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Effect of integrated nutrition on nitrogen use efficiency, productivity and quality of mid-late maturing sugarcane (*Saccharum* spp. Hybrid complex) genotypes under sub tropical Indian conditions

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ABSTRACT

The experimental treatment consisted of eight mid-late maturing genotyes *viz*. ‘CoJ 20193’, ‘CoS 99259’, ‘CoS 96275’, ‘CoPant 99214’, ‘CoH 110’, ‘CoH 119’, ‘CoLk 9616’ and ‘CoJ 99192’**.** The genotypes were planted in furrows at 75 cm spacing during spring season (in the month of February) along with four nitrogen levels viz. control, 150 kg/ha N, Farm Yard Manure (FYM) @ 10t/ha and 150 kg/ha N + FYM 10t/ha. All the treatments were in split plot design replicated three times. The highest nitrogen use efficiency (NUE : 304.7 kg cane/kg N applied at 150 kg N/ha)and apparent recovery (52.5%) was observed with sugarcane genotype ‘CoH 110’. The nitrogen use efficiency of ‘CoLk 9616’ worked out to be 267.7 kg cane/kg N at 150 kg N + 10 t FYM/ha. Significantly highest number of tillers (261.7 thousand/ha in the month of July) and number of millable canes (128.5 thousand/ha) were recorded in genotype ‘CoH 110’, which is also yielded significantly higher (61.8 t/ha). In general, the productivity of sugarcane enhanced at 150 kg + 10 t FYM as compared to 150 Kg N/ha alone. Genotypes ‘CoS 96275’ recorded higher CCS content (12.64%), however, ‘CoH 110’ yielded highest sugar yield (7.64 t/ha) which was statistically at par with those produced by ‘CoS 96275’, ‘CoH 119’ and ‘CoLk 9616’. The root length (34.5 cm) and volume (78.0 cc) was found higher in ‘CoH 110’. The genotype ‘CoH 110’ also exhibited higher number of root hair count (1942.6) as compared to other genotypes.

Keywords: Apparent recovery, Mid-late maturing, Genotypes, Organics, Sugarcane, NUE, Root volume, Root intensity.

Sugarcane is a high biomass-producing crop that requires substantial quantities of nitrogen from soil (Peter *et al.* 2005). Growth of sugarcane plant and stored sucrose in undergoes complex physiological regulations that largely depend on crop nutrition. The primary function of nitrogen in sugarcane is to increase the photosynthetic apparatus like leaf development, leaf expansion and tiller formation. It increases the leaf surface area and functional duration of leaves. Indian soils are mostly deficient in nitrogen hence the application rates are much higher. The yield potential of different genotypes varies with their inbuilt characters. Consequently the uptake of nitrogen by different genotype also varies.

The fertilizer nutrients account for lion’s share among the external production inputs in sugarcane ‘produce to product’ chain. Limited and costly inputs coupled with high production demand of sugarcane made an alarm to researchers for conservation of nutrient resource in general and nitrogen in particular under modern intensive agricultural system. As reported from IISR, Lucknow, a crop of 100 t/ha exhausts 208 kg N, 53 kg P and 280 kg K besides 3.4 kg Fe, 1.2 kg Mn, 0.6 kg Zn, 0.2 kg Cu and 30 kg S (Lal and Singh 2002). Simultaneously, low fertilizer N recovery has been reported from many sugar areas (Hartemink 2008). More so, modern agriculture concerned with yield, nutritional quality and the environmental impact of crop production. Efficient use of fertilizers N is therefore critical (Uribelarrea *et al*. 2006). All these point out to greater opportunity for integrated nutritional feeding for enhancing cane yield, improving produce quality and maintaining system sustainability. Productivity and quality of sugarcane crop are largely dependent upon the quantity and quality of millable canes. Yadav and Sharma (1978) reported direct contribution of 40% of the number of millable canes to the agronomic yield of sugarcane crop followed by the length (27%), girth (3%) and weight (30%) of stalk. Therefore, management of plant nutrients plays a key role in influencing the number of tillers, height, girth and weight of cane apart from maintaining soil health. Considering these points in view present investigation was undertaken to find out high nitrogen use efficient mid-late maturing sugarcane genotypes for higher productivity and quality with integrated nutrient supply.

