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Effect of Rate and Time of Sulphur Application on Sugarcane

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ABSTRACT

Field experiments were conducted on Old Himalayan Piedmont Plain sandy loam soil (Haplaquept) at the farm of North Regional Station (NRS), Thakurgaon to find out the effect of rate, and time of sulphur application on growth, yield and sucrose content of sugarcane. Sugarcane tillering progressively increased with time at different sulphur levels, and attained the highest in May, thereafter gradual reduction occurrred due to tiller mortality. The crop responded significantly to sulphur application, and percentage increase in cane yield in sulphur treated plots over control ranged from 7.9 to 12.5, which was more appreciable up to 40 kg S ha^{-1}. Different time of sulphur application also significantly increased cane yield. Three splits application of 40 kg S ha^{-1} recorded maximum yield, and produced 3.0 and 6.0% yield increase over two splits, and single application of 40 kg S ha^{-1} respectively. The economic dose calculated from quadratic equation was 25.0 kg S ha^{-1}, and it recorded a net return of Tk 17.40 per taka investment on sulphur.

INTRODUCTION

Sulphur is now recognised as the fourth major nutrient limiting sugarcane yield after nitrogen, phosphorus, and potassium. Sulphur deficiencies are occurring with greater frequency, and in more locations throughout the world. In Bangladesh, upto 80% of agricultural lands are deficient in sulphur (Portch and Islam, 1986). The deficiency of sulphur is observed in sugarcane, and soils of Old Himalayan Piedmont Plain which are low in organic matter and pH, and coarse in texture. Besides, adoption of high yielding and fertilizer responsive crop varieties, intensive cropping, and use of sulphur-free fertilizer also added to the intensity of the problem. There are evidences of sugarcane responding to sulphur application in Bangladesh (Rahman *et al.* 1988), India (Ghosh *et al.* 1989), Nigeria (Afolabi, 1988), Sudan (Hanssan, 1976), and USA (Yonemitsu, 1968).

Because of anionic nature, and high solubility of most common salts of sulphate, the leaching losses of sulphate-sulphur are large (Cheema and Arora , 1984) especially in coarse textured soils. Under such condition fertilizer containing sulphate-sulphur may have to be applied more frequently than on fine textured soils.

But information on frequency/time of sulphur application on Old Himalayan Piedmont Plain soils of Bangladesh is quite limited. The present investigation was, therefore, initiated to find out the effect of rate, and time of sulphur application on growth, yield, and sucrose content of sugarcane on coarse textured soils of Old Himalayan Piedmont Plain.

MATERIALS AND METHODS

Field experiments were conducted on Old Himalayan Piedmont Plain soil (Haplaquept) during three cropping seasons 1989–90, 1990–91, and 1991-92 at the farm of North Regional Station (NRS), Thakurgaon of Sugarcane Research & Training Institute. The experiments were laid out in split-plot design of plot size $54m^2$ with four replications. Four levels of sulphur, such as 0,20,40, and 60 kg ha^{-1} applied through gypsum were used as treatments in the main plots. Each main plot was divided into three sub-plots in which sub-treatments, like entire dose of sulphur at time of transplanting (T_1), half of sulphur at time of transplanting + half of sulphur 150 d after transplanting (T_2), and one-third of sulphur at time of transplanting + one-third of sulphur 90 d after transplanting + one-third of sulphur 150 d after transplanting (T_3) were superimposed over sulphur levels. A uniform dose of 170 kg N ha^{-1} as urea, 125 kg P_2O_5 ha^{-1} as triple super phosphate, and 222 kg K_2O ha^{-1} as muriate of potash was applied in all treatments. Whole amount of phosphorus, one-third each of nitrogen and potassium was applied at time of transplanting, one-third each of nitrogen and potassium was applied 90 d after transplanting, and remaining one-third each of nitrogen and potassium was applied 150 d after transplanting.

Forty five days old polybag settlings of sugarcane (*Saccharum* sp. hybrids) cultivar Isd 16 were transplanted in middle of November during all three cropping seasons. All intercultural practices were performed as and when necessary. Tillers were recorded for each treatment from April to August of every cropping season. The crop was harvested in middle of January in each cropping season. Millable cane, recoverable sucrose percentage, and yield of sugarcane were recorded at time of harvest. Recoverable sucrose percentage was determined according to Hornes Dry Lead Method (Meade and Chen, 1977).

