .. .. .. .. .. | 20.28 | 19.75 | 19.72 | 19.86 | 20.16 | 20.03 |
| Purity .. .. .. .. .. .. .. | 90.45 | 91.78 | 91.70 | 91.75 | 91.60 | 91.06 |
| Value (total) of sucrose per acre at £5.76923 per ton (1936) .. .. .. .. .. .. | †£18 12 3 | £23 0 5 | £21 13 10 | £24 19 7 | £26 3 10 | £22 13 5 |
| Value of increase or decrease over controls .. .. | — | 4 8 2 | 3 1 7 | 6 7 4 | 7 11 7 | 4 1 2 |
| Cost of fertiliser treatment .. .. .. .. | 0 8 6 | 0 14 3 | 0 19 3 | 1 11 0 | 2 2 9 | 2 7 9 |
| Nett gain or loss over controls .. .. .. | — | 3 13 11 | 2 2 4 | 4 16 4 | 5 8 10 | 1 13 5 |
| Standard error in tons between treatments at 19 · 1 odds .. .. .. .. .. .. | 0.57 | 0.57 | 0.57 | 0.57 | 0.57 | 0.57 |
| % standard error between treatments .. .. | 10.13 | 10.13 | 10.13 | 10.13 | 10.13 | 10.13 |
| Value of standard error between treatments .. | £3 5 9 | £3 5 9 | £3 5 9 | £3 5 9 | £3 5 9 | £3 5 9 |
| General mean in tons sucrose .. .. .. .. | 3.98 | 3.98 | 3.98 | 3.98 | 3.98 | 3.98 |
| % of yield in tons sucrose on general mean of sucrose per acre .. .. .. .. .. | 82.91 | 100.22 | 94.47 | 108.79 | 114.07 | 98.74 |

| | O | P | NP | NPK | $NPK_2$ | $N_2PK_2$ |
|---|---|---|---|---|---|---|
| | £ s. d. | £ s. d. | £ s. d. | £ s. d. | £ s. d. | £ s. d. |
| Nett gain over controls over both seasons .. .. | — | 7 19 2 | 4 18 5 | 9 2 3 | 11 10 0 | 5 13 5 |
| Value of standard error between treatments over both seasons .. .. .. .. .. | 6 14 8 | 6 14 8 | 6 14 8 | 6 14 8 | 6 14 8 | 6 14 8 |

* Value of tons sucrose less initial basal dressing, which was applied over total area = £24 0s. 3d. — 8s. 6d.

† Value of tons sucrose per acre less initial basal dressing, which was applied over total area = £19 0s. 9d. — 8s. 6d.

## DISCUSSION.

Regarding the soil analysis of the Tongaat experiment, the salient point is the $P_2O_5$ content of the soil. In this connection, it is interesting to refer to the graph, which illustrates the gradual rise in the yield of cane since 1917. It has been pointed out that the field was treated with filter press cake in the past, and it is possible that the actual applications were much heavier than the figures recorded. The other possibility, too, is that more frequent dressings were applied than is often the practice, which leaves no doubt about the possibility of an accumulation of $P_2O_5$, especially since the total tonnage of cane per acre since 1917 was only 142.4 tons.

A comparison between the amounts of plant-food taken up by cane,[6] and the amount of $P_2O_5$ even in a possible 35 tons of filter press cake applied, reveals a balance in favour of the soil of about 500 lbs. $P_2O_5$.

The C horizon shows a very sharp drop in the $P_2O_5$ content, which tends to indicate fixation in the upper layers of the soil. One would not, however, expect fixation in a difficultly available form in this soil, "If the ratio of active calcium to active iron and aluminium is high, the fixation will be largely in the calcium form, and the fixed phosphorus will be readily available."[7]

The total nitrogen is very low, but the ammonia nitrogen very high, whilst nitrate nitrogen is low again. On account of rapid changes of this element in the soil, and leaching, generalisations on the nitrogen status of the soil become difficult, especially under our climatic conditions. The nitrogen cycle in soils has been shown to involve a "successive simplification according to the following scheme: Nitrogenous organic matter—amino acids—and amides—ammonium salts—nitrites—nitrates." [8]

Discussing the "Nitrogen transformation in the decomposition of organic matter in the soil," Waksman says,[9] "When nitrogenous organic substances are added to the soil, a group of complex reactions will result as far as the nitrogen is concerned:—

(1) The hydrolysis of the proteins into polypeptides and amino acids, with the liberation of some ammonia.
(2) This is followed by the decomposition of the amino acids and other products of protein hydrolysis, with a further liberation of ammonia.
(3) Synthesis of microbial protoplasm, which will lead to a storing away of a part or the whole of the ammonia nitrogen; the greater the quantity of available non-nitrogenous organic matter accompanying the nitrogenous substances, the greater will be the synthesis of microbial protoplasm, leading to a greater assimilation of the nitrogen and to a smaller accumulation of ammonia.
(4) Various soil conditions, as well as differences in the composition of the nitrogenous and the accompanying non-nitrogenous organic substances, lead to the development of different micro-organisms capable of decomposing the nitrogenous materials; the carbon-nitrogen metabolism of these micro-organisms is different; this leads, therefore, to differences in the amounts of ammonia liberated in a free state."

