Bangladesh J. Sugarcane, 16 : 74-82 July, 1994

Response of Transplanted Sugarcane to Nitrogen under different Interplant Spacing

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Received on 13.11.93

ABSTRACT

A field experiment was carried out on Old Himalayan Piedmont Plain region of non-calcareous brown flood plain soils (Haplaquept) at two sites, such as Kanta farm of Shetabganj Sugar Mills, Dinajpur, and at the farm of North Regional Station (NRS), Thakurgaon to find out the optimum dose of nitrogen under different inter-plant spacing for transplanted sugarcane. Sugarcane tillering progressively increased under different nitrogen levels, and spacings, and attained the highest in May, thereafter gradual reduction occurred due to tiller mortality. The crop responded significantly to nitrogen application at both the locations, and percentage increase in cane yield in nitrogen treated plots over control ranged from 52.5 to 80.0 at Kanta, and 49.2 to 75.3 at NRS, which was more appreciable up to 200 kg N ha^{-1}. Different inter-plant spacing had also significant effect on the yield of sugarcane. Maximum cane yield was produced by the application of 200 kg N ha^{-1} at 45 cm spacing, and produced 3.4 and 6.9% yield increase over 60 cm, and 75 cm spacing respectively at both the locations. The economic dose calculated from the quadratic equation was 125.0 kg N ha^{-1}, and it recorded a net return of Tk 17.40 per taka investment on nitrogen.

INTRODUCTION

As to the nonbiological inputs, increased use of fertilizer nitrogen is probably the most important single factor that has enabled sugarcane production to increase significantly in recent years (Yadav, 1985). It is also predicted that increasing sugarcane production at the world level will require the use of increasing amounts of fertilizer nitrogen. However, in the developing countries like Bangladesh the availability, and high prices of fertilizer nitrogen are limiting factors for its use on large scale.

Nitrogen plays a vital role to obtain higher sugarcane yield. Sugarcane being a long duration and exhaustive crop, and like other graminaceous crops responds more to nitrogenous fertilizer (Rahman and Khalequzzaman, 1981). Nitrogen requirement of sugarcane varies from place to place according to the soil, agro-climatic condition, and other factors (Singh and Singh, 1972). Inspite of low recovery of applied nitrogen, sugarcane removes huge quantities of nitrogen from soil. A 70 ton crop of sugarcane removes 108-130 kg N ha^{-1} from soil (Yadav, 1981). Therefore, additional nitrogen is required for proper growth and development of sugarcane to supplement the losses of nitrogen from the soil through leaching, fixation, volatilization, and other unknown causes.

Transplanting of sugarcane settling is gaining popularity among the cane growers of Bangladesh for increasing sugarcane yield. Inter-plant spacing govern stalk population of sugarcane (Matherne, 1974; Miah and Rahman, 1981; Oworu, 1986). Uddin *et al.* (1989) observed significant effect of inter-plant spacing on the yield of transplanted sugarcane on the old Himalayan piedmont plain soils of Bangladesh. Although a lot of information is available on nitrogen fertilizer requirement for conventionally planted sugarcane in Bangladesh (Ali, 1974; Chowdhury *et al.* 1982; Rahman *et al.* 1989a) but information on the response of transplanted sugarcane to nitrogen under different inter-plant spacing is rather inadequate. Therefore, the present study was undertaken to find out the optimum dose of nitrogen under different inter-plant spacing for transplanted sugarcane.

MATERIALS AND METHODS

A field experiment was carried out on old Himalayan piedmont plain region of non-calcareous brown flood plain soils (Haplaquept) at two sites, such as Kanta farm of Shetabganj Sugar Mills, Dinajpur and at the farm of North Regional Station (NRS), Thakurgaon of Sugarcane Research & Training Institute during 1990-91 and 1991-92 cropping seasons. The experiment was laid in split-plot design of plot size 54 m^2 with four replications. Three different inter-plant spacings, such as 45,60 and 75 cm were used as treatments in the main plots. Each main plot was divided into six sub-plots in which sub treatments, like 0, 120, 160, 200, 240 and 280 kg N ha^{-1} applied through urea were superimposed over different spacing. Recommended doses of P, K and S were applied equally to all the treatments. The doses in kg ha^{-1} were : 125 P_2O_5 as triple super phosphate, 222 K_2O as muriate of potash, and 33 S as gypsum. Whole amount of phosphorus, and sulphur, one third each of nitrogen and potassium was applied at the time of transplanting, one third each of nitrogen and potassium was applied 90 d after transplanting, and the remaining one third each of nitrogen and potassium was applied 150 d after transplanting.

