Australia

Long-Term Trials Show Sugarcane Needs Potassium

By L.S. Chapman

THE Bureau of Sugar Experiment Stations conducts field research on sugarcane and provides technical advice to growers. Current advice on potassium (K) fertilizer recommendations is based on the calibration of soil tests for exchangeable and nitric acid extractable K with cane yield responses. Recommended K application rates for "plant" crops following a six-month fallow receive approximately 100 kg/ha of K. Ratoons and replant crops with no fallow period receive approximately 120 kg/ha of K.

A long-term K trial has been conducted at Mackay Sugar Experiment Station since 1967. The aim of this research is to monitor the effects of K fertilizer on cane yields and levels of selected soil analytical values.

Experimental Procedure

The trial site belongs to the non-calcic brown great soil group and has a brownish black sandy clay loam top-soil overlying a brown medium clay sub-soil. X-ray diffraction patterns indicate kaolinite and illite to be the major crystalline constituents of the clay fraction of this soil, similar to soils in the district.

Eight levels of K fertilizer, ranging from a control to 196 kg/ha of K, were banded into the soil each crop year in a mixture with nitrogen (N) and phosphorus (P). Only the results of the control and the 112 kg/ha of K treatment, which gave the optimum economic response, are reported here.

Three crop cycles of plant cane and four or five ratoons, plus the plant and two ratoons of a fourth cycle have been harvested. Cane yields were measured by a sampling method or by weighing 10 m plot lengths of mechanically harvested cane from the center three rows of five-row plots.

Ten soil cores were sampled per plot to a depth of 25 cm before fertilizer application, prior to planting or after each harvest. Cores were collected from the inter-rows, thereby avoiding previous fertilizer bands. After drying at 30°C, the soil samples were ground to less than 2 mm and analyzed for exchangeable K in a 0.02 M HC1 extract and for nitric K in a boiling 1 M HNO_3 extract. Non-exchangeable available potassium (NEAK) was calculated as nitric K minus exchangeable K. In 1989, soil samples were analyzed for exchangeable Ca and Mg in a 0.02 M HC1 extract and pH in a 1:5 soil:water extract. The K removed in the 1982 crop was measured in cane samples taken from each plot and analyzed for total K.

Yield data were analyzed for variance. Soil analysis data for exchangeable K, nitric K and NEAK were also analyzed for co-variance using the preplanting data in 1967 as a variable.

Results and Discussion

Cane yields of the controls for the four cycles averaged 77, 76, 61 and 78 tonnes/ha cane. The low yield in the third cycle was associated with lower rainfall. See **Figure 1**.

Yields increased significantly in each crop from the application of K fertilizer, the mean response from 112 kg/ha being 12, 15 and 113 tonnes/ha for the first three

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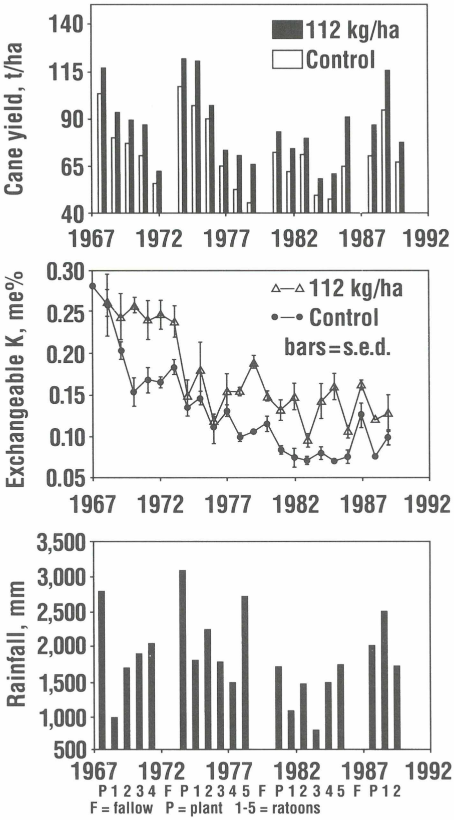

Figure 1. Effect of fertilizer K on cane yield and exchangeable K over four crop cycles involving 20 harvests, including rainfall totals for each crop.

crop cycles, respectively. The largest relative responses, measured as percent yield, were in the fourth and fifth ratoons of the second and third crop cycles. Yields of older ratoons progressively declined in most cases, the exceptions being due to favorable weather conditions.

Exchangeable K levels in soil decreased progressively for both the 112 kg/ha and unfertilized plots. However, there was a small but significant increase from K applications after the first ratoon of the first crop cycle.