The ammonia, as such, or after it has been oxidized to nitrate, is available for plants. "Nitrification, the production, via nitrites, of nitrates from ammonium salts, is an aerobic process, the work of autotrophic bacteria whose energy is obtained from the oxidation involved in this change. The minimum optimum and maximum temperature for this process is about 5°C., 25-35°C. and 55°C. respectively. S. P. Tandon and N. R. Dhar conclude that the optimum temperature for nitrification in tropical soils is about 35°C., against 25°C. in temperate soils. The change, nitrites—nitrates is more rapid than the change, ammonium salts—nitrites; and for this reason nitrites in the free state scarcely occur in soils.

The whole change from ammonium salts to nitrates is, under satisfactory conditions for nitrification, more rapid than ammonification. The presence of ammoniacal nitrogen in amounts of more than a few parts per million of soil, is evidence that conditions are unfavourable for nitrification. Such soils may contain up to 0.05% of ammoniacal N and be devoid of nitrates. Ordinarily, however, it may be said that the rate of nitrification depends on the rate of ammonification."[10]

The previous additions of filter press cake do not appear to have had any effect on the soil organic matter content, which appears very low judging by the figure given for the loss on ignition. The filter press cake appears to decompose rapidly.

A part of the nitrogenous fertiliser was applied in the form of whale guano No. 1 with 11% N. In this connection "Lathrop (612) has shown that in the decomposition of dried blood in soil, a part of the nitrogen is transformed into a protein which is characteristic of the organic matter of the soil. The lower the nitrogen content of the organic fertiliser, the slower is the liberation of the nitrogen in an available form and the greater is the amount of humus produced."[11] It is not thought, however, that this applies to the soil under discussion, since the rapid effect of similar material on cane on an identical soil type at Natal Estates appears indicative of the nitrogen becoming rapidly available.

Referring back to the bacteria forming nitrites from ammonia and nitrates from nitrites, Waksman[12] says that: "In the process of nitrification we are dealing not with one organism, but with a group of closely related organisms. . . . Recently Winogradsky suggested classifying the nitrite-forming bacteria into three groups: 1. Free motile forms, present in the soils as rods and cocci—Nitrosomonas. 2. Zooglea, composed of cocci united in rounded masses and surrounded by a membrane—Nitrocystis. 3. Spiral-shaped forms—Nitrosospira. The various forms occur in different soils, the last found only in uncultivated soils." The oxidation of nitrite to nitrate is carried out by an organism, discovered by Winogradsky, called Nitrobacter. The optimum reaction given for the respiration of the nitrate-forming bacteria is pH 8.3–9.3, with limits at pH 5.6 and 10.3.

Apart from the bacteria just mentioned, there are those which are capable of fixing atmospheric nitrogen in the soil, and non-symbiotic types such as anaerobic, Clostridium pastorianum, Granulobacter, etc., and the aerobic type Azotobacter.

The Tongaat soil showed that Azotobacter are present in the soil. This organism will not exist in soils with a pH much less than 6. It is also suggested that this organism assists in rendering phosphate available.

Lime has been found to have a stimulating effect on nitrate formation, particularly in acid soils. "In alkaline soils which are deficient in organic matter, $CaCO_3$ may have the opposite effect, since it tends to liberate from ammonium salts free ammonia, which retards nitrification. Lime does not stimulate the activities of the nitrifying bacteria, it serves as a base for neutralising the acid formed from the oxidation of the ammonium salt."[13].

The yields of sucrose per acre were considerably influenced at Tongaat by applications of fertiliser and filter press cake in different amounts. The most noticeable feature is the effect produced by potash, since it is often claimed that this ingredient has either negative or depressing effects when used in large dressings. The complicated fertiliser dressing used was prompted on account of so many reports forthcoming that various fertiliser ingredients definitely depressed the yields.