Forty five days old polybag settlings of sugarcane variety Isd 16 were transplanted in middle of November at both the sites. All intercultural practices were performed as and when necessary. Tillers were recorded for each treatment from April to August at an interval of 30 d, and twelve months old crop was harvested in middle of January at both the sites. Millable cane, recoverable sucrose percentage, and yield of sugarcane were recorded at harvest. Recoverable sucrose percentage was determined according to Horne's Dry Lead method (Meade and Chen, 1977).

Soil samples (0-20 cm) were drawn before start of the experiment at both the sites. 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 (extraction with 0.5M $NaHCO_3$ at pH 8.5) by the method of Olsen *et al.* (1954); exchangeable potassium by using neutral normal ammonium acetate (Muhr *et al.*, 1965); and available sulphur by extraction with sodium acetate by developing turbidity using $BaCl_2$, and gum acacia (Chesnin and Yien, 1950). Characteristics of initial soils are given in the Table 1.

Statistical analysis of data on tillering, and yield parameters of sugarcane from experiments of both the locations were carried out according to the procedure described by Gomez and Gomez (1984). Quadratic yield response equation (with pooled yield of Kanta, and NRS) indicating cane yield as a function of applied nitrogen 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 quadratic relationship, maximized response dose, and economic response dose was worked out as follows :

Maximized response dose (kg N ha^{-1}) = -b/2c, and economic response dose (kg N 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 N to price per quintal of sugarcane.

RESULTS AND DISCUSSION

Nitrogen and inter-plant spacing had significant effect on tillering of sugarcane during all the months both at Kanta, and NRS (Table 2). Tillering increased progressively with time at different spacings, and attained the highest in May, thereafter gradual reduction occurred due to tiller mortality.

Table 1. Some properties of the initial soils of experimental plot.

Properties	Kanta	NRS
pH	5.50	5.30
Sand (%)	69 00	65.00
Silt (%)	19.00	21.00
Clay (%)	12.00	14.00
Texture	Sandy loam	Sandy loam
Organic C (%)	0.62	1.12
Total N (%)	0.05	0.08
Avail. P (ppm)	14.00	13.00
Exch. K (me/100g)	0.10	0.07
Avail. S (ppm)	10.70	11.00

Yield of sugarcane presented in the Table 3 clearly indicates significant response to nitrogen application in soil up to 200 kg ha^{-1} at both the locations. There was no significant increase in sugarcane yield due to nitrogen application at 280 kg level. Percentage increase in cane yield in nitrogen treated plots over control ranged from 52.5 to 80.0 at Kanta, and 49.2 to 75.3 at NRS, which was more appreciable up to 200 kg N ha^{-1}. The economic yield response was maximum at 120 kg N level both at Kanta (1.75 q ha^{-1}), and NRS (1.76 q ha^{-1}) and then decreased with increasing level of nitrogen upto 280 kg (0.88 q ha^{-1} at both the sites). Beneficial effect of nitrogen on cane yield has been reported elsewhere (Rahman and Khalequzzaman, 1981; Afolabi, 1988; Rahman *et al.* 1989b). Higher yield was obtained with application of 200 kg N ha^{-1}, and limited response was observed without nitrogen application at both the locations. This may be due to deficient level of nitrogen in the soil supporting growth.

Table 2. Effect of nitrogen and spacing on tillering ($X10^3$ ha^{-1}) of sugarcane.

