Indian Journal of Sugarcane Technology **28(01)**: 12-15, June 2013

Improving soil fertility and yield and quality of sugarcane through integrated application of NPK and compost in calcareous soils of Bihar

S K THAKUR[1], GEETA KUMARI[2], M ALAM[3] and V P SINGH[4]

Sugarcane Research Institute, Rajendra Agricultural University, Pusa, Bihar-848125

ABSTRACT

A field experiment was conducted at Sugarcane Research Institute, Pusa, Bihar during 2008-09 and 2009-10 to evaluate the integrated application of different levels of NPK and compost in improving soil fertility, cane yield and juice quality in calcareous soils of Bihar. The experiment was laid out in a factorial randomized block design with two levels of compost (0, 20 t/ha) and five levels of N-P-K (150 - 37.4 - 49.8, 150 - 44.0 - 66.4, 200 - 44.0 - 83.0, 200 - 55.0 - 99.6 and 250 - 55.0 - 99.6 kg/ha) with three replications. The results revealed that yield attributes *viz.,* tillers, number of millable canes (NMC) and single cane weight were significantly influenced due to increasing levels of fertilizers and compost. The cane yield (84.2 t/ha) was significantly higher in treatment receiving N-P-K (200 - 44.0 - 83.0 kg/ha) over recommended dose of fertilizers (RDF - 69.5 t/ha) receiving N-P-K (150 - 37.4 - 49.8 kg/ha) and it was on par with other treatment. Juice quality remains unaffected due to different levels of fertilizers and compost. Sugar yield and uptake of nutrients followed the similar trend as the cane yield in different treatments. The post harvest soil showed significant improvement in organic carbon content and available soil nutrient status (N, P and K) due to increasing levels of fertilizer and compost. The available N, P and K was highest (258.2, 13.8 and 121.9 kg/ha in maximum level of fertilizers and lowest in RDF (233, 10.4 and 90.4 kg/ha). The interaction effects of compost and fertilizer combinations were non-significant. Thus, the results indicated that application of compost @ 20 t/ha alongwith N-P-K @ 200 - 44.0 - 83.0 kg/ha was found suitable for improving soil fertility, cane yield and juice quality in calcareous soils of Bihar.

Key words: Compost, Integrated nutrient management, NPK, Sugarcane yield and quality.

Sugarcane (*Saccharum* spp. hybrid complex) is an important cash crop of India which is cultivated in an area of about 5.0 million hectare with an average productivity of 68.6 tonnes/ha. The average productivity of the sugarcane in the state has been around 40-50 t/ha in the last decade due to adoption of highly exhaustive, intensive and monocropping system , imbalanced use of chemical fertilizers, least attention paid on addition of organic manures and non-inclusion of pulses in the prevalent cropping systems. The per hectare consumption of fertilizers in Bihar is 162.2 kg/ha which is higher than national average (133.2 kg/ha) but mostly depends on N fertilizer (Indian Fertilizer Scenario 2010). Nitrogen deficiency may decrease cane yields while, excess N availability during the ripening period reduces the juice quality (Tabayoyong and Robeniol 1962). The use of only organic manure or chemical fertilizers is not advantageous due to their limited availability and higher input cost for sustainable crop production. The long-term experiments conducted on manures and fertilizers in sugarcane proved that neither the chemical fertilizer alone nor the organic source exclusively can achieve production sustainability of soil and crop (Singh and Biswas 2000). Application of balanced fertilizers is an important management practice for increasing sugarcane and sugar production. The soil fertility has declined due to insufficient use of soil organic matter and imbalanced use of chemical fertilizers. The application of K fertilizer is very low as compared to its removal from soil. Sugarcane is an exhaustive crop which removes about 205 kg N, 24 kg P, 229 kg K , 30 kg S , 3.5 kg Fe, 1.2 kg Mn, 0.6 kg Zn and 0.2 kg Cu from the soil for the cane yield of 100 t/ha (Singh *et al.* 2007). The crop is responding to higher levels of fertilizers than that of recommended doses for its biomass production. This warrants effective and efficient restoration and sustenance of soil fertility which can only be possible through judicious combination of organic and inorganic fertilizers. Application of organic manures or chemical fertilizers in isolation is not only unfeasible due to their limited availability and higher input cost but also not advantageous for sustained crop production. Therefore, it is imperative to reassess the current fertilizer recommendation in the state for sustained sugarcane production. The present study aimed to study the response of sugarcane crop to different levels of NPK in conjunction with compost on improving soil fertility, cane yield and juice quality in calcareous soils of Bihar.