MATERIALS AND METHODS

Field experiment was conducted during 2007-08 to 2008-09, starting from February, 2007 at the Research Farm of Indian Institute of Sugarcane Research, Lucknow located at $26^0 50'$ N latitude, $80^0 52'$ E longitude and 111 m above mean sea level in central part of Uttar Pradesh state of India falling in subtropical belt of sugarcane cultivation. The soil of experimental site is categorized in order inceptisol under the group Udic Ustochrepts, neutral in reaction (pH 7.4), low in organic carbon (0.34%) and available N (158.5 kg/ha), medium in available P (16.6 kg/ha) and K (265.9 kg/ha). Texture of experimental field was sandy loam (15.2 % clay, 21.4 % silt and 63.4 % sand) of Gangetic alluvial origin. The climate of location (Lucknow) is semi-arid subtropical with dry hot summers (April to June) and cold winters (November to January). The average annual rainfall is 987 mm and nearly 85% of the total rainfall is received through north-west monsoons during second fortnight of June to September.

The experimental treatment consisted of eight mid-late maturing genotyes *viz*. 'CoJ 20193', 'CoS 99259', 'CoS 96275', 'CoPant 99214', 'CoH 110', 'CoH 119', 'CoLk 9616' and 'CoJ 99192'**.** The genotypes were planted in furrows at 75 cm spacing during spring season (in the month of February) along with four nitrogen levels viz. control, 150 kg/ha N, Farm Yard Manure (FYM) @ 10 t/ha and 150 kg/ha N + FYM 10 t/ha. All the treatments were in split plot design replicated three times. The field was prepared by tilling with cultivator and harrows twice each after pre-planting irrigation followed by running of the wooden plank to conserve soil moisture. The plot size was kept 7.5 x 8.0 m. Nitrogen was applied as per the treatment through urea (46.6% N). The recommended doses of P and K were 60 kg P_2O_5 and K_2O/ha each. The sources of P and K were Diammonium Phosphate-DAP (18% N and 46% P) and Muriate of Potash (60% K). Full amount of P and K fertilizers and 1/3[rd] N were applied as basal. Remaining amount of the nitrogen was applied in two equal splits at initial (60days after planting) and final stages (120 days after planting) of tillering in sugarcane. The cultivation of crop was done under assured irrigation supply. Six pre-monsoon irrigations were given in addition to pre-planting irrigation. One post-monsoon irrigation in the month of September in first year and two irrigations during September and October in the second year were given. The harvesting of crop was done manually during third week of January in both the years with the help of spade followed by detrashing and detopping using sickle.

Three healthy clumps (stools) per treatment were selected for root studies. Each stool was dugout carefully making all efforts to minimize loss of roots. The entire stool was then suspended in a water tank to wash-off the clinging soil. After washing, horizontal and vertical spread of roots was measured from base. Thereafter, the root mass was separated from the stalk and the fresh weight of the roots was recorded. The measurement of root spread (vertical/horizontal) led to derivation of a cone shaped 'feeding zone' and was calculated by the volume of a cone represented as

$$\text{Feeding zone} = 1/3\pi\ h^2V \qquad \text{(i)}$$

(where h = one way (1/2 of the diameter) horizontal spread from the core/stalk base to the tip of longest lateral root and V is the vertical spread)

'Root intensity' which encompasses vertical and horizontal spread of the roots and the roots mass was calculated on fresh weight basis as :

$$\text{Root intensity} = \frac{\text{Root mass}}{\text{Feeding zone}} \qquad \text{(ii)}$$

The ratio of above ground plant weight to the weight of below ground plant part (i.e. root mass) taken as measure of shoot:root ratio and also termed as 'root efficiency' computed as:

$$\text{Root efficiency} = \frac{\text{Above ground plant fresh weight}}{\text{Below ground plant fresh weight}} \quad \text{(iii)}$$

