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Research Communication

Effect of nitrogen, phosphorus and potassium levels on sugarcane (*Saccharum* spp. hybrid complex) varieties under upland rainfed conditions of Bihar

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ABSTRACT

A field experiment was conducted during the spring season of 2015–16 on sandy-loam soil, to evaluate the effect of NPK levels (50, 75 and 100% of the recommended dose) on productivity and profitability of sugarcane (*Saccharum* spp. hybrid complex) varieties ('BO 130', 'BO 139', 'BO 153', 'CoP 9301' and 'CoLk 94184') under sub-humid, sub-tropical upland rainfed conditions of Pusa, Bihar (25° 59' N, 85° 40' E). Among the varieties, 'BO 139' showed the highest cane diameter (2.44 cm) and single cane weight (812 g). Variety 'BO 153', being equally efficient in producing millable canes and cane yield with 'CoLk 94184' and 'BO 130', were significantly found superior to 'CoP 9301' and 'BO 139'. The sucrose content (18.34 %) obtained with 'CoP 9301' was on a par with that of 'BO 139' (18.00%) and significantly higher over rest of the varieties, whereas 'BO 153' recorded the highest net returns (₹94,000/ha) and benefit: cost ratio (1.26), followed by 'BO 130', 'CoLk 94184', 'BO 139' and 'CoP 9301'. Among the fertility levels, 100% recommended dose of NPK, being at par with 75% recommended dose of NPK, recorded the significantly highest millable canes (93,400/ha), cane diameter (2.27 cm) and cane : top ratio (4.0) over 50% recommended dose of NPK. Application of 100% recommended dose of NPK also resulted in significantly higher cane yield (64.1 t/ha), sucrose content (18.15%), gross returns (₹163,400/ha), net returns (₹86,700/ha) and benefit: cost ratio (1.13). However, the differences between 75 and 100% recommended dose of NPK were non-significant. Sugarcane 'BO 153' can be grown for higher yield and economic returns with application of 75% recommended dose of NPK under upland rainfed conditions.

Key words: Cane yield, Economics, NPK levels, Sugarcane varieties, Upland rainfed conditions

Sugarcane is an important cash crop having multiple uses. In India, it is cultivated in 5.14 million ha area with average annual production and productivity of 359.3 million tonnes and 69.9 t/ha, respectively (NFCSL, 2015). In Bihar, which lies in sub-humid, sub-tropical region of India, sugarcane is cultivated in an area of 0.25 million ha, of which only 67.28% is irrigated and the remaining is totally rainfed (DES, 2014). As sugarcane is an irrigated crop, economic reasons compel farmers to grow sugarcane under rainfed conditions. Soil depth, profile soil moisture-storage capacity, and amount and distribution of rainfall govern sugarcane yields. The area normally receives an average annual rainfall of 1,097 mm, which is mostly erratic, causes excess and deficient moisture condition during grand growth stage of crop. Being a crop with great water demand, sugarcane is likely to suffer from moisture stress when grown under rainfed condition, which is further aggravated by hot summer months occurring during the formative and grand growth stages of sugarcane crop in Bihar. Poor yield obtained under rainfed conditions is one among many factors accounting for lower its productivity of the state. Lack of suitable variety for the area is also a production constraint. Productivity of rainfed sugarcane can be increased with improved agronomic practices like substitution of traditional variety and application of fertilizer. The selection of suitable variety can improve yield in the range of 28 to 60% (Kathiseran *et al.,* 2001). Further, varietal difference is crucial in determining the ability of varieties to use applied nutrients (Singh *et al.,* 2011). The major hurdles in increasing the productivity are poor soil in which the crop is grown and improper fertilization. Application of NPK in right proportion and in optimum quantity for specific soil-climatic condition is the key for sustained crop production. But in view of its inadequacy and low availability of nutrients, productivity of sugarcane per unit area is very low. Therefore, soil fertil-

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ity and varietal management is of utmost importance. As the works done in sugarcane under rainfed conditions are limited, the present experiment was undertaken to identify suitable variety and appropriate NPK level under such conditions in calcareous soil of Bihar.

