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Effect of Plant Density and Nitrogen Management for Realizing Higher Cane Yield under Bud Chip Method of Planting in Sugarcane (*Saccharum officinarum*)

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Authors' contributions

This work was carried out in collaboration among all authors. Author NS designed the study, performed the field work, statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Author NS managed in work planning and preparation of the manuscript. Authors TPR, GR, GER and PJN managed the literature searches. Author MV managed the supervision of the present research work and corrected the manuscript. All authors read and approved the final manuscript.

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ABSTRACT

A field experiment was conducted at Regional Sugarcane and Rice Research Station, Rudrur, during 2018-19 to study the effect of plant density and nitrogen management for realizing higher cane yield under bud chip method of planting in sugarcane (*Saccharum officinerum*). The

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treatments were plant geometry and nitrogen doses with three and four splits of application in split plot design. The recommended dose of nitrogen was 250 kg N ha^{-1}. Among the geometry, 150 x 60 cm spacing recorded significantly higher cane length which was statistically at par with 150 x 30 cm. 150% RDN (375 kg N ha^{-1}) with four splits of application recorded significantly higher cane length. Among the split application of nitrogen, four splits with 150% RDN at basal, 60, 90 and 120 DAP recorded significantly higher number of tiller at 90 and 120 DAP. Significantly higher single cane weight was recorded in 150% RDN with four splits of application in 150 x 60 cm. Significantly higher cane yield was recorded in 150% RDN with four splits of application in 150 x 60 cm spacing and was statistically at par with 150 x 30 cm spacing. This was followed by 100% RDN with four splits of application in 150 x 60 cm spacing.

Keywords: Plant spacing; sugarcane; nitrogen application; cane yield; splits of application.

1. INTRODUCTION

Sugarcane is the only source of white sugar in India, cultivated over an area of about 0.17 million hectares annually with an average yield of 55 t ha^{-1} [1]. Being a long duration crop and heavy feeder of nutrients it removes a considerable nutrients from soil. As a result, the nutrient ability of soil to supply plant nutrients is declining day by day which leads to decline in productivity of sugarcane.

It is well agreed that a blend of organic and inorganic fertilizer can improve the cane production besides maintaining the soil health [2] by continuous application of farmyard manure (FYM) along with NPK fertilizer improves physical chemical properties of soil, cane yield and juice quality. The pressmud is a rich source of organic carbon (35-37%) and supplies 1.0-1.5% N, 2.5-3.5% P_2O_5 and 0.3-0.8% K_2O. Besides, it is a good source of micro-nutrient and qualities to amend the soil nature. Nitrogen from the atmosphere is potentially an important indirect source of N in the soil. Within the soil an internal cycle functions, through which a small amount of this atmospheric N source becomes available as part of the organic N pool through microbial symbiotic and/or non-symbiotic fixation of N by microorganisms, and also through ammonia and nitrates in rainfall [3].

[4] reported that the N requirement of sugarcane have focused on factors such as climate, soil type, cane cultivar, crop class, legume usage during the fallow, rainfall, length of time green cane trash blanketing has been practiced, and irrigation. The mineralization of organic N to ammonium and subsequent nitrification of the ammonium to nitrate, is a continuous process but is largely driven by the organic matter status of soils, drying and wetting cycles, the duration of drying prior to wetting up, temperature changes, soil pH, biological activity and soil disturbance through tillage operations.

The significant effect of organic matter and soil mineralization potential on N requirement of sugarcane has also been recognized in India, N rates range from 0–50 kg Nha^{-1} in Bihar, to 250–300 kg Nha^{-1} in Karnataka and Maharashtra, to over 350 kg Nha^{-1} in the south-east coastal area of Tamil Nadu [5]. In general, the rate matches the intensity of irrigation which is higher in the tropics than in the subtropics (except Punjab). As a simple rule, 1 kg Nt^{-1} cane expected is given for plant cane and 1.25–1.50 kg Nt^{-1} cane expected for ratoon crops. The optimum for ratoons is at least 25% greater than for plant cane [6]. The rate is adjusted to the extent of 10% of the recommended rate to allow for leguminous green manure of compost and farm yard manure which has been used, but no correction is permissible for any residual N from one sugarcane crop to the next. The purpose of this experiment is better, to study the effect of plant density and nitrogen management for realizing higher cane yield under bud chip method of planting in sugarcane (*Saccharum officinarum*).

