Solid and Fluid Sugarcane Fertilization in Brazil[1]

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ABSTRACT

Sugarcane growers in Brazil have shown great interest in using fluid fertilization to reduce production costs. Normally aquammonia, powdered KCl, rock phosphate, sulfuric and phosphoric acid are used as raw materials for preparing the fertilizer suspension. The purpose of this study was to compare the behavior of solid as compared to fluid fertilizer on sugarcane in Brazil. For this, three trials in ratoon cane (where the aquammonia and urea sources were compared) and two trials in plant-cane (where the behavior of different sources of NPK were observed) were carried out. From the results obtained, it was possible to conclude that the two nitrogen sources (aquammonia and urea) showed similar effects on sugarcane yield increase. Specifically for plant-cane, the different phosphorus sources in NPK formulations showed that the effectiveness of phosphorus response is a function of the level of phosphorus solubility, regardless of fertilizer form (solid or fluid).

COMPENDIO

Los productores de caña de azúcar de Brasil tienen interés por la utilización de fertilización fluida, con el fin de reducir los costos de producción. Normalmente se usa aquamonia, KCl, rocas fosfatadas y ácidos sulfúrico y fósforo como fuentes de materiales para preparar la suspensión de fertilizantes. Este estudio compara el desempeño de fertilizante sólido en relación con el fluido en caña de azúcar en Brasil. Se instalaron tres ensayos en retoño de caña, para comparar las fuentes aquamonia y urea, y dos de planta de caña, para observar el comportamiento de diferentes fuentes de NPK. Los resultados de las dos fuentes nitrogenadas mostraron efectos semejantes en la productividad de caña de azúcar. Específicamente para caña en planta, las diferentes fuentes fosfatadas de formulación N-P-K mostraron que la respuesta al fósforo es función de la cantidad de fósforo soluble, independiente de la forma de fertilizante (sólido o fluido).

INTRODUCTION

The State of São Paulo is the most important sugarcane region of Brazil, with a cultivated area of some 2 000 000 ha.

Sugarcane growers in Brazil have recently shown interest in using fluid fertilization to reduce production costs (2).

Although fluid fertilizers have been used in Europe and the USA for many years (4, 5), in Brazil this form of fertilization has only recently been employed, especially in sugarcane.

In general, the fluid fertilizers are prepared at the sugar mill and alcohol distilleries using aquammonia, rock phosphate, phosphoric acid, sulfuric acid and powdered KCl as raw materials. In this way, rock phosphate reacting with phosphoric and/or sulfuric acid tends to decrease the cost of the fluid fertilizer; in addition, the cost of nitrogen from aquammonia is lower than that of solid forms.

Under Brazilian conditions, the efficiency of fluid fertilizer in sugarcane has not been studied in depth and there are few data available in the literature; therefore, studies comparing solid and fluid fertilizer in sugarcane are required.

According to Wang and Li (6) and Davidson (3), the different nitrogen sources (solid, liquid and gaseous) have shown the same effect in raising cane yield, provided the application is made with due care to avoid N losses by volatilization. Thus, all fertilizers were covered with a soil layer as soon as they were applied.

According to Bittencourt (1), it is possible to decrease phosphorus fertilizer cost in sugarcane by using

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mixture of phosphoric and sulfuric acids and rock phosphate.

The objective of this research was to study different levels of fluid fertilizer on cane and sugar yields as compared with the traditional solid sources, by means of field trials in plant-cane and ratoon.

MATERIAL AND METHODS

Five trials were carried out to compare sugarcane solid and fluid fertilization.

Two trials in a Haplustox soils and one trial in a Tropudalf soil were set up at Santa Adelaide sugar mill - SP to study aquammonia and urea on ratoon crops.

In Haplustox soils, two trials were carried out. One received 100 m^3 vinasse/ha as the potassium source and in the other, 130 kg K_2O/ha as KCl were used. Vinasse is a liquid waste material obtained from the alcohol distillation process. One m^3 of vinasse is equivalent to 2 kg K_2O. The variety cultivated was SP70-1143 first ratoon, and the trials were set up in August 1984 and harvested in September 1985.