[1] Sr. Scientist, [2] Jr. Scientist, [3] Director, SRI, Pusa and [4] Director Research, RAU, Pusa

MATERIALS AND METHODS

The field experiments were conducted during 2008-09 to 2009-10 at the Sugarcane Research Institute, Pusa, Bihar (25°57' N, 85°40' E, 52.0 m above mean sea level) to assess the effect of different levels of NPK and compost on improving soil fertility, cane yield and juice quality in calcareous soils of Bihar. The climate of Bihar is subtropical and mean annual rainfall of the area is about 1200 mm. The experiment was laid out in a factorial randomized block design with two levels of compost (0, 20 t/ha) and five levels of N-P-K (150-37.4-49.8, 150-44.0- 66.4, 200-44.0-83.0, 200-55.0-99.6 & 250-55.0-99.6 kg/ha) with three replications. Nutrient content of compost (N-P-K: 0.48 -0.19 – 0.44%) were analyzed on dry weight basis. The compost was applied at the time of planting in furrow and mixed with desi plough. The recommended dose of fertilizers is 150-37.4- 49.8 kg/ha. The experimental soil was sandy loam, calcareous ($CaCO_3$ 29.2 %) having pH 8.31 and EC 0.18 dS/m. The soil was low in organic C (0.480 %), available N, P and K (232, 10.6 and 97.9 kg/ha). The NPK fertilizers were applied through urea (46% N), diammonium phosphate (18% N and 46% P_2O_5) and muriate of potash (60% K_2O), respectively. Nitrogen was applied in split doses, half at the time of planting, one fourth at the time of first irrigation and rest one at the time of earthing up *i.e.* on onset of monsoon. The mid late variety of sugarcane 'BO 137' was planted at a row distance of 90 cm in last week of February and harvested after one year. Four irrigations were given before monsoon. Other recommended practices for sugarcane crop were followed to raise the crop. Soil samples were collected initially and after harvest of crop were analyzed for organic carbon, available N, P, K contents by method described by Jackson (1973). Cane juice was extracted with power crusher and juice quality was estimated as per method given by Spencer and Meade (1955). Sugar yield was calculated as; Sugar yield (t/ha) = [S-0.4(B-S) x 0.73] x cane yield (t/ha) / 100; where S and B are sucrose and brix percent in cane juice. Whole cane samples were analyzed for N, P and K contents. The uptake of N, P and K were calculated by multiplying their concentration with dry matter yield. The economics was worked out on prevailing market prices using pooled data considering input and output of last year of study.

RESULTS AND DISCUSSION

Cane and Sugar yield

The application of different levels of NPK and compost had significant impact on tillers, number of millable canes (NMC), cane length, single cane weight and cane yield while, the effect on germination was non- significant (Table 1). The highest number of tillers (156300/ha), millable cane (118800/ha), cane length (236 cm) and single cane weight (762.2 g) were significantly higher in F_5 receiving maximum level of fertilizers over control F_1 but on par with F_4 and F_3. Sugarcane productivity in different treatments was influenced significantly by integrated application of NPK and compost. The cane yield (84.2 t/ha) was significantly higher in F_3 receiving NPK of 200-44.0-83.0 kg/ha over control (RDF: 150-37.4-49.8 kg/ha) and was on par with F_4 and F_5. However, highest cane yield (86.1 t/ha) was recorded in F_5 and lowest in control (69.5 t/ha). This could be attributed to higher yield attributing characters like NMC and average cane weight due to increasing levels of fertilizers which contributed directly to the higher yield. The application of compost along with the NPK fertilizers further significantly increased the cane yield. This might be due to immediate and quick supply of plant nutrients through inorganics and steady supply of plant nutrients by organics throughout the growth period of the crop. Virdia and Patel (2010) reported that organics released nutrients following decomposition and mineralization that would have increased the availability of plant nutrients at later stage and brought improvement in physical, chemical and biological properties of soil. As a result of this, the fertility status of the soil might have increased and thus increasing the absorption of plant nutrients. Hence, more tillers were converted into NMC which lead to more yield. The results are in agreement with the findings of Khan *et al.* (2005) and Thakur *et al.* (2007). Fertilizers are the costlier input. The economics is the important