The lower levels of phosphate had very little effect on the yield, but the high level $P_3$ with $N_2$ and $K_2$ increased the yield by 1.03 tons of sucrose per acre over $N_2P_2K_2$ and 0.32 tons of sucrose over NPK. The high dressing of potash at 400 lb. of $K_2O$ per acre had the same effect as the high dressing of phosphate; the middle level, however, had a depressing effect, whereas the low level caused a considerable increase.

Nitrogen appears to have had very little effect apart from N in NP, which increased the yield, and $N_3$, which apparently decreased it. These effects are quite possibly those of some interaction which it is not possible to detect with this layout, and it is impossible to ascribe the full increase or decrease to any one particular element without further knowledge of interaction effects.

The application of quantities of filter press cake at the rate of twenty and forty tons per acre in conjuction with fertiliser has shown interesting results. With twenty tons, heavier applications of fertiliser appear to have no effect; when 40 tons were applied, however, big increases of yield were obtained. The most profitable yield was obtained by using 34.73 lb. N, 38.2 lb. $P_2O_5$ and 120.22 lb. $K_2O$ per acre, which gave a nett profit of £6 9s. 4d. per acre; and 34.73 lb. N, 38.2 lb. $P_2O_5$ and 120.22 lb. $K_2O$, together with 20 tons filter press cake per acre, which gave a nett profit of £7 7s. 9d. per acre.

An extraordinarily interesting feature of this experiment is the effect of the fertiliser applications and the ultimate yields compared to the counts of shoots and growth measurements recorded in the very early stages of growth. The total length of stick obtained from the different plots with different fertiliser dressings shows an excellent correlation between number of shoots per plot, height of shoots and ultimate yield. Fig. 2

On the experiment at Natal Estates the lower levels of superphosphate used at Tongaat were not applied. The superphosphate level was maintained at 600 lb. per acre. Here, on a soil practically identical in all respects to the one at Tongaat, with the exception of a higher lime content, the same application of superphosphate as that which produced a big increase in the yield of sucrose at Tongaat, in conjunction with a dressing of nitrogen and potash, depressed the yield at Natal Estates when used alone.

The outstanding feature of the whole experiment at Natal Estates was the beneficial effects of the applications of nitrogenous fertiliser, both in the form of whale guano alone, ammonium sulphate alone, and the two together. NP giving 1.05 tons of sucrose per acre, $N_2P$ 1.48 tons of sucrose per acre, and $N_3P$ 1.94 tons per acre. Unfortunately no comparison is possible between the two forms of nitrogen.

Potassium at 60 lb. and 90 lb. $K_2O$ per acre appears to have helped to overcome the depressing effect of the phosphate and, in conjunction with N and $N_2$, raised the yield well. K and $K_2$ failed to produce further increases in conjunction with $N_3$, and a possible explanation of this is an unbalanced condition between N and K, with N in excess, which it was not possible to counteract with only 60 lb. and 90 lb. $K_2O$ per acre.

The total yields were extremely disappointing, but the fertilisers certainly showed interesting effects, and again bring forward the necessity to go further and investigate possible interactions. Reference to the analysis of the soil of this experiment will show that the same comments apply to it as were brought forward for the soil at Tongaat.

The astonishing thing about the two experiments at Tongaat and Natal Estates is the almost total lack of organic matter in the soil and the high content of available phosphate and lime. These two soils again compare with a soil carrying an experiment at Umbogintwini, with the exception that no filter press cake has ever been applied there and the available $P_2O_5$ and CaO were both very low. That soil gave very high yields of Co.290 and P.O.J.2725 with fertiliser dressings giving very similar quantities of N, $P_2O_5$ and $K_2O$ to those applied to the cane at Natal Estates.[14]

The most profitable yields at Natal Estates were obtained by using 44 lb. N, 114.6 lb. $P_2O_5$ and 90 lb. $K_2O$ per acre, which gave a nett profit of £4 9s. 9d. per acre.

The experiment at Kearsney, on a red doleritic clay soil, is of great interest from the point of view that