In Tropudalf soils, urea and aquammonia were studied, using 100 m^3 vinasse/ha as potassium source. Variety NA56-79, first ratoon, was used. The trial was set up in August 1983 and harvested in July 1984.

Table 1. Chemical soil analyses of trials at Costa Pinto, Modelo and Santa Adelaide sugar mills.

Sugar mill	pH (H_2O)	P	K	Ca	Mg	Al	C (%)
		ppm		eq mg /100 ml			
Modelo (Haplustult soil)	4.00	30	92	0.50	0.32	1.33	0.55
Costa Pinto (Quartzpsament soil)	5.20	11	26	0.55	0.52	0.22	0.52
Sta Adelaide (Haplustox soil)	4.40	9	23	0.16	0.05	1.34	0.45
Sta Adelaide (Tropudalf soil)	5.40	12	26	2.50	1.20	0.11	1.44

The split plot design was used for the three ratoon trials using four replications (blocks). The nitrogen sources (urea and aquammonia) were considered as primary treatments (plots), while nitrogen levels were studied as secondary treatments (subplots). Each subplot consisted of seven 10 m rows. The three central rows were harvested for cane yield determination.

Tables 2 and 3 show the different treatments. Only the treatments with aquammonia were liquids.

Table 2. Treatments and average yield results, Test F of the two trials set up at Santa Adelaide sugar mill, ratoon cane, in Haplustox soil.

Sources of nitrogen	N (kg/ha)	Sources of potassium - vinasse: t cane/ha	vinasse: t pol/ha	HCl: t cane/ha	HCl: t pol/ha
	0	83	14.6	69	11.8
Urea	50	86	14.8	79	13.5
	100	87	15.0	82	14.1
	150	94	16.1	78	13.1
	0	79	13.9	69	11.7
Aquammonia	50	86	15.2	75	12.7
	100	84	14.4	76	12.8
	150	87	14.9	74	12.4
Effects		F values			
Sources of N		2.39	1.37	28.89	44.9**
N' (linear)		10.13**	3.97 +	7.44*	4.64*
N'' (quadratic)		0.01	0.01	7.37	5.97*
Sources x N'		0.52	0.56	0.71	0.83

+ = significant at the 10% level
* = significant at the 5% level
** = significant at the 1% level

Table 3. Treatments and average yield results, F-test of trial set up at Santa Adelaide sugar mill, ratoon cane, Tropudalf soil.

Sources of nitrogen	N (kg/ha)	t cane/ha	t pol/ha
	0	93	13.4
Urea	50	92	13.2
	100	96	13.7
	150	97	14.0
	0	90	12.7
Aquamonia	50	90	13.0
	100	93	13.4
	150	100	14.4
Effects		F values	
Sources of N		0.45	0.86
N' (linear)		3.90+	6.14*
N'' (quadratic)		0.60	0.70
Sources x N'		0.48	0.94

+ = significant at the 10% level
* = significant at the 5% level

Two trials were set up (in Happlustult soil at Modelo sugar mill and in Quartzpsament soil at Costa

Pinto sugar mill) to study NPK fluid as compared to solid fertilization of sugarcane (plant-cane).

Variety NA56-79 was used at Modelo sugar mill (planting in April 1984 and harvest in June 1985) and SP70-1143 at Costa Pinto sugar mill (planting in March 1984 and harvest in June 1985).

A randomized block design with four replications was used for plant-cane. Each plot consisted of seven 15 m rows. The three central rows (10 m) were considered for cane yield determination. The treatments for plant-cane are presented in Table 4.

Table 4. Treatments, average yield results, and statistical analyses of plant cane of trials set up at Modelo sugar mill, (Haplustult soil) and Costa Rica sugar mill (Quartzpsament soil).

