YIELD AND QUALITY OF SUGARCANE AS AFFECTED BY PHOSPHATE APPLICATION ON SOILS OF VARIOUS PHOSPHORUS LEVELS

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ABSTRACT

Effects of phosphate application on the growth, yield and quality of sugarcane (*Saccharum officinarum* L.) were studied on the soils having various phosphorus levels. Superphosphate was applied to bring the available soil P at 5, 15, 25 and 35 mg P_2O_5 100 g^{-1} designated as A, B, C and D levels, respectively. Leaf area index (LAI) and dry matter increased on the higher P plots over the lower P plots. The highest cane yield (74 t ha^{-1}) and sugar yield (10.2 t ha^{-1}) were obtained from the B plot and the lowest cane yield (51 t ha^{-1}) and sugar yield (6.9 t ha^{-1}) were from the A plot. The D plot failed to give the highest cane and sugar yield due to lower millable canes accompanied with poor juice quality. Heavy P application showed bad effects on leaf quality by decreasing N, K, Zn and Cu contents.

KEYWORDS

Dry matter production, leaf area index, phosphate, soil P level, sugarcane, sugar yield

INTRODUCTION

Sugarcane is a vigorous and long duration crop which produces high dry matter per unit field area. The yield contributing characters like number of tillers, functional leaves and millable cane are affected if fertilizer is a limiting factor. Use of sugarcane as a forage crop has been reported by Takmura and Nakano (1986). Application of P, especially on P deficient soils promotes root growth, stimulates tillering and influences favorably for better growth and thereby better yield and juice quality (Malie *et al*., 1982). Toit *et al*. (1962) showed that application of phosphate to soils showing less than 176 ppm P_2O_5 in soil extracted with 0.1N caustic soda would produce a response, but above that sugarcane would be unlikely to respond. In Okinawa, Japan, about 16,000 ha of land are under sugarcane cultivation. Farmers apply P fertilizer to sugarcane every year without considering the existing P contents of the soil. Thus, it is very much essential to determine the optimum level of available soil P considering both the existing soil P and fertilizer P on a cumulative basis for obtaining higher cane yield. The objective of this study was to investigate the growth, yield and quality of sugarcane as affected by phosphate application on the soils of various P levels. This information would be useful also for the forage researcher.

MATERIALS AND METHODS

This experiment was conducted on a dark red soil having four different soil P levels, namely A, B, C and D with 3.37, 6.34, 7.73 and 10.09 mg P2O5 100 g-1, respectively obtained after harvest of a ratoon crop (*Sacchrum officinarum* L.). Before starting the experiment, the available soil P were adjusted to 5, 15, 25 and 35 mg P2O5 100 g^{-1} by superphosphate application calculated on the basis of an incubation trial. The experiment was laid out in a completely randomized design with six replications. One month old settlings of cv. F-177 were transplanted on May 20, 1995. Plot size was 5.5 x 3.0 m with 1.0 m interrow and 0.35 m interplant spacings. Cultural practices viz. irrigation, weeding and fertilization (only N and K_2O, 180 and 110 kg ha^{-1}, respectively) were done. Soil pH was measured in a 1:2.5 soil water suspension. Available phosphate was extracted with 0.002N H_2SO_4 and determined by the molybdenum blue method. Phosphate absorption coefficient was determined following the ammonium vanadomolybdate method by saturating the soil with 2.5% $(NH_4)HPO_4$ solution. The soil chemical properties were: pH ranged from 6.08 to 6.41. And after harvesting cane, the available soil P ranged from 3.55 to 33.03 mg P2O5 100 g^{-1} on A through D plots. Phosphorus absorption coefficient ranged from 1,072 to 1,110 mg P2O5 100 g^{-1} soil, with the highest value on the A and lowest on the D plots.

Tiller population, leaf area index and dry matter production were determined at 120, 180 and 300 DAP, respectively. Number of millable canes and cane yield were recorded at harvest. Chemical analysis of cane juice were done for percentages of pol, brix, purity, and reducing sugar. Leaf samples collected at 180 DAP were dried at 70°C and after digesting with conc. H_2SO_4 and H_2O_2 were analyzed for N, P, K, Zn and Cu.