2. MATERIALS AND METHODS

A field experiment was conducted at Regional Sugarcane and Rice Research Station, Rudrur (India) during 2018-19 situated at an altitude of 286.3 m above mean sea level (amsl) at 18^0 49'41" N latitude and $78^0$56'45" E longitude. The experimental site is in Northern Telangana agro climatic zone of Telangana state, India and experiences semiarid climate. The soil was sandy loam with pH of 8.1 and organic carbon 0.18% with EC of 0.19 d Sm^{-1}. The soil was low (191 kg N ha^{-1}), medium (22 kg P_2O_5 kg ha-1) and high (365 kg K ha^{-1}) in available nitrogen, phosphorus and potassium, respectively. According to Trolls classification, the site falls under semi arid tropics (SAT). Total rainfall of 532 mm was received in 30 rainy days during the crop growth period. The weekly mean minimum and maximum temperatures during entire crop period ranged from 24.3 to 32.4^{0}C and 33.2 and 38.3^{0}C, respectively. The weekly mean relative humidity ranged from 50.9 to 83.1% while average relative humidity was 72.5%. The experimental plots (9 m × 9 m = 81 m^2) were laid out in split plot design with three replications. Main plot treatments were four plant spacing (M_1 : 90 x 30 cm; M_2 : 150 x 30 cm; M_3 : 120 x 30 cm and M_4: 150 x 60 cm) and sub plot treatments were 4 nitrogen applications (T_1: 100% RDN (Recommended Dose of Nitrogen) with three split applications of N at basal, 45 and 90 DAP (Days After Planting); T_2: 100% RDN with four split applications of N at basal, 45, 90 and 120 DAP; T_3: 150% RDN with three split applications of N at basal, 45 and 90 DAP and T_4: 150% RDN with four split applications of N at basal, 45, 90 and 120 DAP). The total treatment combinations were 48. Each plot was separated by 1m of transition zone while replication was demarcated by a buffer zone of 1.5 m in between. To prevent seepage, polythene sheets were pushed into the edges of the levees along the inner perimeter of all plots. Recommended dose of fertilizers (RDF) were applied at the rate of 250:120:100 kg ha^{-1}. Except at basal application (broadcasted), top dressing was done by spot application of fertilizers at 5 cm below soil. The crop variety selected was ‘Co 86032’ which is having high profuse tillering nature. Tiller count was taken at 90 and 120 DAP. Cane length, single cane weight and cane yield was recorded at the time of harvest. The data were analysed statistically by applying the technique of analysis of variance for split plot design and significance was tested by F-test. Critical difference for treatment means tested for their significance was calculated at 5% level of probability.

3. RESULTS AND DISCUSSION

The sugarcane experiment was planted by giving irrigation from Bore wells as there was no rain during planting of sugarcane *i.e.* in the month of January. Eight irrigations were given throughout crop period at a frequency of 15 days intervals due to high temperatures during the months of April and May 2019. Monsoon was delayed and first effective rainfall received on 16th June 2019 which helped grand growth stage of sugarcane crop. The diurnal temperature variation in the month of October and November resulted in sucrose accumulation in sugarcane crop. The humid condition and temperature differences resulted in flowering in sugarcane.

3.1 Cane Length (Cm)

Among the plant spacing, 150 x 60 cm spacing recorded significantly higher cane length which was statistically at par with 150 x 30 cm. 150% RDN with four splits of application recorded significantly higher cane length followed by 150% RDN with three splits of application. Like before [7] extended period of nitrogen application at required dose lead to higher cane length. (Table 1).

3.2 Tiller Count

Data regarding tiller count at 90 and 120 DAP was presented in Table 1. 150 x 60 cm spacing recorded significantly superior tiller count at both 90 and 120 DAP which was statistically at par with 150 x 30 cm spacing. Lowest number of tillers were recorded in 120 x 60 cm spacing at 90 DAP and 90 X 60 cm at 120 DAP. Among the split application of nitrogen, four splits with 150% RDN at basal, 60, 90 and 120 DAP recorded significantly higher number of tiller at 90 and 120 DAP. This implies that prolonged application of nitrogen fertilizer leads to vegetative growth in sugarcane up to 120 DAP [8] and [9].

3.3 Number of Internodes $Cane^{-1}$

There was no significant difference among the number of internodes $cane^{-1}$. Numerically 90 x 30 cm spacing and 150% RDN with four splits of application recorded higher number of internodes.

3.4 Internode Length (Cm)

Significantly higher internode length was recorded in 150 x 60 cm spacing and was statistically at par with 150 x 30 cm spacing. Among the split application of nitrogen fertilizer 150% RDN with four splits recorded significantly higher internode length which was statistically on par with 150% RDN with three split application. Lowest internodal length was recorded in with 100% RDN with four splits of application at basal, 60, 90 and 120 DAP (Table 1). Sugarcane crop extends vegetative growth with extended application of fertilizers up to 120 days of planting [10].