The field experiment was conducted at the Sugarcane Research Institute, Pusa, Bihar, during the spring season of 2015–16 with 5 early-maturing sugarcane varieties, viz. 'BO 130', 'BO 139', 'BO 153', 'CoP 9301' and 'CoLk 94184', and 3 NPK levels, viz. 50, 75 and 100% recommended dose of fertilizer, using in randomized block design with 3 replications. The soil of the experimental site was sandy loam in texture and alkaline in reaction (*p*H 8.3), low in organic carbon (0.43%) and available N (215.3 kg/ha) and medium in P (10.3 kg/ha) and K (118.9 kg/ha). The recommended dose of NPK (100%) for normal condition was 150 : 37.1 : 49.8 kg N : P : K/ha. Each experimental plot received farmyard manure @ 20 t/ha, while half of N and full doses of P and K as per treatment were applied basal and remaining N was top-dressed at the time of earthing-up. The crop was fertilized with urea, diammonium phosphate and muriate of potash. Three-bud sets were planted in furrow at the row distance of 90 cm.The crop was planted on 16 February 2015 and harvested in 28 January 2016. Total rainfall during the period of investigation was 932.6 mm, of which the maximum was received in August (456.8 mm). The maximum temperature of 36.7°C during the experimentation was recorded in June, whereas the minimum in January. The maximum relative humidity 91% in August and the minimum 43% in April. Agronomic practices and plant-protection measures were carried out uniformly, whenever required. Soil samples from 0–15 cm depth was taken periodically at the time of planting, 60 days after planting (DAP) and 120 DAP for moisture-depletion pattern measurement. The soil-moisture content at planting, 60 DAP and 120 DAP were 13.5, 18.6 and 16.9%, respectively, and their respective values for available soil moisture as compared to field capacity were 59.7, 82.3 and 74.8% respectively. Data recorded on growth, yield attributes, yield and quality parameters at various stages in the experimentation were analysed as per the standard statistical procedures. Juice sucrose per cent was estimated as per method given by Spencer and Meade (1964).

Varieties differed significantly with respect to various yield attributes (Table 1). Variety 'BO 153' gave more millable canes (96,700/ha), which was significantly higher than 'CoP 9301' (84,600/ha) and 'BO 139' (67,900/ha), but at par with 'CoLk 94184' (92,500/ha) and 'BO 130' (92,300/ha). Variety 'BO 139' recorded significantly higher cane diameter (2.44 cm) and single cane weight (812 g) than the other varieties, and 'CoP 9301' and 'BO 153' were at par with each other in respect to cane : top ratio. Singh *et al.* (2008) also reported variation in yield attributes among different varieties of sugarcane. With successive increase in NPK levels from 50 to 75% recommended dose, the millable canes, cane diameter and cane : top ratio increased significantly (Table 1). The highest millable canes (93,400/ha), cane diameter (2.27 cm) and cane : top ratio (4.0) were obtained with 100% recommended dose of NPK, which was significantly higher than 50% recommended dose of NPK but was at par with 75% recommended dose of NPK.

Variety 'BO 153' gave significantly higher cane yield

Table 1. Effect of varieties and NPK levels on yield attributes, yield, quality and economics of sugarcane

Treatment	Millable canes ($\times 10^3$/ha)	Cane diameter (cm)	Single cane weight (g)	Cane: top ratio	Cane yield (t/ha)	Sucrose (%)	TC: TS ratio	Total cost ($\times 10^3$₹/ha)	Gross returns ($\times 10^3$₹/ha)	Net returns ($\times 10^3$₹/ha)	Benefit: cost ratio
Variety											
'BO 130'	92.3	2.11	673	3.6	60.8	17.79	8.13	74.6	155.1	80.5	1.08
'BO 139'	67.9	2.44	812	2.8	54.3	18.00	8.10	74.6	138.5	63.8	0.85
'BO 153'	96.7	2.13	695	3.9	66.1	17.45	8.19	74.6	168.6	94.0	1.26
'CoP 9301'	84.6	2.06	623	4.2	51.4	18.34	8.04	74.6	131.2	56.5	0.75
'CoLk 94184'	92.5	2.10	667	3.2	60.1	17.87	8.17	74.6	153.3	78.6	1.05
SEm±	3.06	0.072	32.1	0.09	2.24	0.130	0.065	–	5.71	3.79	0.038
CD (P=0.05)	8.9	0.21	93.0	0.3	6.50	0.38	NS	–	16.6	11.0	0.11
NPK level (% recommended dose)											
50	78.8	2.03	664	2.7	51.5	17.54	8.29	72.5	131.3	58.8	0.81
75	88.2	2.21	698	3.9	60.1	17.98	8.08	74.6	153.2	78.6	1.05
100	93.4	2.27	720	4.0	64.1	18.15	8.00	76.7	163.4	86.7	1.13
SEm±	2.37	0.056	24.9	0.07	1.74	0.101	0.050	–	4.43	2.93	0.029
CD (P=0.05)	6.9	0.16	NS	0.2	5.0	0.29	0.15	–	12.8	8.5	0.08

