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Effects of Magnesium on Sugarcane in Piedmont Plain Soils of Bangladesh

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ABSTRACT

Field experiments were conducted on the old Himalayan piedmont plain region of non-calcareous flood plain soils (Typic Haplaquept) at two sites, such as Kanta farm of Shetabgong Sugar Mills, Dinajpur, and North Regional Station farm of Bangladesh Sugarcane Research Institute, Thakurgaon, Bangladesh during two cropping seasons 1991-92 and 1992-93 to study the effects of magnesium on sugarcane. Sugarcane tillering progressively increased under different magnesium levels and attained the highest in May, thereafter gradual reduction occurred due to tiller mortality. The crop responded significantly to magnesium application at both the sites. Percentage increase in cane yield in magnesium treated plots over control ranged from 3.7 to 10.9 at Kanta, and 4.4 to 11.7 at NRS, which was more appreciable at 10 kg Mg ha^{-1}. The maximum response dose calculated from cubic equation was 9.5 kg Mg ha^{-1} for both the sites.

INTRODUCTION

Until recently, the importance of secondary nutrient elements in general, and magnesium in particular in Bangladesh agriculture had received little research effort. With the introduction of high-yielding varieties, use of high analysis fertilizers, and adoption of multiple cropping practice in potentially developed areas, deficiency of this nutrient has been increasingly reported. Magnesium deficiency is actually more widespread than it is realized. It is because of the fact that there is very inadequate scientific data about the effects of magnesium fertilizers on crops. Magnesium is a constituent of chlorophyll molecule that is essential for photosynthesis and its application causes good growth of plants especially of foliage (Singh *et al.*, 1981).

Magnesium is of considerable significance in acid soils. Magnesium content in acid soils of Bangladesh is low (Anon., 1989). Crop responses to applied magnesium have been reported either on acid soils (Tajuddin, 1991) or on sandy soils (Aulakh and Pasricha, 1977; Kumar *et al.*, 1981; Singh and Singh, 1990), which have low amount of exchangeable magnesium. Increase in sugarcane yield due to applied magnesium has been reported in Queensland, Australia (Shahjahan, 1980), British Guiana (Evans, 1979), Puerto Rico (Landrau and Samuels, 1986; Bonnet, 1985), and Taiwan (Chao and Li, 1989). There is paucity of information on the effects of magnesium on the yield of sugarcane in Bangladesh. In view of this, the present investigation was conducted to study the effects of magnesium on sugarcane in the old Himalayan piedmont plain soils of Bangladesh.

MATERIALS AND METHODS

Field experiments were conducted on the old Himalayan piedmont plain region of non-calcareous brown flood plain soils (Typic Haplaquept) at two sites, such as Kanta farm of Shetabgonj Sugar Mills (Kanta), Dinajpur, and North Regional Station (NRS) farm of Bangladesh Sugarcane Research Institute, Thakurgaon, Bangladesh during two successive cropping seasons 1991-92 and 1992-93. The experiments were set up in randomized complete block design with four replications. The treatment consisted of four levels of magnesium (0, 10, 20, and 30 kg ha^{-1}) as commercial grade magnesium oxide (45%). Location specific recommended doses of N, P, K, and S were applied equally to all the treatments. The doses for both Kanta and NRS in kg ha^{-1} were: 160 N, 120 P_2O_5, 150 K_2O and 40 S. Whole amount of phosphorus, sulphur, and magnesium, and one third each of nitrogen and potassium was applied at the time of transplanting, the rest two thirds of nitrogen and potassium was applied at two equal splits at 90 d and 150 d after transplanting.

Forty-five days old settlings of sugarcane variety Isd-16 grown in polybags were transplanted in middle of November at both the sties during both the cropping seasons. All intercultural practices were performed as and when necessary. Tillers were recorded in all the treatments in March, May, and July at an inteval of 60 d, and the crop was harvested in middle of January at both the sites. Number of millable cane, percentage recoverable sucrose, and yields of cane were recorded at harvest. Recoverable sucrose percentage was determined according to Home's dry lead method (Meade and Chen, 1977).

Soil samples (0-25 cm) were collected before start of the experiment at both the locations in both the cropping seasons. The samples were air-dried, ground with a wooden pestle and mortar, and passed through a 2 mm sieve. Soil pH was determined in 1: 2.5 Soil: distilled water suspension by pH meter, organic carbon by chromic acid wet oxidation method of Walkley and Black; texture by hydrometer method; total nitrogen by modified Kjeldahl method; available phosphorus was determined after extraction with 0.5M $NaHCO_3$ at pH 8.5 following Chlorostannous reduced molybdophosphoric blue colour method; exchangeable potassium was estimated flame photometrically in NH_4OAc extract, and exchangeable magnesium in NaOAc extract was estimated by titrating with EDTA solution (Jackson, 1973). 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.