Soil samples (0-20cm) were collected before start of experiment in every cropping season. The samples were air-dried, ground with a wooden pestle and mortar, and passed through 2 mm sieve. Soil pH was determined in 1: 2.5 (soil : distilled water) suspension by pH meter (Jackson, 1973); organic carbon by chromic acid wet oxidation method of Walkley and Black (Jackson, 1973); mechanical analysis by the International Pipette Method (Piper, 1966); total nitrogen by modified Kjeldahl method (Jackson, 1973); available phosphorus was determined after extraction with 0.5M $NaHCO_3$ at pH 8.5 following chlorostannous reduced molybdophosphoric blue colour method (Jackson, 1973); exchangeable potassium was estimated flame photometrically in NH_4OAc extract (Jackson, 1973) and available sulphur was determined after extraction with NaOAc by developing turbidity using $BaCl_2$ and gum acacia (Chesnin and Yien,1950). Characteristics of the initial soils are given in the Table 1.

Data on tillering, and yield parameters of sugarcane from experiments in each cropping season were subjected to pooled analysis, and the significance of mean difference was adjusted as per CD (Gomez and Gomez, 1984). Quadratic yield response equation indicating cane yield as a function of applied sulphur was computed, and the response function was compared for efficiency by estimating the coefficient of determination as :R^2=sum of squares due to regression/treatment sum of squares. From the quadratic relationship, maximized response dose and economic response dose was worked out as follows:

Maximized response dose (kg S ha^{-1}) =-b/2c, and economic response dose (kg S ha^{-1})= (b-R)/-2c, where b and c are the estimates of the regression coefficients, and R denotes the ratio of cost per unit nutrient to price per unit of produce, i.e. ratio of cost per kg S to price per quintal of sugarcane.

RESULTS AND DISCUSSION

Sulphur, time and interaction of sulphur -time had significant effect on tillering of sugarcane during all the months (Table 2). Tillering progressively increased under different sulphur levels and time, and attained the highest in May, thereafter gradual reduction occurred due to tiller mortality.

Table 1. Characteristics of soils of experimental fields.

Character	1989-90	1990-91	1991-92
pH	5.20	5.30	5.20
Sand (%)	65.00	66.00	65.00
Silt (%)	20.00	20.00	22.00
Clay (%)	15.00	14.00	13.00
Texture	Sandy loam	Sandy loam	Sandy loam
Organic C (%)	1.22	1.26	1.23
Total N (%)	0.07	0.08	0.07
Avail. P (ppm)	13.00	14.00	13.00
Exch. K (meq%)	0.07	0.06	0.07
Avail. S (ppm)	11.00	12.00	12.00

Yield of sugarcane presented in the Table 3 clearly indicates significant response to sulphur application in soil upto 40 kg ha^{-1}.There was no significant increase in sugarcane yield due to application of sulphur at 60 kg level. Percentage increase in cane yield in sulphur treated plots over control ranged from 7.9 to 12.5, which was more appreciable up to 40 kg S ha^{-1}. The yield response was maximum at 20 kg sulphur level (2.42 q ha^{-1}), and then decreased with increasing level of sulphur upto 60 kg (0.88 q ha^{-1}). Several workers (Dutt, 1962; Ghosh *et al.* 1990; Gravois and Golden, 1984; Saha *et al.* 1984) recorded significant increase in cane yield with increasing levels of sulphur in sugarcane. Higher yield was obtained with application of 40 kg S ha^{-1}, and limited response was observed without sulphur application. This may be due to deficient levels of sulphur in soil supporting growth. These findings conform to observation of Nagarasan and Sundararaj (1964) that in sulphur deficient soils application of sulphur may increase cane yield.

Table 2. Effect of rate and time of sulphur application on tillering of sugarcane ($X10^3$ ha^{-1}) on Old Himalayan Piedmont Plain soils.

