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Agronomic Characters, Productivity and Nutrient Contents of Sugarcane (*Saccharum officinarum* L) Affected by Nitrogen

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Abstract: A field experiment was conducted to study the effect of various nitrogen levels (0, 75, 150 and 225 kg ha^{-1}) on agronomic characters, productivity, maturity and nutrient contents of sugarcane at the National Agricultural Research Centre Islamabad during 1996-98. All the treatments were given a constant dose of 120 kg ha^{-1} of P_2O_5 and 150 kg ha^{-1} of K_2O. Early stalk population increased as the N dose was increased. Maximum number of tillers per hectare were found at 225 kg N ha^{-1} at all growth stages. Similarly at harvest, millable canes per hectare were the maximum (139.7 thousands) at 225 kg N ha^{-1}. Stalk height increased significantly as the N levels were increased and it was the maximum (264.67 cm) at N level of 225 kg ha^{-1}. Nitrogen also increased stalk girth significantly. Brix percentage was similar at early maturity stages at all N levels, however, at harvest it was significantly lower in N applied plots than the control. Cane yield increased significantly with increasing N levels with the maximum (149.4 t ha^{-1}) at 225 kg N ha^{-1}. Although sugar recovery was maximum (11.8 %) in the control plots but it was statistically similar to other treatments. Application of 225 kg N ha^{-1} produced the maximum sugar yield of 16.87 t ha^{-1}. Phosphorus, K, Zn, Mg and B contents in the plant tissue increased significantly with increasing N application levels.

Key Words: Sugarcane, nitrogen, agronomic characters, productivity, nutrient contents

Introduction

Sugarcane in Pakistan is grown on an area of more or less 1.0 million hectares. The Punjab, Sindh and NWFP share 62.4, 26.0 and 11.2 % area, respectively (Akhtar, 1999). Pakistan occupies the fifth position in cane producing countries of the world and almost the 15th position in sugar production (Akhtar, 1999). The production of higher cane and sugar depends on the selection of high yielding cultivars and proper management of the crop including application of fertilizer at appropriate rate and time. Nitrogen is essential for the growth of plants. It is well known fact that a proper supply of nitrogen to crop plants is associated with the enhancement of photosynthetic activity, vigour vegetative growth and a dark green colour of plant leaves due to increased chlorophyll contents (Black, 1993). Clements (1980) regarded nitrogen as the most influential plant element in the regulation of sugarcane growth and production.

Unfortunately the fertilizer costs are very high all over the world. On the other hand the apparent recovery of applied nitrogen by the crop plants seldom exceeds 50 % and the rest is lost from the soil plant system one way or the other (Shah *et al.*, 1993). Better management practices can help improve nitrogen uptake efficiency. Akhtar and Silva (1998) have reported N uptake efficiency of sole sugarcane up to 73.2 %, whereas it was 44.3 % in intercropped cane.

The objective of the present study was to find out the effect of various nitrogen application rates on growth characters, productivity, maturity and nutrient contents of sugarcane.

Materials and Methods

The experiment was conducted at the research area of National Agricultural Research Centre, (NARC), Islamabad, during 1996-98. A promising sugarcane cultivar RB 72-454 was planted at a row spacing of 1 m during the month of September in both the years. Two budded double setts were planted end to end. The experiment was laid out in a randomized complete block design with three replicates. Phosphorus was applied @ 120 kg P_2O_5 ha^{-1}. Potash was applied @ 150 kg K_2O ha^{-1}. Nitrogen was applied at the following rates:

N 0 kg ha^{-1} or Control	N 75 kg ha^{-1}
N 150 kg ha^{-1}	N 225 kg ha^{-1}

All P & K was applied at the time of planting. Nitrogen was applied in five equal splits. First dose of N was applied at the time of planting. Other doses of N were applied during March, April, May and June. Gesapax Combi (80 WP) was applied as pre-emergence herbicide to control the weeds. Further weeding was done by cultural operations and earthing up during April, May and June. Data on tillering was recorded at early growth stages during June and July from an area of 10 m^2. Plant tissue samples were collected during the month of August and these samples were analyzed for various nutrients. Five stalks from each treatment were selected and leaf number +3, +4, +5, and +6, counting the spindle as +1, were removed from the stalks (Clements, 1980). Leaf blades and leaf sheaths were separated and leaf blades were cleaned with the distilled water. Middle six inches of the leaf blades without the midrib were used for the nitrogen analysis while the leaf sheaths were used for the analysis of other elements. Brix %age (total soluble solids) was also recorded during October, November and December with high contrast hand refractometer.

The crop was harvested during December and the data on stalk height, stalk girth, Brix percent and cane yield were recorded. Final data on cane yield was recorded from an area of 15 m^2. Ten stalks were used to record the stalk height and the recorded data were averaged. Stalk girth was measured with digital caliper from the same ten stalks. Stalk girth was measured from 20 cm above ground, from the middle, and from 20 cm below the topmost node and then was averaged. Stalks from the harvested samples were used to determine the sugar recovery. These stalks were crushed with power crusher to extract the juice. Brix reading was taken by brix hydrometer and POL reading was taken by Saccharimeter. Sugar recovery was calculated with the help of Winter-Crap formula (Geerlings, 1904) using Australian fibre constant (12.5%).