Below ground plant fresh weight

Five millable canes (ripen canes ready to send to sugar mills) were randomly sampled for observations on yield attributed (length, girth and average cane weight) and juice quality parameters (Corrected brix %, pol % and purity%). Juice purity and commercial cane sugar were calculated by the formulae as described by Gupta (1977) :

Juice purity (%) = Sucrose (%) in juice/corrected brix x 100 (iv)

CCS (%) = { S-(B-5) x 0.4} x 0.73 —— (v)

Where S is sucrose % in juice, and B is corrected brix (%) was determined as per the method of Meade and Chen (1977)

The apparent N recovery and Nitrogen Use Efficiency has been envisioned by Yadav *et al* (1997):

$$\text{Apparent N recovery,} \quad AR_n = \frac{N_t - N_c}{Na} \qquad \text{(vi)}$$

$$\text{Nitrogen Use Efficiency,} \quad NUE = \frac{Y_n - Y_c}{Na} \qquad \text{(vii)}$$

Where :

N_t = N uptake in treated plots

N_c = N uptake in control plot

y_n = cane yield kg/ha in treated plot

y_c = cane yield kg/ ha in control plot

Na = applied N, kg/ha

The data were statistically analyzed for various characters as described by Panse and Sukhatme (1977).

RESULTS AND DISCUSSION

Growth and yield of sugarcane

The highest percentage of germination (42.4%) was observed by 'CoLk 9616', followed by 'Co H 110' (Table 1). The lowest germinating ability was observed in 'CoJ 99192'. The effect of application of nitrogen and its fortification by FYM was not found significant for enhancing germination. Tillering behaviour of the genotypes also showed significant variation at different period of growth starting from May to August. At initial stage in May, highest number of tillers were recorded by the genotype 'CoLk 9616' (131.9 thousands/ha). At grand growth phase which lies in the month of August, highest number of tillers (246.4 thousands/ha) were recorded by genotype 'CoH 110'. Application of FYM along with 150

Table 1 Growth, yield and quality of mid- late maturing sugarcane genotypes and effect of N levels

Treatment	Germ-ination (%) 45 DAP	Number of tiller (000/ha)				NMC (000/ha)	Yield (t/ha)	^{0}brix	Pol (%)	Purity (%)	CCS (%)	CCS (t/ha)
Genotype		May	June	July	Aug							
'CoJ 20193'	33.40	103.38	136.55	202.55	197.48	100.01	48.50	20.40	18.02	88.33	12.45	6.05
'CoS 99259'	30.40	94.61	126.38	183.90	177.25	93.04	43.53	20.86	18.01	86.41	12.31	5.36
'CoS 96275'	34.59	104.84	158.88	232.45	222.73	104.08	58.86	20.14	18.12	90.00	12.64	7.44
'CoPant 99214'	31.33	108.03	149.95	230.75	218.45	98.93	53.08	19.58	17.04	87.04	11.70	6.20
'CoH 110'	36.18	128.76	172.20	261.70	246.35	128.51	61.80	20.59	17.96	87.30	12.34	7.64
'CoH 119'	30.33	105.06	145.30	235.95	220.25	99.93	54.61	21.10	18.13	86.10	12.37	6.74
'CoLk 9616'	42.44	131.86	174.40	268.23	232.33	125.49	61.31	19.89	16.74	84.09	11.30	6.88
'CoJ 99192'	28.15	108.69	144.95	236.78	219.38	101.50	54.93	19.48	16.97	87.12	11.66	6.34
C D (P=0.05)	4.36	8.68	11.63	18.89	14.55	10.76	7.86	NS	0.78	2.65	0.84	1.16
N levels												
0- control	33.39	92.64	123.16	205.98	197.39	86.19	36.53	20.25	17.68	87.33	12.16	4.44
150 kg N /ha	33.29	117.38	168.55	245.05	222.09	112.84	63.21	20.01	17.42	87.08	11.96	7.54
10 t FYM	33.01	100.49	135.15	213.19	202.94	97.84	51.10	20.41	17.77	87.11	12.20	6.22
150kg N +10t FYM	33.71	132.09	177.44	261.94	244.69	128.86	67.47	20.35	17.62	86.68	12.07	8.13
CD (P=0.05)	NS	5.26	9.69	14.37	8.39	6.83	5.13	NS	NS	NS	NS	2.77