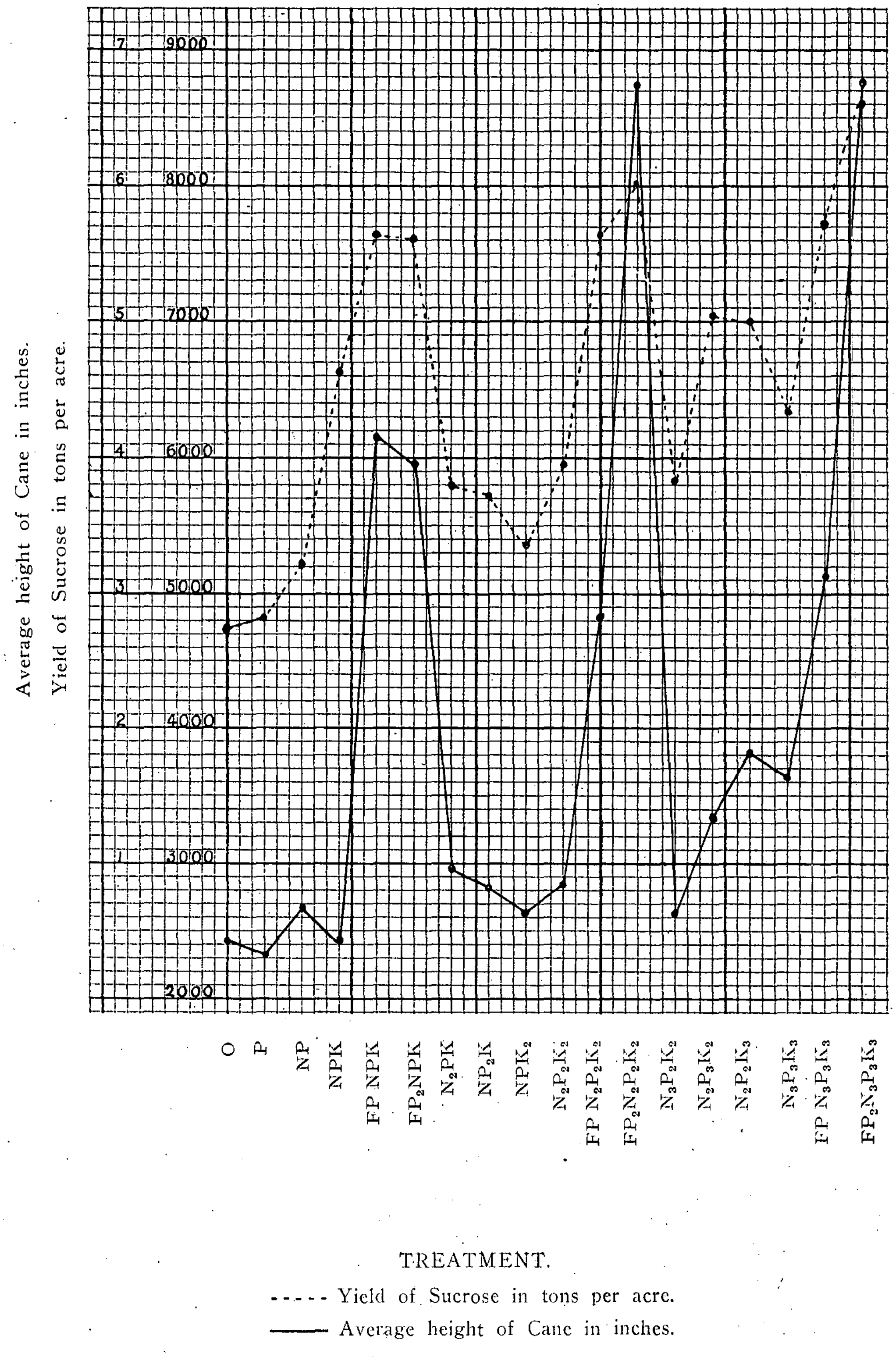


**FIGURE 2.**

The curve of total length of cane in inches on the different treatments compared to yields in tons sucrose per acre.

the first ratoon yields show exactly the same trend as was shown by the plant cane in response to the various fertilisers applied.

It is curious to note, however, that the plots NP and $N_2PK_2$ did not recover from the apparent depressing effect caused by the nitrogen in the absence of sufficient potash on the plant cane.

This soil has responded admirably to treatment, and it is interesting to compare the yields obtained from this soil at a considerable altitude with a very low content of $P_2O_5$, with those which have just been discussed, with a high available $P_2O_5$ content. The powers of absorption of this soil are probably considerable—it is a clay soil, high in organic matter, with a low pH, and high content of free iron and alumina. Non-symbiotic nitrogen-fixing bacteria are inexistent.

The salient point of this experiment is the fact that quantities of fertiliser much higher than ordinarily used have increased the yield considerably and given excellent returns per acre, this point being of considerable interest from the point of view of the $K_2O$ applied. The highest returns per acre were obtained by using 25.62 lb. N, 68.4 lb. $P_2O_5$ and 218.25 lb. $K_2O$ per acre, which gave a nett profit of £6 1s. 2d. for plant cane and £5 8s. 10d. per acre for first ratoon.

## Summary.

Three experiments are discussed, dealing with two soil types—wind-blown sand of recent origin, and a heavy red clay soil of doleritic origin.