Variation in the levels of exchangeable K from year to year could not be related to the rainfall received for each crop. After each fallow period of approximately six months, there was a small increase in exchangeable K compared to the level at the previous harvest. This was attributed to the continued mineralization of K in the soil and to a lack of uptake by plants, as the fallows were generally weed free. During the fallow, a mixing of the fertilizer enriched bands with the plow layer could also be a contributing factor, but this effect was not measured.

The nitric K level was 1.57 me% at the commencement of the trial, an indication of high reserves of K in the soil, typical of illitic clays. NEAK levels were also high, with no trend for increased levels as a result of fertilization, except in 1987 at the beginning of the fourth crop cycle. In the control plots, there was a linear decline in NEAK and exchangeable K levels of 0.0058 and .0072 me% per year, respectively. This represents a total loss of 18 kg/ha/year of K in the topsoil, much less than the 69 kg/ha of K removed by the crop in 1982 for the unfertilized plots. By comparison, the plots fertilized with 112 kg/ha of K lost considerably more K, with 148 kg/ha of K removed by the crop.

Obviously, the total K removed by the crop cannot be estimated directly by soil analyses. This evidence supports the view that equilibria exist among exchangeable K, NEAK and lattice K. Therefore, as K is used by the crop, a considerable amount of K must be released from the lattice K fraction of the soil.

Soil analysis data for 1989 showed a non-significant trend for plots fertilized with K to have higher levels of exchangeable calcium (Ca) and magnesium (Mg) than the control plots. Exchangeable Ca levels were 2.41 and 2.96 me%, and exchangeable Mg levels were 0.66 and 0.80 me% for the control and 112 kg/ha of K treatments, respectively. These data indicate that it may be possible for cane plants to substitute other cations for K ions if the latter are in short supply. It appears that exchange sites on the soil were occupied by hydrogen (H) ions as Ca and Mg ions were taken up by plants, since the plots receiving 112 kg/ha of K had a pH of 5.13, significantly higher than the pH of 4.90 in the unfertilized plots.

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Table 1. Effect of application of different sources of K on soybean yield and leaf K concentration at Mococa.

Treatments	Soybean yield, kg/ha 3rd yr.	K in the leaves, % 1st yr.	2nd yr.	3rd yr.
T_1	2,683	3.0	2.1	1.0
T_2	3,220	3.1	2.6	1.8
T_3	3,087	3.0	2.5	1.3
T_4	2,875	3.0	2.7	1.5
T_5	3,212	2.8	2.8	1.5

Table 2. Effect of application of different sources of K on soybean yield and leaf K concentration at Paraguaçu Paulista.

Treatments	Soybean yield, kg/ha 2nd yr.	K in the leaves, % 1st yr.	2nd yr.
T_1	1,050	2.1	0.74
T_2	1,758	2.8	1.53
T_3	1,722	2.2	1.50
T_4	1,697	2.9	1.50
T_5	1,622	2.2	1.65

ently, decomposition of remaining shrubs and grass released K which satisfied the needs of the soybeans. In the second year, there was a response.

All sources of K produced similar yields and surpassed the yield of the check. In the check plots, there were leaf symptoms of K deficiency. This K deficiency affected seed quality, as shown in the photo. There was a similar decrease in K concentration in the leaves from the first to the second year as observed at Mococa.

It is interesting to note that since vinasse was applied annually, one would expect a higher yield and higher concentration of K in the leaves when compared with other treatments. This did not occur. The results obtained by the research workers of the Pedology Department of IAC showed that due to heavy rains in the summer, more than 60 percent of K is usually leached out. Note in the photo the well developed pods nourished with K fertilization. In the absence of K, the raceme shows the lack of pods, malformation, pods without seeds and white color of young pods.

This study found that all four sources of K had similar effects on soybean response to fertilization. ■

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Conclusions

The major conclusions that can be drawn from these trial data are:

- Cane yield of unfertilized plots declined with older ratoons. The lower yields in the third crop cycle were largely due to lower rainfall.
- Mean yield responses from K fertilizer were significant and constant from crop cycle to crop cycle.
- Responses were obtained each year, with proportionally larger responses in fourth and fifth ratoons of the second and third crop cycles.
- Exchangeable K in soil gradually declined in fertilized plots, although the decline was greater in the unfertilized plots, particularly in the first crop cycle.
- NEAK levels in soil of the unfertilized plots are also declining, but at a modest rate considering the amount of K removed by each crop.
- Fertilized plots were less acid than the unfertilized plots in 1989.

Industry Significance

The significance of these results is that applications of K fertilizer are necessary to maximize yield, even on this soil type which has high reserves of K. There is little concern at this stage that exchangeable K levels are declining in the fertilized plots, for yield responses appear stable between crop cycles. Higher applications of K fertilizer do not appear to be warranted. ■