kg N/ha significantly increased the tiller population. The percent increase in the number of tillers due to nitrogen and FYM was found maximum with the genotype 'CoS 99259' (29.9%), however, the increase by 'CoH 110' was not found significant.

The number of millable canes (NMC) was observed significantly highest by the genotype 'CoH 110' (128.5 thousand/ha) which was comparable to 'CoLk 9616'. Genotypes 'CoJ 20193' and 'CoS 99259', were found at par in yield with each other. Significantly highest yield was observed with 'CoH 110' which was almost equal to 'CoS 9616'. Growth and yield are strongly linked to N availability in grass crops (Ranjith and Meinzer 1997). The low germination percentages of the genotypes are only due to genotypic variation (Singh *et al* 2002). Tillers are the basis for optimizing the plant density and ultimately contributing to number of Millable Canes (NMC). Higher tillering in the genotype 'CoLk 9616' genotypes is due to their high NUE capability which may also enhanced photosynthetic rate, stomatal conductance, transpiration ratio and leaf area index. Higher number of tiller followed by higher NMC is responsible for targeted yield of the genotype 'CoLk 9616' and 'CoH 110'.

Cane juice quality

The quality parameters of the genotypes significantly varied. Among the quality parameters pol %, purity % and CCS % were found to be significantly higher for the genotype 'CoH 119' and was comparable to the genotypes 'CoJ 20193', 'CoS 99259', 'CoS 96275'. Sugar yield is a function of CCS% and cane yield. The higher sugar yield of the genotype 'CoH 110' (7.64 t/ha) and 'CoS 96275' (7.44 t/ha) were due to higher CCS% and cane yield

N uptake, NUE and Apparent Recovery

The Nitrogen efficiency (NUE) of 'CoH 110' was found highest among midlate maturing genotypes (304.7 kg cane/kg N), followed by 'CoLk 9616' (267.7 kg cane/kg N) and 'CoJ 99192' (207.7 kg cane/kg N) at 150 kg N/ha (Table 2). The nitrogen uptake by different genotypes varied according to their yield potential. 'CoH 110'accounted for the highest N uptake (134.8 kg N/ha) at 150 kg N + FYM application . The N recovery was also observed highest (52.5%) with the genotype 'CoH 110'.The wider root spread (29.2 cm), feeding zone (3.18m3/stool), high root volume (78.0 cc) longer length of roots (34.5 cm) were recorded for the genotype 'CoH 110' which was followed by 'CoLk 9616' and 'CoJ 99192'.Root growth and feeding cane root parameters were directly influenced by application of FYM @ 10 t/ha along with 150 kg N/ha. The increase in NUE of the genotypes under study may be due to application of FYM in the treatment resulted in improvement of soil conditions (Singh *et al* 2007). The number of root hairs in upper and lower portion of roots may also play an important role in increasing the NUE. Yadav *et al* (1997) demonstrated that the responses and N recovery declined sharply as the N dose increased from 75 to 300 kg/ha to sugarcane grown in subtropical region. It is to be noted that

Table 2 Nitrogen uptake, use efficiency, apparent recovery and root characters of different mid- late sugarcane genotypes