Fertiliser applications augmented the yields considerably, and certain levels of N, $P_2O_5$ and $K_2O$ gave very remunerative returns. Applications of filter press cake appear to have had considerable effect in increasing the $P_2O_5$ and CaO content of the soils where used. Also high dressings of filter press cake appear to give a bigger yield when applied in conjunction with heavy applications of N, $P_2O_5$ and $K_2O$. There is evidence of interaction between the ingredients used at different levels which calls for further invesitgation.

The fertiliser applications appear to influence the germination and growth of the cane from the very early stages, and there is an interesting correlation between observations made in this connection and the ultimate yield.

Thanks are due to Prof. J. M. Hector, of the Pretoria University; the staff of the South African Sugar Experiment Station, Mount Edgecombe; Dr. J. Orchard, Division of Chemistry, Pretoria; Mr. Ingham, chemist, African Explosives and Industries, Ltd., Umbogintwini; the technical field staff of Natal Estates; the field staff of Tongaat Sugar Milling Co.; and Captain J. Woollam, for doing the analytical work in connection with these experiments and for general co-operation.

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[10] As reference 8, p. 156.

[11] Humus, by S. A. Waksman, p. 211.

[12] As reference 11, pp. 71-73.

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Mr. CUTLER: Mr. Chairman, I would like to express my appreciation of Mr. Lintner's paper. I think it is one of the best got-up papers I have read for a long time. The only thing about it is that it leaves so little to the imagination, answers every detail so thoroughly that it stifles any chance of making a discussion on it. There is one thing I would like to ask in regard to the second experiment, where his yields are low. I notice he has no insoluble calcium or potassium, he has free iron alumina to the tune of 1.9. I take it that is in money equivalents?

Mr. LINTNER: Actually, the exchangeable $K_2O$ was done at Umbogintwini by Mr. Ingham but unfortunately his results did not compare, so we were unable to publish it.

Mr. CUTLER: In the last experiment there seems to be a comparatively low amount of calcium there. I take it that on that account the high potash gave maximum returns?

Mr. LINTNER: Yes, I think I agree with you.

Mr. CUTLER: The third thing is I noticed the interesting point—we hear a good deal about fixation of $P_2O_5$ in the top layer of the soil. In regard to these experiments it points out very clearly that under normal conditions in the cane field, your $P_2O_5$ fixation takes place in the maximum of zone feeding roots. It illustrates very well the extent to which that fixation does take place.

Mr. LINTNER: I would like to have your opinion on the work done by Floyd Hech in America regarding the amount of lime in the soil and the availability of phosphate.

Mr. CUTLER: The only thing I can say about that is that in our pot experiments in Pretoria and in what Neubauer work that I have done, where one has any slight amount of free alumina, the results are visible immediately. Immediately you get any displacement of alumina, then you can look for that as being the governing factor in your experiment.

Mr. LINTNER: Irrespective of the lime content?

Mr. CUTLER: Well, you will not get your alumina there if you have any lime content at all.

Dr. McMARTIN: Mr. Chairman, I should like to associate myself with Mr. Cutler in recording appreciation of the manner in which Mr. Lintner has stated the case for the use of fertilisers. I find particularly interesting here the effect of these applications of fertiliser on the earlier stages of cane. It so often happens when one looks at a fertiliser trial when it is a few months old, the difference between the plots looks so enormous. Then it appears to even up. Later on, by visual inspection, it appears that one is not getting response, or the same response as one expected when the cane was young. However, these figures here prove to be rather interesting, because we find that if we take the number of shoots per plot and multiply that by the average height of the shoot when about three months old, comparing that with the ultimate crop cut, we get a correlation of plus 0.9, a very high correlation indeed between the vigour imparted to the plant when young and the ultimate yield, showing how this early "kick," so to speak, was maintained during the life of the crop. Actually we find, by working out the equation that in this experiment referred to, every increase of 10,000 inches of young shoot per acre gave us an increase of one ton per acre when the cane was cut.

Mr. FOWLIE: Mr. Chairman, I also would like to associate myself with the others who have already spoken in appreciation of Mr. Lintner's effort to explain to us so many of the things which go to make up fertility, or what passes as fertility, in soils. I feel, like Mr. Cutler, that Mr. Lintner has gone so fully into the whole matter that there is nothing to enlarge on, and certainly I do not want to criticise, so I will just content myself by saying "Thank you" to Mr. Lintner for his paper.

The PRESIDENT: There seems to be no inclination for further discussion on Mr. Lintner's paper. I think, Mr. Lintner, you have done your work so thoroughly that you have stifled discussion this morning, which is a very great compliment to yourself. I will ask you, gentlemen, to show your appreciation in the usual way. (Applause).