Table 1 Effect of NPK and compost on cane yield and yield attributing characters

Treatment	Germination (%)			Tillers (000/ha)			Cane length (cm)			NMC (000/ha)			Single Cane weight (g)			Cane Yield (t/ha)		
	C_0	C_1	Mean	C_0	C_1	Mean	C_0	C_1	Mean	C_0	C_1	Mean	C_0	C_1	Mean	C_0	C_1	Mean
F_1	34.5	34.0	34.3	123.5	140.9	132.2	209	216	213	101.5	107.9	104.7	696.0	708.0	702.0	67.4	71.5	69.5
F_2	35.4	34.9	35.2	131.0	143.2	137.5	211	225	218	102.9	115.5	109.2	723.5	729.5	726.5	70.9	80.6	75.6
F_3	34.9	33.6	34.3	145.0	151.8	148.2	229	226	228	109.4	121.2	115.3	732.0	759.0	745.5	81.2	87.5	84.2
F_4	35.1	34.8	35.0	148.4	152.9	150.7	224	226	225	114.2	117.8	116.0	745.5	753.5	749.5	81.5	88.1	84.8
F_5	35.1	34.2	34.7	150.7	161.9	156.3	239	232	236	114.9	122.3	118.8	759.5	765.0	762.2	82.6	89.0	86.1
Mean	35.0	34.3		139.6	150.3		222	225		108.6	116.1		731.3	741.0		76.9	84.0	
	C	F	C x F	C	F	C x F	C	F	C x F	C	F	C x F	C	F	C x F	C	F	C x F
SEm±	1.0	1.6	2.2	2.4	3.7	5.3	2.7	3.1	1.6	1.7	2.7	3.4	6.3	9.9	14.1	1.4	2.3	3.2
CD (P=0.05)	NS	NS	NS	6.7	10.6	NS	NS	9.0	NS	4.8	7.6	NS	NS	28.4	NS	4.1	6.5	NS

F_1:150-37.4- 49.8; F_2:150–44.0 -66.4; F_3:200-44.0-83.0; F_4:200-55.0-99.6 & F_5:250-55.0-99.6
Pooled data of two years (2008 – 09 & 2009 -10)

parameter for recommendation of fertilizers. The highest net profit (Rs. 104797/ha) was observed in highest level and lowest in control (Rs.74026/ha). But, as per benefit: cost (B: C) ratio, it was observed that application of fertilizer NPK @ 200-44.0-83.0 kg/ha gave the highest B: C ratio (2.56) and addition of fertilizer alongwith compost also exhibited comparatively higher B: C ratio (2.57) indicating the suitability of these treatments for increasing sugarcane production (Table 2). The significantly higher sugar yield (10.5 t/ha) were observed in F_5 over control F_1 (8.45 t/ha) but on par with F_4 and F_3. Since, brix and sucrose percent in cane juice was not affected significantly with different levels of fertilizers and compost. Sugar yield, which is function of cane yield and CCS% followed almost similar trend with that of cane yield.

Nutrient uptake

Uptake of nutrients (NPK) by sugarcane crop increased significantly with different levels of NPK and compost (Table 3). Uptake of N, P and K varied from 151.6 -213.7, 13.8- 18.9 and 170.0 -229.2 kg/ha, respectively due to different levels of fertilizers. The highest crop yield and nutrient uptake was recorded in F_5, while the lowest values were recorded in F_1. The addition of compost with inorganic fertilizers further increased nutrient uptake by sugarcane crop. The results thus indicated that integration of nutrients had beneficial impact on availability of N, P and K in soil resulting to more uptakes. Addition of organic manures also helped in increasing the availability of nutrients resulting higher uptake of nutrients by crops. The results further indicated that among the major nutrients, relatively higher uptake of K was recorded followed by N and P irrespective of treatments. The results are in close agreement with the findings of Thakur *et al.* (2012).