Sulphur (kg ha^{-1})	Time of sulphur application							
	T_1	T_2	T_3	Mean	T_1	T_2	T_3	Mean
	*April				May			
0	59.3	60.9	64.6	61.6	129.4	137.4	144.6	137.1
20	65.1	65.5	66.8	65.8	167.4	171.4	173.9	170.9
40	76.3	75.7	77.9	76.6	173.1	176.2	180.5	176.6
60	69.6	66.5	78.5	71.5	151.6	167.5	158.3	159.1
Mean	67.6	67.2	72.0		155.4	163.1	164.3	
	June				July			
0	113.0	119.2	121.8	118.0	80.6	82.2	83.6	82.1
20	118.9	122.2	124.7	121.9	82.5	83.0	84.3	83.3
40	124.6	129.5	132.3	128.8	83.8	85.2	86.4	85.1
60	123.0	126.1	127.4	125.5	82.5	83.7	84.5	83.6
Mean	119.9	124.3	126.6		82.4	83.5	84.7	
	August							
0	72.0	72.9	73.9	72.9				
20	74.3	74.9	76.7	75.3				
40	75.0	76.3	77.6	76.3				
60	73.3	75.1	75.6	74.7				
Mean	73.7	74.8	76.0					

CD (P=0.01)	April	May	June	July	August
Sulphur (S)	0.44	0.35	0..27	0.41	0.29
Time (T)	0.18	0.19	0.23	0.27	0.15
SXT	0.50	0.41	0.58	0.53	0.37

* Pooled data of three years.

Different time of sulphur application also significantly increased yield of sugarcane. Three splits application (T_2) of 40 kg S ha^{-1} recorded maximum yield but single (T_1) or two splits (T_2) application of 60 kg S ha^{-1} did not prove effective over 40 kg S level. An increase in dose of sulphur to 60 kg ha^{-1} did not have further effect on cane yield which may be ascribed to nutrient imbalance, and metabolic disturbances in plants. Response per kg sulphur decreased with increasing doses of sulphur, which might be due to less increase in yield as compared to amount of sulphur applied whereby following law of diminishing return.

Table 3. Effect of rate and time of sulphur application on yield parameters of sugarcane on Old Himalayan Piedmont Plain soils.

Time of S application	Sulphhur levels (kg/ha)				
	0	20	40	60	Mean
			*Millable cane ($X10^3$ ha^{-1})		
T_1	67.4	70.7	72.5	71.1	70.4
T_2	68.6	71.3	73.3	72.1	71.3
T_3	69.7	71.7	74.2	72.7	72.1
Mean	68.6	71.2	73.3	72.0	
			Yield of cane (TCH)		
T_1	60.3	64.5 (2.10)**	66.2 (1.48)	64.8 (0.75)	63.9 (1.44)
T_2	60.5	65.4 (2.45)	68. 1(1.90)	66.0 (0.92)	65.0 (1.76)
T_3	61.0	66.4 (2.70)	70.2 (2.30)	66.8 (0.97)	66. 1(1.99)
Mean	60.6	65.4 (2.42)	68.2 (1.89)	65.9 (0.88)	
			Recoverable sucrose (%)		
T_1	9.62	9.95	10.20	10.09	9.97
T_2	10.25	10.29	10.46	10.32	10.33
T_3	10.42	10.50	10.74	10.57	10.56
Mean	10.10	10.25	10.47	10.33	
			TSH		
T_1	5.8	6.4	6.8	6.5	6.38
T_2	6.2	6.7	7.1	6.8	6.70
T_3	6.4	7.0	7.5	7.1	7.00
Mean	6.13	6.70	7.13	6.80	

CD (P=0.01)	Millable cane	TCH	Sucrose	TSH
Sulphur (S)	0.28	0.15	0.04	0.03
Time (T)	0.17	0.11	0.03	0.02
S X T	0.37	0.22	0.09	0.07

*Pooled data of three years.

** Figures in parentheses are response per kg S (q ha^{-1}).

Three splits application of 40 kg S ha^{-1} produced 3.0 and 6.0 % yield increase over two splits and single application of 40 kg S ha^{-1} respectively. Three splits application of 40 kg S ha^{-1} proved better than two splits (T_2) or single (T_1) application of 40 kg S ha^{-1} because in coarse textured soils the leaching losses of sulphate sulphur are large. This is in agreement with findings of Cheema and Arora (1984) that because of anionic nature, and high solubility of the most common salts of sulphate, leaching losses of sulphate sulphur are large especially in coarse textured soils.