Sugar Recovery % (SR) = [POL in juice - (Brix - POL in juice) x 0.4] x 0.63

Sugar Yield = SR x Cane yield

The data collected were analyzed with analysis of variance technique at 5% probability using MSTATC computer software.

Results and Discussion

Stalk Population : Data collected on the number of tillers per hectare showed that application of 225 kg N ha $^{-1}$ produced the maximum number of tillers per hectare (Table 1). Tillers population increased up to the first week of July in all the plots receiving nitrogen. However, total number of tillers per hectare started decreasing after the first week of July when the cane crop attained full canopy cover (Fig. 1). Competition for nutrients, light and moisture resulted in the mortality of the weaker tillers when the crop was at its peak growth stage. Nitrogen application significantly affected the millable canes at harvest (Table.1, Fig. 1).

Millable canes at harvest ranged from 84.4 thousand per hectare in the control plots to 139.7 thousands per hectare in plots receiving 225 kg N ha^{-1}. The maximum number of millable canes per hectare were produced with the application of 225 kg N ha^{-1}. Akhtar and Silva (1999) have reported significant differences in stalk population of sole and intercropped cane at various nitrogen levels. They also reported similar differences in the stalk population at harvest and application of 300 kg N ha^{-1} produced the maximum number of stalks per hectare at all stages of growth. Patil *et al.* (1977) have reported significant increase in tillering of sugarcane with N application. Ali *et al.* (1993) have observed positive effect of N on tillering upto 168 kg N ha^{-1}. Reduction in the number of tillers with the passage of time due to canopy cover, mortality of the young tillers due to competition for different resources has been reported by Akhtar and Silva (1999).

Stalk height and girth: Stalk height and the girth are two of the most important characters contributing final productivity of the cane crop. Taller and thicker stalks are greater in weight and have more capacity of storing cane juice and sugars. Recorded data on stalk height and girth indicated that there were significant differences in the stalk height and in the girth among various nitrogen levels. Both the stalk height and the girth increased significantly with increasing levels of nitrogen application (Table 1.) Stalks were the tallest in plots receiving 225 kg N ha^{-1}, whereas, these were the shortest in plots with no N. Similarly application of 225 kg N ha^{-1} produced the stalks with the maximum girth and the stalks in the control plot had the minimum girth. Earlier studies have reported similar effects of nitrogen on growth and development of sugarcane. Akhtar and Silva (1997, 1998) have observed increased plant height in sugarcane with increasing nitrogen levels. They have reported the maximum stalk height and girth with the application of 300 kg N ha^{-1} both in sole and intercropped sugarcane. Nitrogen has been regarded as the most influential plant nutrient element, controlling sugarcane growth, by Clements (1980) and is associated with vigorous growth of plants (Tisdale *et al.*, 1993). Marschner (1986) has indicated that shoot elongation is enhanced by applied nitrogen. Effects of nitrogen on better growth of sugarcane and significantly increasing plant height have been reported by White (1991).

Cane yield: Data collected on the cane yield indicated that the application of N significantly increased cane yield (Table 1). Maximum cane yield of 149.4 t ha^{-1} was produced with the application of 225 kg N ha^{-1} , whereas the control plots produced the minimum cane yield of 42.4 t ha^{-1}. Cane yield increased with each increment of nitrogen. The trend of cane yield increase was similar to those of stalk height and stalk girth.

Higher number of stalks at harvest, taller and thicker canes are the factors those effect the ultimate yield of sugarcane. All of these characters are significantly improved by the application of balanced dose of fertilizers at appropriate time. As sugarcane is a long duration crop and produces huge biomass, its nutritional and fertilizer requirements are much higher than the other field crops. Increase in cane yield with increasing N levels has been reported by Akhtar and Silva (1998, 1999), and Clements (1980). Akhtar and Silva (1998, 1999) have reported maximum cane yield in sole cane at 150 kg N ha^{-1} and in intercropped cane at 300 kg N ha^{-1} .

Total soluble solids (TSS %), sugar recovery and sugar yield: The results of the study indicated that TSS %age was similar at all nitrogen levels upto December 09. However, Total soluble solids were significantly different at various N levels at the time of harvest. TSS was the maximum in the control plots (20.04 %) and the minimum (18.5 %) in plots receiving 225 kg N ha^{-1}(Table 2). There was a non significant difference in the sugar recovery at various N levels. However, Sugar recovery was maximum when no nitrogen was applied and minimum with the highest rate of nitrogen i.e. 225 kg N ha^{-1}(Table 2).