Treatments	April		May		June		July		August	
	Kanta	NRS	Kanta	NRS	Kanta	NRS	Kanta	NRS	Kanta	NRS
Spacing (cm)										
45	86.2	89.1	89.2	92.1	87.8	90.7	81.9	84.8	80.3	83.9
60	83.2	86.0	85.9	88.7	84.6	87.6	78.2	81.2	77.1	80.2
75	79.7	82.9	83.0	85.5	81.9	84.9	76.5	79.4	75.6	78.6
CD (P=0.01)	0.11	1.42	1.47	2.64	1.05	2.47	0.63	0.57	0.44	1.28
N levels (kg ha^{-1})										
0	60.4	63.4	63.5	66.1	62.5	65.6	56.9	59.3	55.9	58.8
120	84.0	86.9	87.0	89.5	85.1	88.1	78.6	81.6	77.5	80.5
160	88.6	91.6	91.6	94.1	90.2	93.3	83.9	87.1	82.9	86.0
200	93.6	96.3	96.6	99.2	95.4	98.4	89.2	92.6	88.1	91.3
240	85.3	88.2	88.3	91.1	87.1	90.1	82.3	85.1	81.3	84.2
280	86.1	89.5	89.1	92.7	88.2	90.9	82.2	85.1	81.3	84.3
CD (P=0.01)	0.62	1.11	0.66	1.48	1.03	1.51	0.63	0.97	0.51	1.39

Different inter-plant spacings, such as 45, 60, and 75 cm had also significant effect on yield of sugarcane at both the locations (Table 3). Closer spacing (45 cm) resulted in higher yield of cane than wider spacing (75 cm). Maximum cane yield was produced by application of 200 kg N·ha^{-1} at 45 cm spacing, and produced 3.4 and 6.9% yield increase over 60 cm, and 75 cm spacing respectively at both the locations. But 280 kg N ha^{-1} at 75 cm spacing did not prove effective over 200 kg N ha^{-1}, at 45 cm spacing at both the locations. Application of 200 kg N ha^{-1} at 45 cm spacing proved better than N_0S_{45} or N_{200} S_{60} or $N_{200}S_{75}$. However, an increase in the dose of nitrogen to 280 kg ha^{-1} or spacing to 75 cm did not have further effect on cane yield which may be ascribed to nutrient imbalance, and metabolic disturbances in plants. Response to per kg nitrogen decreased with increasing doses of nitrogen, which might be due to less increase in yield as compared to the amount of nitrogen applied whereby following the law of diminishing return.

Table 3. Effect of nitrogen levels on millable cane and yield of sugarcane under different spacings.

Nitrogen levels (kg ha^{-1})	Kanta : Spacing (cm)				NRS : Spacing (cm)			
	45	60	75	Mean	45	60	75	Mean
	Millable cane ($X10^3$ ha^{-1})							
0	56.1	54.2	54.1	54.8	58.9	57.0	56.9	57.6
120	78.1	75.6	75.2	76.3	81.1	78.6	78.2	79.3
160	85.3	81.1	78.1	81.5	88.5	84.3	81.3	84.7
200	90.1	86.0	84.0	86.7	93.5	89.4	87.4	90.1
240	84.2	80.1	76.3	80.2	87.0	82.9	79.1	83.0
280	83.9	79.2	75.7	79.6	86.9	82.2	78.7	82.6
Mean	79.6	76.0	73.9		82.7	79.1	76.9	
	Yield of cane (TCH)							
0	41.5	40.0	38.5	40.0	44.4	42.9	41.4	42.9
120	63.1 (1.80)*	61.2 (1.77)	58.7 (1.68)	61.0 (1.75)	66.1 (1.81)	64.2 (1.78)	61.7 (1.69)	64.0 (1.76)
160	68.5 (1.69)	66.0 (1.63)	63.5 (1.56)	66.0 (1.63)	71.6 (1.70)	69.1 (1.64)	66.6 (1.58)	69.1 (1.64)
200	74.6 (1.66)	71.5 (1.58)	69.9 (1.57)	72.0 (1.60)	77.8 (1.67)	74.7 (1.59)	73.1 (1.59)	75.2 (1.62)
240	67.3 (1.08)	65.0 (1.04)	62.7 (1.01)	65.0 (1.04)	70.2 (1.08)	67.9 (1.04)	65.6 (1.01)	67.9 (1.04)
280	66.3 (0.89)	64.4 (0.87)	62.8 (0.87)	64.5 (0.88)	69.3 (0.89)	67.4 (0.88)	65.8 (0.87)	67.5 (0.88)
Mean	63.5 (1.42)	61.4 (1.38)	59.4 (1.34)		66.6 (1.43)	64.4 (1.39)	62.4 (1.35)	