Genotypes	*N uptake (Kg/ha)	*NUE (Kg cane /Kg N)	*Apparent N recovery (%)	Root spread (cm)	Feeding zone (m3/stool)	Root Intensity (g/m3)	Root volume (cc)	Root lenth (cm)	Number of root hairs/cm root length/clump
'CoJ 20193'	76.00	146.67	21.08	24.3	0.017	18054	45.87	26.92	758.93
'CoS 99259'	64.75	138.67	26.04	22.3	0.015	18917	43.80	27.22	524.89
'CoS 96275'	75.77	217.33	37.41	23.3	0.016	18092	57.76	53.31	1332.75
'CoPant 99214'	55.45	197.33	19.27	20.8	0.014	17767	41.98	29.70	750.94
'CoH 110'	95.49	304.67	52.45	29.2	0.032	11434	78.03	34.48	1942.62
'CoH 119'	83.39	170.33	29.48	21.7	0.015	22642	43.79	29.88	738.06
'CoLk 9616'	94.39	267.67	44.15	25.8	0.025	11954	65.57	35.23	1491.17
'CoJ 99192'	96.06	207.67	40.49	25.5	0.022	13691	45.81	31.05	1308.54
CD (P=0.05)				-	-	-	-	6.78	354.6
N levels									
0- control				20.8	0.012	22917	42.33	38.20	581.76
150 kg N /ha				25.4	0.021	14593	55.64	30.57	1208.33
10 t FYM				22.3	0.016	17752	51.56	30.82	1133.93
150kg N +10t FYM				27.8	0.028	11014	61.77	34.31	1499.92
CD (P=0.05)								3.26	286.9

* observed at 10 t FYM/ha + 150Kg N/ha

the highest response and N recovery are obtained at lower level of N dose (75 kg/ha). It is admitted that N recovery barely exceeds 30 to 40 %. After application, a part is used by plants, a part remains in the soil, and remaining is depleted through gaseous loss and leaching. Applied nitrogen from soil whether cropped or uncropped may be lost through leaching, NH_3 Volatilization, Nitrification, Denitrification, Run off, NH_4 fixation, Biological immobilization including the uptake of nitrogen by plants, weeds and microbes.

REFERENCES

Gupta A P. 1977. Method for assessment of sugarcane quality. *Indian Sug. Crop J.* **4**: 87-88.

Hartemink A E. 2008. Sugarcane for bioethanol : Soil and environmental issues. *Advances in Agronomy* **99**:125-182.

Lal M and Singh A K. 2002. Importance of plant nutrient management in sugarcane. *Fertilizer News*. **47**(11):91-98.

Meade G P, Chen J C P. 1977. Cane Sugar Hand Book. Edn. 10. John Wiley & Sons, New York.

Panse V G and Sukhatme P V. 1985. Statistical Methods for Agricultural workers. Indian Council of Agricultural Research, New Delhi.

Peter J T, Elizabeth A M and Mervyn E P. 2005. Modelling nitrogen dynamics in sugarcane systems: Recent advances and applications. *Field crops research* **92** (2-3): 337-351.

Ranjith S A and Meinzer F C. 1997. Physiological correlates of variation in Nitrogen – Use Efficiency in two contrasting sugarcane cultivars. *Crop Sci*. **37**: 818-825.

Singh A K, Lal M and Prasad S R. 2002. Enhancing productivity of early maturing high sugarcane genotypes through management of crop geometry and nitrogen nutrition. *Indian Journal of Sugarcane Technology* **17,** 1&2: 43-46.

Singh K P, Suman A, Singh P N and Lal M. 2007. Yield and soil nutrition balance of sugarcane plant- ratoon system with conventional and organic nutrient management in subtropical India. *Nutrient Cycl. Agroecosyst* ***79:**209-219.*

Uribelarrea M, Moose S P, Below F E. 2006. Divergent selection for grain protein affects nitrogen use in maize hybrids. *Field Crops Research* **100**: 82-90

Yadav R L, Singh R V, Singh R and Srivastava V K. 1997. Effect of planting geometry and fertilizer N rates on nitrate leaching, nitrogen use efficiency and sugarcane yield. *Tropical Agriculture* (Trinidad). **74**: 115-120.

Yadav R L, Sharma R K. 1978. Correlation and regression studies between yield and its attributes in sugarcane varieties. *Indian J. Sug. Cane Technol*. **1:** 17-22.