Table 1. Characteristics of soils of experimental fields

Character	Kanta*	NRS*
pH	5.40	5.20
Sand (%)	71.00	67.00
Silt (%)	18.00	20.00
Clay (%)	11.00	13.00
Soil texture	Sandy loam	Sandy loam
Organic carbon (%)	0.65	1.15
Total N(%)	0.06	0.08
Available P (ppm)	13.00	12.00
Exchangeable K (me/100g)	0.11	0.08
Available S (ppm)	10.00	11.50
Exchangeable Mg (me/100g)	0.60	0.50

* Average of two years.

Data on tillering, and yield parameters of sugarcane, from experiments in each cropping season, and location, were subjected to statistical analysis, and the significance of mean difference was carried out as per LSD (Gomez and Gomez, 1984). The treatment sums of squares were partitioned into linear, quadratic, and cubic response equation (with pooled yield of Kanta, and NRS). Cubic ($Y = a + bx + cx^2 + dx^3$) yield response equation indicating cane yield as a function of applied magnesium was computed, and the response function was computed for efficiency by estimating the coefficient of determination as: R^2 = sum of squares due to regression / treatment sum of squares. From the cubic relationship, maximum response dose was worked out as follows:

Maximum response dose (kg Mg ha^{-1}) = $1/3d \{-c \pm (c^2-3bd)\}$,

where b, c, and d are the estimates of the regression coefficients.

RESULTS AND DISCUSSION

Magnesium application had significant effects on tillering of sugarcane during all the recorded months both at Kanta, and NRS. Monthly count of tillers starting from 120 d after transplanting revealed peak tiller population in May that declined as tiller mortality set in thereafter (Table 2). Application of magnesium produced more tillers over control with maximum at 10 kg ha^{-1} at both the sites.

Table 2. Effects of magnesium on yield parameters of sugarcane on the Old Himalayan Piedmont plain soils (average of 2 years).

Location	Treatme -nts (kg Mg ha^{-1})	Tiller population ($x10^3 ha^{-1}$)			Millable cane ($x10^3 ha^{-1}$)	Yield of cane (t ha^{-1})	Respon se/kg Mg (t ha^{-1})	Recover able sucrose (%)	Yield of sugar (t ha^{-1})
		March	May	July					
	0	60.1	140.4	83.1	71.1	65.0	-	9.2	6.0
KANTA	10	67.8	172.8	89.6	76.8	72.1	7.1	9.8	7.1
	20	64.7	169.8	87.2	73.5	68.4	1.7	9.5	6.5
	30	64.0	147.8	84.6	72.6	67.4	0.8	9.4	6.3
CD(P=0.01)		7.6	7.4	4.3	3.4	2.7	-	0.2	0.2
	0	65.1	143.7	86.1	74.0	67.6	-	9.4	6.4
	10	71.3	176.0	93.1	80.0	75.5	7.9	10.0	7.6
	20	67.9	173.3	90.4	77.0	71.7	2.1	9.7	7.0
	30	66.9	150.8	87.5	76.5	70.6	1.0	9.6	6.8
CD(P=0.01)		2.4	6.2	6.1	2.4	2.5	-	0.2	0.2

Yield of sugarcane presented in the Table 2 clearly indicates significant response to magnesium application in soil at 10 kg ha^{-1} at both the sites. There was a decreasing trend in sugarcane yield due to magnesium application at 20 and 30 kg level compared to 10 kg level. Percentage increase in cane yield in magnesium treated plots over control ranged from 3.7 to 10.9 at Kanta, and 4.4 to 11.7 at NRS, which was more appreciable at 10 kg Mg ha^{-1}. The economic yield response was maximum at 10 kg magnesium level both at Kanta (7.1 q ha^{-1}), and NRS (7.9 q ha^{-1}), and then decrease with a increased level of magnesium at 30 kg (0.8 q ha^{-1} at Kanta, and 1.0 q ha^{-1} at NRS). Similar beneficial results with applied magnesium in sugarcane in acid soil were reported by Rahman *et al.* (1986) in Bangladesh and Landrau and Samuels (1986) in Puerto Rico. Chao and Li (1989) reported that application of magnesium increased yields of sugarcane by 10 to 15% in Taiwan. The highest yield of cane and sugar was obtained with application of 10 kg Mg ha^{-1} at both the sites. This may be due to deficient levels of magnesium in soil needed to support for the growth of sugarcane. This is in conformity with the findings of Evans (1979) and Bonnet (1985) that application of magnesium may increase cane yield in magnesium deficient soil.