Soil fertility

Available soil nutrients (N, P & K) and organic carbon content of soil after the harvest of the sugarcane increased significantly due to different levels of NPK and compost (Table 4). Soil organic carbon was significantly higher in increasing levels of NPK fertilizers over control (RDF). The soil organic carbon (0.501%) was significantly higher in F_3 which is on par with F_4 and F_5. Addition of compost further improved the soil organic carbon of the soil. This might be due to stimulated growth and activity of microorganisms on account of improved rhizospheric environment resulting better root and shoot growth which ultimately leads to accumulation of higher biomass in the soil. These results corroborates with the findings of Thakur *et al.* (2010). The highest available N, P and K (258.2, 13.82 and 121.9 kg/ha) was registered in treatment

Table 2 Effect of NPK and compost on juice quality parameters and economics

Treatment	Brix (%)			Sucrose (%)			Purity (%)			Sugar Yield (t/ha)			Net profit (Rs./ha)			B:C ratio		
	C_0	C_1	Mean	C_0	C_1	Mean	C_0	C_1	Mean	C_0	C_1	Mean	C_0	C_1	Mean	C_0	C_1	Mean
F_1	20.0	20.4	20.2	17.37	18.17	17.77	86.9	89.1	88.0	7.7	9.2	8.45	72026	76026	74026	2.14	2.14	2.14
F_2	20.2	19.7	20.2	17.70	17.19	17.45	87.8	87.4	87.6	8.3	9.4	8.85	78591	93793	86192	2.24	2.39	2.32
F_3	20.1	20.1	20.1	17.49	17.41	17.82	87.3	86.7	87.0	9.4	10.6	10.0	98463	100863	99363	2.54	2.57	2.56
F_4	20.4	20.2	20.3	17.71	17.92	17.54	87.1	88.7	87.9	9.9	10.9	10.4	98464	107464	102964	2.53	2.56	2.55
F_5	20.1	20.0	20.1	17.56	17.51	17.54	87.4	87.8	87.6	10.4	10.7	10.5	100097	109497	104797	2.53	2.57	2.55
Mean	20.2	20.1		17.57	17.64		87.3	87.9		9.4	10.2	9.6	89258	97528		2.40	2.48	
	C	F	C x F	C	F	C x F	C	F	C x F	C	F	C x F						
SEm±	0.1	0.2	0.2	0.07	0.12	0.17	0.3	0.5	0.9	0.2	0.3	0.4						
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	0.5	0.9	NS						

F_1:150-37.4- 49.8; F_2:150–44.0 -66.4; F_3:200-44.0-83.0; F_4:200-55.0-99.6 & F_5:250-55.0-99.6
Pooled data of two years (2008 – 09 & 2009 -10)

Table 3 Effect of NPK and compost on uptake of nutrient (kg/ha).

Treatment	Uptake of Nutrient (kg/ha)								
	N			P			K		
	C_0	C_1	Mean	C_0	C_1	Mean	C_0	C_1	Mean
F_1	142.9	160.3	151.6	12.9	14.6	13.8	157.6	182.4	170.0
F_2	152.1	175.5	163.8	13.9	16.6	15.2	171.0	200.4	185.7
F_3	181.5	215.4	198.5	15.9	19.0	17.5	197.8	233.1	215.4
F_4	187.9	218.2	203.0	16.8	19.1	17.9	216.3	242.1	229.2
F_5	201.4	226.1	213.7	17.7	20.1	18.9	230.0	251.8	204.9
Mean	173.2	199.1		15.4	17.9		194.5	221.9	
	C	F	C x F	C	F	C x F	C	F	C x F
SEm±	3.1	4.8	7.0	0.3	0.5	0.7	3.9	6.3	8.9
CD (P=0.05)	8.9	14.2	NS	0.9	1.5	NS	11.3	17.9	NS

F_1:150-37.4- 49.8; F_2:150–44.0 -66.4; F_3:200-44.0-83.0; F_4:200-55.0-99.6 & F_5:250-55.0-99.6
Pooled data of two years (2008 – 09 & 2009 -10)

Table 4 Effect of NPK and compost on organic carbon and available soil nutrients on post harvest soil