Sugar yield is a product of cane yield and sugar recovery. As there was a significant difference in the cane yield at various N levels and no difference in the sugar recovery, significant differences in the sugar yields per hectare at various N levels were found. Maximum sugar yield was produced when the highest rate of nitrogen was applied i.e. 225 kg ha^{-1} and the minimum in plots where no nitrogen was applied (Table 2). Akhtar and Silva (1997) have reported a significant increase in sugar yield with the application of nitrogen. They have found maximum sugar yield of 18.88 t ha^{-1} in sole cane with the application of 150 kg N ha^{-1}, 15.92 t ha^{-1} of sugar yield in cane intercropped with sweet corn at 300 kg N ha^{-1}, and 14.33 t ha^{-1} of sugar yield in cane intercropped with wheat at 300 kg N ha^{-1}.

Nutrient contents of plant tissues: Results indicated that there were significant differences in all the nutrient contents of sugarcane tissue at various N levels (Table 3). Concentration of P, K, Zn, Mg, and B increased in the sugarcane tissue as the nitrogen application levels were increased. Maximum concentration of P, K, Zn, Mg, and B was found at 225 kg applied N ha^{-1}, whereas, these concentrations were the minimum in plants in the control plots (Table 3). This trend clearly shows that by the balanced fertilizers, cane plants were also able to absorb more nutrients from the soil because of efficient plant metabolism, and hence better root and shoot growth. Adequate fertilization of surface soil encourages not only top growth but also a more vigorous and extensive root system. Root development is related to the buildup of N and P

Table 1: Mean Tillers (000 ha^{-1}) during crop growth period, stalk height, stalk girth and cane yield at harvest affected by various N levels during 1996-1998

Nitrogen kg ha^{-1}	June 03	July 04	July 19	At harvest	Stalk height (cm)	Stalk girth (mm)	Cane yield (t ha^{-1})
0 (Control)	175.4 b	152.0 b	150.0 b	84.4 c	138.67 d	26.20 b	42.4 d
75	208.6 ab	230.0 a	181.3 ab	113.0 b	237.00 c	30.00 a	104.0 c
150	216.7 ab	241.0 a	187.0 ab	132.7 a	256.00 b	32.23 a	124.0 b
225	245.6 a	252.0 a	203.3 a	139.7 a	264.67 a	31.33 a	149.4 a
LSD	44.9	47.4	37.9	15.3	7.07	2.36	5.85

Table 2: Mean Brix % (Total Soluble Solids) at various maturity stages, sugar recovery and sugar yield affected by various N levels during 1996-1998

Nitrogen kg ha^{-1}	Total Soluble Solid (TSS %)						Sugar recovery (%)	Sugar yield (t ha^{-1})
	Oct. 24	Nov. 04	Nov. 12	Nov. 24	Dec. 09	At harvest		
0 (Control)	15.7	17.9	18.6	18.8	19.2	20.4 a	11.8	5.00 d
75	16.2	17.4	17.7	18.3	19.0	19.5 b	11.5	12.00 c
150	16.5	17.4	17.7	18.6	19.0	19.5 b	11.5	14.26 b
225	15.0	16.4	17.6	17.8	18.4	18.5 c	11.3	16.87 a
LSD	N.S	N.S	N.S	N.S	N.S	0.6	N.S	1.9

Table 3: Nutrient concentration of sugarcane plant tissues affected by various nitrogen levels during 1996-1998

Nitrogen kg ha^{-1}	P(%)	K (%)	Zn (mg kg^{-1})	Mg (mg kg^{-1})	B (mg kg^{-1})
0 (Control)	0.18 b	1.3 d	5.0 c	28.23 c	6.4 d
75	0.27 a	1.5 c	16.5 b	30.17 b	7.6 c
150	0.26 a	1.8 b	16.4 b	30.61 b	8.7 b
225	0.25 a	1.9 a	20.0 a	32.18 a	9.8 a
LSD	0.02	0.09	0.97	47.23	0.46

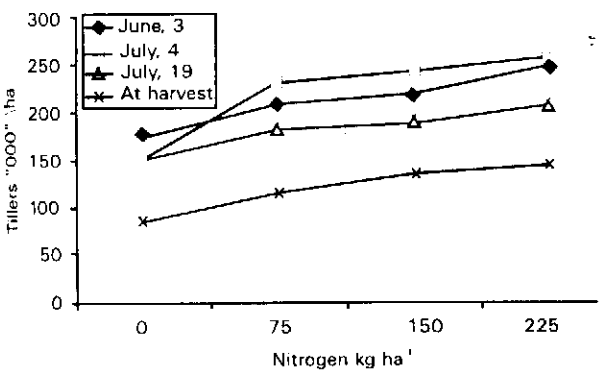

Fig. 1: Effect of nitrogen on tillering of sugarcane at early growth stages and at harvest

in the cells that hastens division and elongation. Extensive and vigorous root system has a capability of better absorption of applied and soil nutrients (Tisdale *et al.*, 1993). Application of proper amounts of N, P and K improved the root system and ultimately absorption of various nutrient elements in cane plants.

The present study indicates that an application of 225 kg N ha^{-1} along with 120 kg P_2O_5 and 150 kg K_2O is required for maximum cane and sugar yields. Nitrogen may be applied in five equal splits (at planting, during March, April, May, and June) to September planted cane crop and in four equal splits (at planting, during March, April, May, and June) to February-March planted crop.

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