	CD (P=0.01)		CD(P=0.01)	
	Millable cane	TCH	Millable cane	TCH
Spacing (S)	0.28	1.10	1.89	1.13
Nitrogen (N)	0.43	0.66	1.28	0.99
SXN	0.74	1.14	2.21	1.71

* Figures in parentheses are response per kg N (qha $^{-1}$).

Spacing and nitrogen had significant effect on recoverable sucrose content (Table 4). Wider inter-plant spacing gave significantly higher sucrose content than closer inter-plant spacing at both the locations. The higher sucrose content under wider spacing might be due to uniform interception of light on leaves. But the highest sugar yield was recorded under closer spacing due to higher millable cane, and cane yield.

Table 4. Effect of nitrogen levels on sucrose content and yield of sugar under different spacings.

Nitrogen levels (kg ha^{-1})	Kanta : Spacing (cm)				NRS : Spacing (cm)			
	45	60	75	Mean	45	60	75	Mean
	Recoverable sucrose (%)							
0	10.1	10.1	10.2	10.1	9.8	9.8	9.9	9.8
120	10.5	10.5	10.6	10.5	10.1	10.1	10.2	10.1
160	10.6	10.6	10.7	10.6	10.1	10.2	10.3	10.2
200	10.7	10.7	10.8	10.7	10.4	10.4	10.6	10.5
240	10.5	10.6	10.6	10.6	10.1	10.2	10.2	10.2
280	10.5	10.5	10.6	10.5	10.0	10.0	10.1	10.0
Mean	10.5	10.5	10.6		10.1	10.1	10.2	
	Yield of sugar (TSH)							
o	4.2	4.1	3.9	4.1	4.4	4.2	4.1	4.2
120	6.6	6.4	6.2	6.4	6.7	6.5	6.3	6.5
160	7.3	7.0	6.8	7.0	7.2	7.1	6.8	7.0
200	8.0	7.7	7.5	7.7	8.1	7.8	7.7	7.9
240	7.1	6.9	6.6	6.9	7.1	6.9	6.7	6.9
280	7.0	6.8	6.6	6.8	6.9	6.8	6.6	6.8
Mean	6.7	6.5	6.3		6.7	6.6	6.4	

	CD (P=0.01)		CD(P=0.01)	
	Sucrose	TSH	Sucrose	TSH
Spacing (S)	0.12	0.07	0.21	0.17
Nitrogen (N)	0.17	0.11	0.26	0.21
SXN	0.33	0.26	0.45	0.37

Table 5. Economics of nitrogen fertilization of sugarcane production.

Location	Nitrogen levels (kg ha^{-1})	Cost of nitrogen fertilizer (Tk.)	Yield of cane (TCH)	Increased cane yield over control (ton)	Net income (Tk.)	Net benefit (Tk ha^{-1})
Kanta	0	—	40.0	—	—	—
	120	1302	61.0	21.0	21000	19698
	160	1736	66.0	26.0	26000	24264
	200	2170	72.0	32.0	32000	29830
	240	2604	65.0	25.0	25000	22396
	280	3038	64.5	24.5	24500	21462
NRS	0	—	42.9	—	—	—
	120	1302	64.0	21.1	21100	19798
	160	1736	69.1	26.2	26200	24464
	200	2170	75.2	32.3	32300	30130
	240	2604	67.9	25.0	25000	22396
	280	3038	67.5	24.6	24600	21562

(Cane price Tk. 1000.00 t^{-1}, and nitrogen Tk. 10.85 kg^{-1})