The economical analysis on the yield of sugarcane was done, and is shown in the Table 3. The highest net benefit was obtained with 10 kg Mg ha^{-1} at both Kanta, and NRS. The yield data (pooled yield of Kanta and NRS) were also fitted to cubic response curve (Fig. 1), of which coefficient of determination (R^2) was found to be highly significant. The regression equation was $Y = 65.0 + 1.7x - 0.1215x^2 + 0.00225x^3$ for $0 \leq x \leq 30$ ($R^2 = 0.95^{**}$) where, Y is the expected yield (t h^{-1}) and x is the level of magnesium (kg ha^{-1}). Results indicate that yield response of sugarcane to magnesium fertilization can be adequately described by cubic equation. The computed R^2 value of 0.953 indicates that 95.3% of total variation in the mean yields was explained by cubic regression equation estimated. Sugarcane responded significantly at 10 kg Mg ha^{-1} but magnesium dose that maximises yield calculated from cubic equation was 9.5 kg ha^{-1} with a cane yield of 72.1 t ha^{-1}.

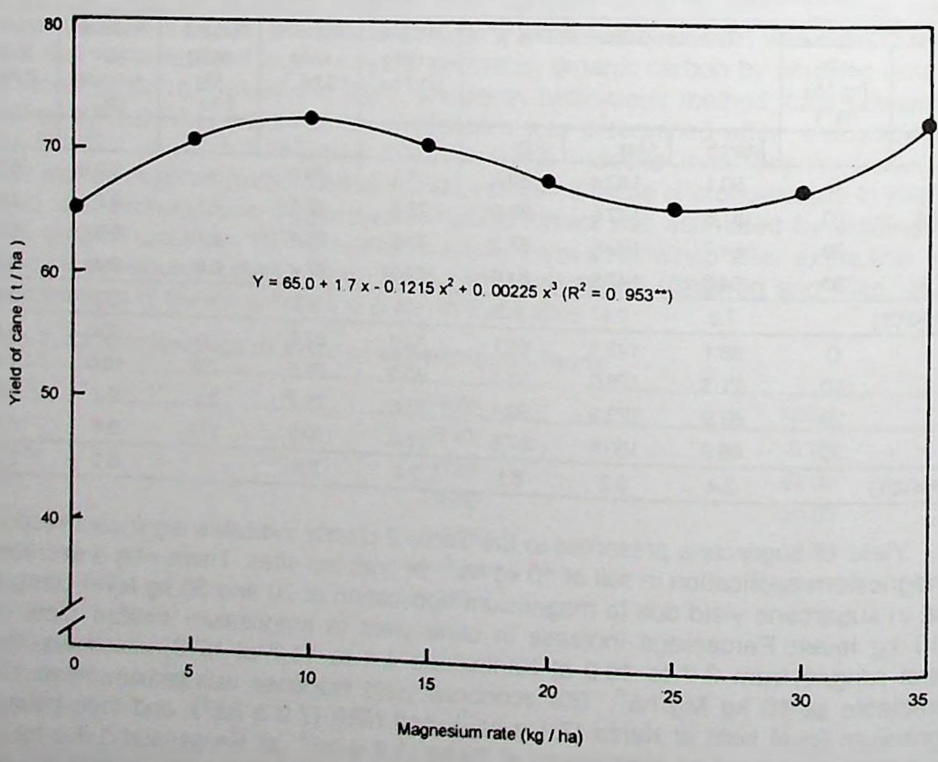

Figure 1. Cubic magnesium response curve estimated from sugarcane yield.

Table 3. Economics of magnesium fertilization on sugarcane production

Location	Mg levels (kg ha^{-1})	Cost of Mg fertilizer (Taka)*	Yield of cane (ton ha^{-1})	Increased cane yield over control (ton ha^{-1})	Net income (Tk. ha^{-1})	Net benefit (Tk. ha^{-1})
	0	-	65.0	-	-	-
	10	3000	72.1	10.9	10900	(+)7900
KANTA	20	6000	68.4	5.2	5200	(-)800
	30	9000	67.4	3.7	3700	(-)5300
	0	-	67.6	-	-	-
	10	3000	75.5	11.7	11700	(+)8700
NRS	20	6000	71.7	6.1	6100	(+)100
	30	9000	70.6	4.4	4400	(-)4600

* Local currency

(Cane price Taka 1000.0 t^{-1}, and magnesium Taka 300.0 kg^{-1})

Application of magnesium had a significant effects on percentage recoverable sucrose at both the sites. The highest percentage recoverable sucrose was produced by application of 10 kg Mg ha^{-1} followed by 20 kg Mg ha^{-1}. and 30 kg Mg ha^{-1} at both the sites.

Thus, it could be concluded that sugarcane grown on the old Himalayan piedmont plain region of non-calcareous brown flood plain soils (Typic Haplaquept) of Bangladesh, low in magnesium availability, requires to be fertilized with 9.5 kg Mg ha^{-1} along with the recommended doses of N, P, K, and S for better yield.

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