3.5 Single Cane Weight (Kg/Cane)

Single weight directly influences the cane yield presented in Table 2. Significantly higher single cane weight was recorded in 150% RDN with four splits of application with 150 x 60 cm followed by 150x 30 cm. lowest single cane weight was recorded in 100% RDN in 90 x 30 cm. Single cane weight increases when there is less competition for light water and nutrients which achieved by maintaining plant to plant spacing [11].

3.6 Cane Yield

The data regarding cane yield was presented in Table 3. Significantly superior cane yield was recorded in 150% RDN with four splits of application in 150 x 60 cm and it was statistically at par with 150% RDN with four splits of application in 150 x 30 cm spacing. Among three and four splits of nitrogen application, four splits of application in both 100% RDN and 150% RDN recorded higher yield. In sugarcane, vegetative growth and tiller formation extends up

Table 1. Effect of plant spacing and nitrogen split application on growth parameters of sugarcane

Treatments	Cane length (cm)	Tiller count ('000) ha^{-1}		Number of Internode / cane	Internode length (cm)
		90 DAP	120 DAP		
Plant spacing (cm)					
90x60	3.11	111	128	23	11.59
150x30	3.33^{ab}	119	136^{b}	21	13.94^{ab}
120x60	3.09	104	131	21	12.15
150x60	3.56^{a}	122^{a}	148^{a}	22	14.71^{a}
SEm (+)	0.07	3.54	2.80	0.35	0.33
CD (p=0.05)	0.26	13.54	6.10	NS	1.02
Nitrogen application					
100% (3 splits)	3.06	109bc	130	21	11.31
100% (4 splits)	3.06	113^{bc}	135^{bc}	21	11.21^{bc}
150% (3 splits)	3.19	116^{b}	138^{b}	22	12.57^{b}
150% (4 splits)	3.77^{a}	128.6^{a}	156^{a}	23	13.29^{a}
SEm (+)	0.11	2.91	2.29	0.53	0.44
CD (p=0.05)	0.33	7.49	7.55	NS	1.29
Interaction (plant spacing x nitrogen application)	NS	NS	NS	NS	NS

Note: 3 splits: At basal, 45 days and 90 days and 4 splits: At basal, 45 days, 90 days and 120 days
DAP: Days after planting

Table 2. Effect of plant spacing and nitrogen split application on single cane weight of sugarcane

Plant spacing (cm)	Single cane weight (kg $cane^{-1}$)				
	100% RDN		150% RDN		Mean
	3 splits	4 splits	3 splits	4 splits	
90x60	1.03	1.23	1.33	1.6	1.30
150x30	1.33	1.46	1.44	1.64^{b}	1.47
120x60	1.44	1.09	1.42	1.57	1.38
150x60	1.45	1.57	1.46	2.63^{a}	1.78
Mean	1.35	1.31	1.41	1.86	
	Plant spacing	Nitrogen Application	Plant spacing X Nitrogen application		
SEm(+)	0.04	0.06	0.14		
CD (p=0.05)	0.15	0.19	0.53		

Note: 3 splits: At basal, 45 days and 90 days and 4 splits: At basal, 45 days, 90 days and 120 days
RDN: Recommended Dose of Nitrogen

Table 3. Effect of plant spacing and nitrogen split application on cane yield

Plant spacing (cm)	Cane yield (t ha^{-1})				
	100% RDN		150% RDN		Mean
	3 splits	4 splits	3 splits	4 splits	
90x60	103	127	142	143	124
150x30	142	163	159	165 [ab]	157
120x60	141	143	150	162	150
150x60	148	164	160	179[a]	162
Mean	134	150	153	162	129
	Plant spacing	Nitrogen Application	Plant spacing X Nitrogen application		
SEm(+)	4.31	5.69	6.23		
CD (p=0.05)	15.21	15.64	30.26		

Note: 3 splits: At basal, 45 days and 90 days and 4 splits: At basal, 45 days, 90 days and 120 days
RDN: Recommended Dose of Nitrogen

to 120 days (grand growth stage) and after that sucrose accumulation will takes up to harvest of the crop (formative stage). Vegetative growth is directly proportional to the extent of nitrogen application up to 375 kg nitrogen per hectare [12].

4. CONCLUSION

Extended application of nitrogen fertilizer up to 120 days after planting in sugarcane realized higher vegetative growth characters viz., cane length, internode length and number of tillers in wider row spacing that is 150 cm row to row distance and 60 or 30 cm intra row spacing.

Single cane weight and cane yield which are directly related to vegetative growth showed increased weight in single cane and overall cane yield of sugarcane with the extended application of nitrogen up to 120 days after planting which enhances in productivity and profitability of sugarcane to the farming community.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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