Treatment	Organic carbon (%)			Available Soil Nutrients (kg/ha) N			P			K		
	C_0	C_1	Mean	C_0	C_1	Mean	C_0	C_1	Mean	C_0	C_1	Mean
F_1	0.467	0.479	0.479	229.5	236.5	233.0	9.42	11.48	10.43	88.4	92.5	90.4
F_2	0.475	0.506	0.491	235.0	248.0	241.5	10.69	12.19	11.40	95.4	98.9	97.1
F_3	0.481	0.521	0.501	240.0	255.0	247.5	11.40	12.80	12.10	106.7	11.4	94.1
F_4	0.489	0.527	0.508	245.0	260.0	252.5	12.23	13.49	12.85	115.3	121.3	118.3
F_5	0.487	0.531	0.509	247.5	269.0	258.2	12.98	14.70	13.82	116.9	127.0	121.9
Mean	0.480	0.515		239.4	253.7		11.31	12.94		104.5	110.2	
	C	F	C x F	C	F	C x F	C	F	C x F	C	F	C x F
SEm±	0.004	0.007	0.009	1.8	2.9	4.0	0.35	0.57	0.82	1.0	1.6	2.2
CD (P=0.05)	0.011	0.02	NS	5.2	8.2	NS	1.06	1.67	NS	2.8	4.5	NS

F_1:150-37.4- 49.8; F_2:150–44.0 -66.4; F_3:200-44.0-83.0; F_4:200-55.0-99.6 & F_5:250-55.0-99.6
Pooled data of two years (2008 – 09 & 2009 -10)

receiving highest level of fertilizers (NPK) and lowest in control (233.0, 10.43 and 90.4 kg/ha). Application of compost in conjunction with inorganic fertilizers significantly improved the available NPK in post harvest soil. This could be attributed to greater microbial activity due to addition of compost which resulted higher mineralization leading to higher available N while, improved P might be due to reduced P sorption and K might be due to addition of K in available pool due to mineralization. These results are in conformity with the findings of the Thakur *et. al* (2012) and Patel *et.al* (2010).

The results of this study indicated that integrated application of N-P-K @ 200 - 44.0- 83.0 kg/ha and compost @ 20t/ha was found beneficial for improving soil fertility, cane yield and juice quality in calcareous soils of Bihar.

REFERENCES

Indian Fertilizer Scenario. 2010. Department of fertilizers, ministry of chemicals and fertilizers, Government of India. *p*-60.

Jackson M L. 1973. *Soil Chemical Analysis*, Prentice Hall of India Private Limited, New Delhi.

Khan I M, Khatri A, Nizamani G H, Siddiqui M A, Raza S and Dahar N A. 2005. Effect of NPK fertilizers on the growth of sugarcane clone AEC86-347 developed at NIA, Tando Jam, Pakistan. *Pak. J. Bot.* **37** (2): 355- 360.

Patel V S, Raj V C and Patel D D. 2010. Effect of different sources and levels of organics on sugarcane (*Saccharum officinarum). Indian J. Agron.* **55(**2):152-156.

Singh G B and Biswas B P. 2000. Balanced and integrated nutrient management for sustainable crop production. Limitations and future strategies. *Fert. News* **45**(5): 55-60

Singh K P, Suman A, Singh P N and Lal M. 2007 yield and soil nutrient balance of a sugarcane plant – ratoon system with conventional and organic nutrient management in sub –tropical India. *Nutr Cycl Agroecosyst*.**79**:209-219.

Spencer G L and Meade GP. 1955. *Cane Sugar Hand Book.* John Wiley and Sons, London.

Tabayoyong F T and Robeniol M. 1962. Yield response of sugarcane fertilizers. *Proceeding ISSCT,* **11**: 177-185.

Thakur S K, Jha C K, Alam M and Singh V P. 2012. Productivity, quality and soil fertility of sugarcane (*Saccharum* spp complex hybrid) plant and ratoon grown under organic and conventional farming system. *Indian J. of Agric. Sci.* **82** (10): 896 -99.

Thakur S K, Alam M and Umesh U N. 2007. Long term effect of integrated nutrient management on productivity and sustainability of sugarcane in calciorthent. *Indian J. Sugarcane Technol.* **22** (1&2): 9-13.

Thakur S K, Jha C K, Kumari G and Singh V P. 2010. Effect of *Trichoderma* inoculated trash, nitrogen level and biofertilizer on performance of sugarcane (*Saccharum officinarum*) in calcareous soils of Bihar. *Indian J. Agron.*, **55**(4) 55-58.

Virdia H M and Patel C L. 2010. Integrated nutrient management for sugarcane (*Saccharum* spp. hybrid complex) plant-ratoon system. *Indian J. Agron.***55(**2):147-151.