The economic analysis on yield of sugarcane was done, and is shown in the Table 4. The highest net benefit was obtained with 40 kg S ha^{-1}

Table 4. Economics of sulphur fertilization on sugarcane production.

Sulphur (kg ha^{-1})	Cost of sulphur fertilizer (Tk/ha)	*Yield of cane (TCH)	Increased cane yield over control (Ton)	Net income (Tk)	Net benefit (Tk/ha)
0	-	60.6	-	-	-
20	280	65.4	4.8	4800	4520
40	560	68.2	7.6	7600	7040
60	840	65.9	5.3	5300	4460

*Average of three years (cane price Tk 1000.00 t^{-1} and sulphur Tk 14.00 kg^{-1}).

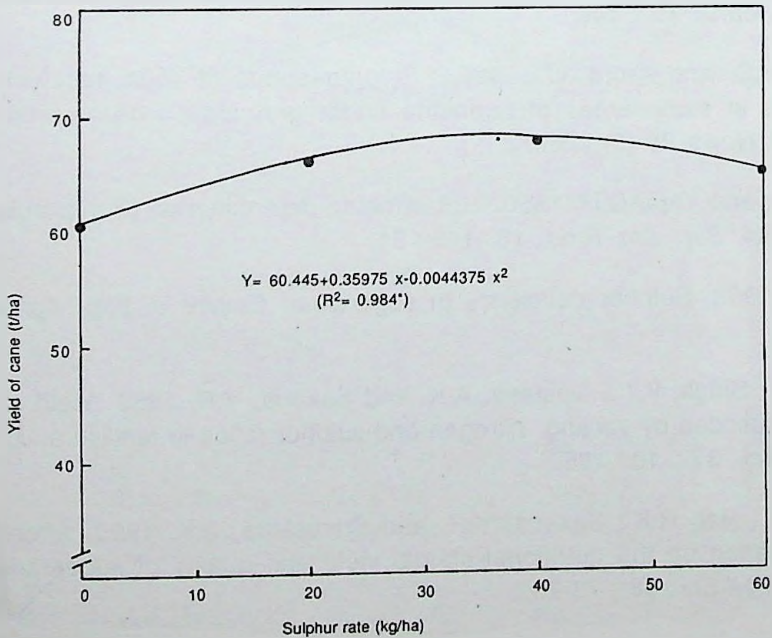

Figure 1. Quadratic sulphur response curve estimated from sugarcane yield.

The yield data were also fitted to quadratic response curve (Figure 1), of which coefficient of determination (R^2) was found to be significant. Y= 60. 445 +0.35975 X -0.0044375 X^2 for 0 $\leq X \leq$ 60 (R^2=0.984*), where, 'Y' is the expected yield (t ha^{-1}) and 'X' is the level of sulphur (kg ha^{-1}). Results indicate that the yield response of sugarcane to sulphur fertilization can-be adequately described by the equation. The computed R^2 value of 0.984 indicates that 98.4% of total variation in mean yields was explained by quadratic regression equation estimated. Sugarcane responded significantly up to 60 kg S ha^{-1} but the sulphur dose that maximizes yield calculated from quadratic equation was 41.0 kg S ha^{-1} with a cane yield of 67.7 t ha^{-1}. On the other hand economic dose calculated from quadratic equation was 25.0 kg S ha^{-1} with a cane yield of 66.7 t ha^{-1}. The increase in cane yield at economic dose was 6 t ha^{-1} which fetched a net return of Tk 6,100.00 ha^{-1} over no sulphur (cane price Tk 1000.00 t^{-1}, and sulphur Tk 14.00 kg^{-1}). It recorded a net return of Tk 17.40 per taka investment on sulphur.

Thus, it could be concluded that sugarcane grown on coarse textured Old Himalayan Piedmont Plain soils low in sulphur availability required to be fertilized with three splits application (one-third at transplanting, one-third 90 d after planting, and the remaining one-third 150 d after planting) of 25 kg S ha^{-1} along with recommended doses of N,P, and K for these soils.

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