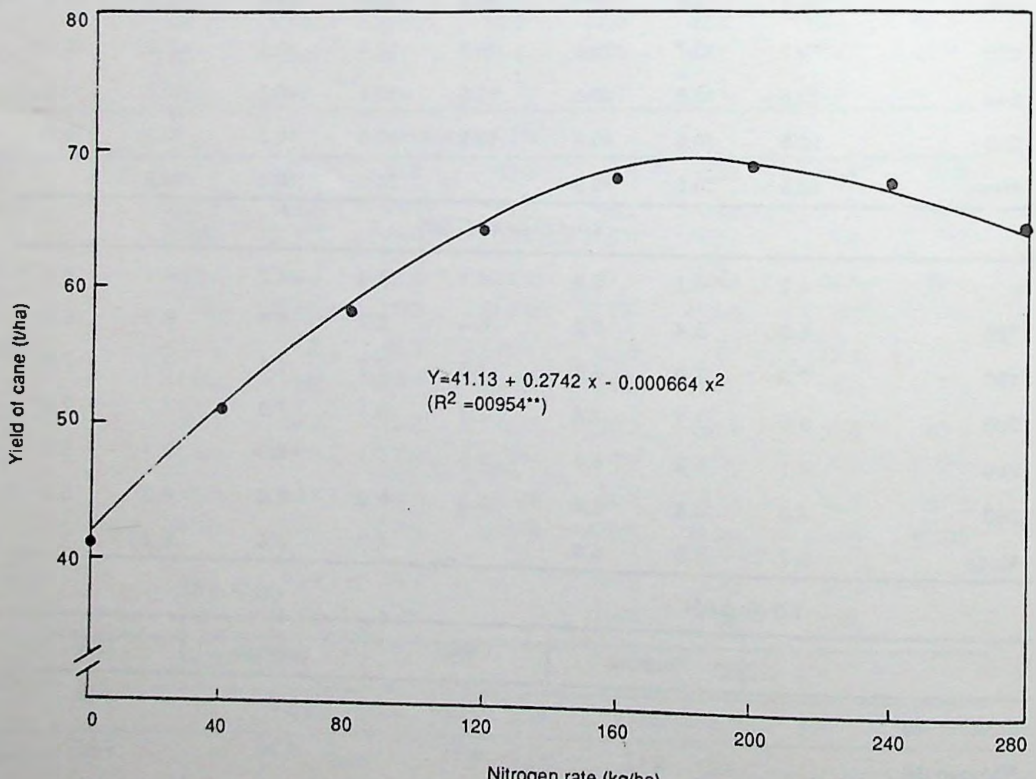

Figure 1. Quadratic nitrogen response curve estimated from sugarcane yield.

The economic analysis on the yield of sugarcane was done, and is shown in the Table 5. The highest net benefit was obtained with 200 kg N ha^{-1} at Kanta, and NRS. The yield data (pooled yield of Kanta and NRS) were also fitted to quadratic response curve (Fig. 1), of which coefficient of determination (R^2) was found to be highly significant. $Y=41.13 + 0.2742 X - 0.000664 X^2$ for $0\leq X \leq 280$ ($R^2 = 0.954^{**}$) where, 'Y' is the expected yield (t ha^{-1}) and 'X' is the level of nitrogen (kg ha^{-1}). Results indicate that yield response of sugarcane to nitrogen fertilization can be adequately described by quadratic equation. The computed R^2 value of 0.954 indicates that 95.4% of total variation in the mean yields was explained by quadratic regression equation estimated. Sugarcane responded significantly up to 240 kg N ha^{-1} but nitrogen dose that maximises yield calculated from quadratic equation was 206.5 kg N ha^{-1} with a cane yield of 69.4 t ha^{-1} On the other hand the economic dose calculated from quadratic equation was 124.8 kg N ha^{-1} with a cane yield of 65.0 t ha^{-1} . The increase in cane yield of economic dose was 23.5 t ha^{-1} which fetched a net return of Tk 23510.00 ha^{-1} over no nitrogen (cane price Tk 1000.00 t^{-1}, and nitrogen Tk 10.85 kg^{-1}). It recorded a net return of Tk 17.4 per taka investment on nitrogen.

Thus, it could be concluded that sugarcane should be transplanted using closer plant spacing (45 cm) on coarse textured old Himalayan piedmont plain region of non-calcareous brown flood plain soils low in nitrogen content, and required to be fertilized with 125 kg N ha^{-1} along with recommended doses of P, K, and S for these soils.

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