Treatment	N	P_2O_5	K_2O	Form
	(kg/ha)			
A.Control	0	0	0	-
B.Urea + KCl	60	0	120	solid
C.Urea + single superphosphate + KCl	60	150	120	solid
D.Aquammonia + KCl	60	0	120	fluid
E.5 - 15 - 15	60	150	150	fluid
F.Urea + FAPS(1) + KCl	60	150	120	solid
G.Urea + Rock phosphate (2) + KCl	60	150	120	solid

Treatment	Modelo Sugar Mill		Costa Pinto Sugar Mill	
	t cane/ha	t pol/ha	t cane/ha	t pol/ha
A. Control	150	19.7	62	10.6
B. Urea + KCl	158	20.0	73	12.5
C. Urea + single superphosphate + KCl	179	23.5	104	17.4
D. Aquemmonia + KCl	161	21.3	64	11.0
E. 5 - 15 - 15	177	23.5	102	17.7
F. Urea + FAPS + KCL.	168	22.2	81	14.1
g. Urea - Rock phosphate (2) + KCl	161	21.5	73	13.1
Test F	18.26**	7.29*	32.12**	25.55**
M.S.D. (5%)	11	2.40	26	4.89
M.S.D. (1%)	13	2.90	32	5.89
C.V. (%)	3	5	13	14

(1) 20% P_2O_5 total, 5% P_2O_5 soluble in water
(2) 40% P_2O_5 total, 1% P_2O_5 soluble in water
** significant at the 1% level.

A double-row furrower was used for applying fluid fertilizer in plant-cane through a peristaltic pump driven by the tractor's wheels. To minimize nitrogen losses by volatilization, the fluid fertilizar was slightly buried in the botton of the furrow.

For ratoons, fluid fertilizer was applied subsurface (20 cm) using a shank in both sides of the row, by means of equipment which performed fertilizer application, subsoiling and harrowing simultaneously. A centrifuge pump was used for applying the fertilizer.

Solid fertilizers were applied manually in all trials, banded on the row and covered with soil to avoid losses of N by volatilization.

Climatic conditions may be considered normal for all trials, considering the average of rainfall, solar radiation and maximum and minimum temperatures of the last 10 years.

Table 1 shows the chemical soil analyses of trials at Costa Pinto, Modelo and Santa Adelaide sugar mills. Determination of pH was effected using a soil- water ratio of 1:2.5. Phosphorus and potassium were extracted with 0.5 N H_2SO_4. Calcium, magnesium aluminum were extracted with 1.0 N KCl.

RESULTS AND DISCUSSION

Results in terms of cane and sugar yield are shown in Tables 2, 3, 4 and 5. Table 2 shows that, in the Haplustox soil with vinasse, there was a linear cane yield increase with nitrogen fertilization. Both nitrogen sources (aquammonia and urea) showed the same behavior in sugarcane nutrition. Similar effects were observed in terms of tons of pol/ha.

In the same soil, but using KCl as the source of potassium (Table 2), a quadratic effect of nitrogen on cane yield was observed, the urea showing better results than aquammonia. However, the comparative magnitude of the responses between the different nitrogen sources was very low. These tendencies were also found for t pol/ha.

In Tropudalf soils (Table 3), the sugarcane ratoon showed a linear response to nitrogen fertilization in terms of cane and sugar yields. The trial comparative did not reveal any difference between the two sources.

The three ratoon trials did not reveal any significant interactions between nitrogen sources (solid urea x aquammonia) and dosages.

Although the nitrogen sources showed differences in their physical and chemical properties, the effects on cane and sugar yields in the three ratoon trials were similar. This is in agreement with Wang and Li (6) and Davidson (3). Considering that the price of nitrogen in aquammonia is lower than in urea, the feasibility of aquammonia utilization in sugar cane fields becomes more evident. Presently in Brazil, aquammonia costs are 15% lower than urea.

Plant-cane results (Table 4) showed the same results in terms of nitrogen. Table 4 also show that the highest yields were obtained when the NPK solid formulation (urea, single superphosphate and KCC) and the fluid formulation, (5-15-15) completely soluble, were used.

The yields obtained when partially soluble phosphorus (treatment F) and rock phosphote (treatment G) were used in the furrow were lower than those of soluble forms in both trials. These observations are not in agreement with those obtained by Bittencourt (1), which showed economic advantages of the mixture of rock phosphate and H_3PO_4 in fertilizing plant-cane.

CONCLUSIONS

1. Urea and aquammonia showed similar increases in cane and sugar yields.
2. The different phosphorus sources used for NPK fertilization of plant-cane showed that the efficiency of phosphorus is only related to the amount of soluble phosphorus, regardless of form, fluid or solid.

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