Selling price of sugarcane, ₹2,550/t

(66.1 t/ha), which was statistically similar to 'BO 130' (60.8 t/ha) and 'CoLk 94184' (60.1 t/ha) and out yielded 'BO 139' and 'CoP 9301' with a magnitude of 21.7 and 28.6% respectively. This could be attributed to its growth and yield attributes. Similar results were reported by Shankar (2015) and Oliveira *et al.* (2016). Significantly higher sucrose percentage was obtained with the variety 'CoP 9301' (18.34%). However, the differences between 'CoP 9301' and 'BO 139' were not significant (Table 1). Improvement in sucrose content in 'CoP 9301' was owing to its genetic potential compared to the other varieties. Chakrawal and Kumar (2014) also observed significant improvement in sucrose content juice owing to different varieties. Varieties did not differ significantly for unit amount of cane required to produce unit amount of sugar (TC : TS ratio).

There was a progressive increase in cane yield and sucrose content with increasing NPK level up to 75% recommended dose (Table 1). Application of 100% recommended dose of NPK recorded significant increase of 24.5% in cane yield and 3.5% in sucrose content juice over 50% recommended dose of NPK. However, an application of 100% recommended dose of NPK was at par with 75% recommended dose of NPK with respect to cane yield and sucrose content juice. No marked response of NPK beyond 75% recommended dose might be attributed to nutrient imbalances and consequent metabolic disturbances in absence of optimum soil moisture at formative stage of crop growth under upland rainfed condition leads to comparatively lesser plant population and cane yield. Naidu *et al.* (2008) and Kumar *et al.* (2012) also reported increase in cane yield with increasing fertility levels. Different NPK levels had significant impact on TC : TS ratio. The significantly highest value (8.29), being observed with the application of 50% recommended dose of NPK, indicated the negative relationship between NPK levels and TC : TS ratio.

The highest gross returns (₹168,000/ha) were obtained with 'BO 153', which was significantly superior to that of 'BO 139' and 'CoP 9301', but were at par with rest of the varieties (Table 1). 'BO 153' gave significantly highest net returns (₹94,000/ha) and benefit: cost ratio (1.26), followed by 'BO 130' and 'CoLk 94184'. The successive increase in recommended dose of NPK up to 75% significantly increased gross returns, net returns and benefit: cost ratio (Table 1). The application of 100% recommended dose of NPK fetched the highest gross returns (₹163,400/ha), net returns (₹86,700/ha) and benefit: cost ratio (1.13), which was at par with 75% recommended dose of NPK, proved significantly better than 50% recommended dose of NPK.

Millable canes, gross returns, net returns and B : C ratio were significantly and positively correlated with cane yield. However, cane diameter, single cane weight and cane : top ratio were positively correlated but did not show significant correlation. Further, correlation and regression analysis accomplished with regression equation, which showed that millable canes (0.7986), gross returns (1.000), net returns (0.9976) and B : C ratio (0.9888) were positively correlated with each other (Table 2). Kumar *et al.* (2009) also reported similar results on millable canes.

On the basis of these results, it can be concluded that 'BO 153' is a better variety for getting higher profitability and application of 75% recommended dose of NPK was found optimum for maintaining higher sugarcane productivity and profitability in upland rainfed conditions of Bihar.

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Table 2. Correlation coefficient (r) and regression equations (R^2) showing relationship between independent variables and dependent variables

Dependent variable	Independent variable	r	R^2	Response equation (y = a + bx)
Sugarcane yield (t/ha)	Millable canes (×10³/ha)	0.7986	0.6378	15.4368 + 0.4965×
	Cane diameter (cm)	0.2832	0.0802	31.9992 + 12.2513×
	Single cane weight (g)	0.2100	0.0441	42.5901 + 0.0230×
	Cane : top ratio	0.4117	0.1695	47.8090 + 3.0543×
	Sucrose (%)	–0.0225	0.0005	65.6969 – 0.3989×
	TC : TS ratio	–0.3476	0.1208	194.8381 – 16.7734×
	Gross returns (₹/ha)	1.0000	1.0000	–0.0115 + 0.3923×
	Net returns (₹/ha)	0.9976	0.9951	27.4116 + 0.4169×
	Benefit: cost ratio	0.9888	0.9777	25.9082 + 32.7173×

*P=0.05; **P=0.01

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