RESULTS AND DISCUSSION

Summary of the growth, yield and quality of sugarcane as affected by phosphate application on the soils of various P levels are shown in Table 1. LAI and dry matter increased on the higher P plots compared to the low P plot. Tillers, millable cane and cane yield were significantly increased on the B, C and D plots compared to the A plots. The highest cane yield of 74 t ha^{-1} was obtained from the B plot while the lowest of 51 t ha^{-1} was from the A plot. Higher cane yield in B plot was attributed to the higher number of millable canes with higher unit cane stalk weight. The maximum sugar yield (10.2 t ha^{-1}) was obtained from the B plot while the minimum (6.9 t ha^{-1}) was from the A plot. However, sugar yield was decreased in the D plot (very high P level) compared to B and C plots. The reduction in sugar yield in the D plot was attributed to the lower cane yield and poor juice quality. Cane juice from the D plot showed lower percentages for brix, pol and purity with higher reducing sugar compared to B and C plots. Pannu *et al.* (1985) reported the adverse effect of very high soil P on juice quality and sug-ar yield. Leaf nitrogen content decreased in the D plot compared to other plots. Thus, higher P application to cane field may reduce the forage quality of leaf. Leaf P contents increased with the level of soil P. The highest leaf K2O content (1.25%) was from the B plot while the lowest (0.92%) was from the A plot. Micronutrients like Zn and Cu contents were reduced on the very high P plot (D) compared to other plots. Reduced Zn and Cu uptake of fiber flax (*Linum usitatissimum* L.) and wheat (*Triticum aestivum* L.) under very high soil P has also been reported by Burleson et al. (1961) and Javadi *et al*. (1994). Many explanations have been put forward for such phosphorus-induced Zn and Cu deficiencies in plants. These are: (i) dilution of Zn and Cu in plant tissues by promotion of plant growth by increased P levels, (ii) inhibition of Zn and Cu absorption by the cation like Ca++ added with P fertilizers, (iii) P enhancement of Zn adsorption by oxides of Fe and Al in soil and (iv) inhibition of Zn and Cu translocation from roots to the leaf due to elevated P concentration.

Thus from the results obtained, it is understood that phosphate applied to adjust the available soil P at 15 mg P_2O_5 100 g^{-1} soil gave the highest cane yield and sugar yield of good quality. Decrease of sugar yield under the lower and very high phosphate application plots suggests a potential danger of inadequate or overuse of phosphorus.

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Table 1
Yield, yield contributing characters, nutrient content in leaf and juice quality as affected by phosphate application on the soils of various P levels

Adjusted soil P levels	Tiller no. (x1000 ha^{-1})	Millable cane (x1000 ha^{-1})	Yield of cane ($t\ ha^{-1}$)	Sugar yield ($t\ ha^{-1}$)	Leaf area index	Dry matter ($g\ m^{-2}$)
A	95	80.4	51.4	6.9	2.8	2276
B	111	92.4	74.1	10.2	3.5	2441
C	109	87.2	73.4	9.9	3.6	2492
D	105	85.3	70.7	9.4	4.2	2568
SE (±)	4.5	2.2	2.1	0.49	-	-

Continued Table 1

Adjusted soil	Nutrient contents in cane leaf					Cane juice quality			
P levels	N	P_2O_5	K_2O	Zn	Cu	Brix	Pol	Purity	Red. sugar
	%	%	%	ppm	ppm	%	%	%	%
A	1.32	0.42	0.92	14.8	4.8	20.5	18.9	92.2	0.11
B	1.39	0.47	1.25	12.6	4.9	20.8	19.5	93.6	0.08
C	1.43	0.49	1.16	12.4	4.6	20.5	19.0	92.7	0.12
D	1.36	0.51	0.97	12.0	4.1	20.5	18.8	91.9	0.12