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Effect of Graded Dose of Potassium on Yield and Juice Quality of Sugarcane Genotypes Grown under Waterlogged Condition in Calcareous Soil

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ABSTRACT

A field experiment related was carried out to study the response of graded dose of fertilizers Potassium (K) on different sugarcane genotypes grown under waterlogged condition in calcareous soil during spring season for two consecutive years. The application of graded doses of potassium fertilizer (K_2O) up to K @120 kg /ha as basal dose was found significantly superior for improving yield attributes and cane yield. The mean cane yield varied significantly and ranged from 54.25-72.49 t/ha among treatments. The highest cane yield was recorded in the treatment receiving K_2O @ 120 kg/ha which was found at par with treatment receiving K_2O @ 90 kg/ha and being lowest in control. The mean sugar yield varied (6.35-8.71t/ha) significantly due to application of graded doses of fertilizer K. Among sugarcane genotypes BO153, COP 2061, COLK 94184 and BO 154 were fighting fit under waterlogged condition over BO 91 **(**Check) in terms of cane yield. The mean value for brix (19.27-20.32%) and pol (16.54-17.67) varied significantly among varieties. However, purity coefficient remains unaffected. The results indicated that the light textured sandy-loam soil rich in free calcium carbonate and low in available K responded well up to application of 200% potassium (120 kg K_2O /ha) for accelerating productivity of sugarcane, however it was on par with 150% potassium (90 kg K_2O /ha). The application of K fertilizer @ 90 and 120 kg/ha resulted in the positive balance of available K in post harvest soil. The soil application of basal dose of K_2O @ 90 kg/ha was found favorable over recommended dose of K_2O (60 kg/ha) for improving productivity of sugarcane grown under waterlogged condition in calcareous soils of Bihar.

Keywords Potassium, Yield , Juice quality, Sugarcane, Waterlogged condition.

INTRODUCTION

Potassium requirement of sugarcane is quite high as compared to other nutrients. Potassium is one of the seventeen elements, which are essential for growth and development of plants. It is a major plant nutrient because of large amount in which it is absorbed by roots is second to that of nitrogen (N) for most of the cultivated plants. Sufficient amount of potassium is required for improving the yield and quality of different crops because of its effect on photosynthesis, water use efficiency and plant tolerance to diseases, drought

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and cold as well for making the balance between protein and carbohydrates. The application of potassium fertilizer in sugarcane increase the soil available K and thereby sugarcane production and juice quality (Kumar *et al.* 2000). The response of potassium in sugarcane may also differ for different varieties of sugarcane as genotypes. Potassium in sugarcane helps in the translocation of sugar and thus primate's higher recovery of sugar. The application of K in the range of 120 or 180 kg K_2O/ha$^-$ along with N can provide higher cane yield and improve further the cane quality attributing characteristics and benefit : Cost ratio and sustain the soil health (Kumar *et al.* 2019). The readily available K constitutes only 1-2% of total K and exists in soil in two forms, viz., solution and exchangeable K adsorbed on soil colloidal surface . These forms remain in a dynamic equilibrium with one another. Nevertheless, due to continuous removal of potassium by crops and through leaching losses from soil, a static equilibrium probably never occurs and there is a continuous but slow conversion of potassium from primary minerals to the exchangeable and slowly available forms (Tisdale *et al.* 1985). The availability of applied K as fertilizer to plants is influenced by soil mineralogy, environmental factors and rate of K application. It has been estimated that in 1980, the available K status of 90% soils of Bihar was high and the remaining 10% were medium. Nevertheless, due to intensive cropping, continuous mining and limited/ no use of K-fertilizer, the available K status of Bihar soils has depleted. About 30, 45 and 25% of Bihar soils have became low, medium and high in available K status, respectively. Soils have begun to show response to K application, particularly under intensive use of N and P fertilizers.

The recommended dose of potassium (60 kg K_2O/ha) and response of sugarcane genotypes need to be assessed for improving sugarcane cultivation under waterlogged condition in Bihar. The cultivation of sugarcane in most of the part of north Bihar faces the problem of water logging and poor aeration, resulting in significant morphological and physiological changes, besides limiting the nutrition of plant. On an average 40% sugarcane growing area in Bihar fall under waterlog condition resulted in significant reduction of cane yield and sugar recovery. Losses due to water logging mainly depends up on depth and duration of water logging and sugarcane genotypes grown. The sugarcane growing farmers of Bihar have a tendency to apply frequent and high dose of nitrogenous fertilizer which leads to deterioration in juice quality, damage by insect-pest, lodging of the cane and soil health. Therefore, a field study was conducted to study effect of potassium application on yield and juice quality of different varieties of sugarcane under waterlogged condition in calcareous soil.

MATERIALS AND METHODS

The experiment was carried to study the response of graded doses of mineral fertilizers potassium (K) on different sugarcane genotypes grown under waterlogged condition during spring season 2012-2014 on sugarcane under station trial at Crop Research Center, RPCAU, Pusa, Bihar. The farm is situated at 25^{o}98' N latitude, 85o 67' E longitude and at an altitude of 52.0 m above mean sea level. The climate of study area was sub-tropical with mean annual rainfall of about 1200 mm out of which 75% received during the monsoon period (mid June - mid September). The experimental farm has hot and humid summers and cold in winters. The mean annual temperature is 24.5^{o}C with maximum 38.6^{o}C during April and minimum 7.4^{o}C in January. The experimental soil was sandy loam in texture with high in free calcium carbonate (> 25%) with moderate in fertility. The pH of initial soil was 8.35, EC 0.44 dS/m and 0.44 % organic carbon. The available N, P and K content of initial surface soil was 228.93, 19.78 and 105.08 kg/ha, respectively. The factors under study comprised of four graded levels of potassium (0, 60, 90 and 120 kg/ha) with recommended dose of fertilizer N and P with six sugarcane genotypes. The experiment was formulated in split plot design with three replications. The different varieties of sugarcane BO 91, BO 110, BO 153, BO 154, COP 2061 and COLK 94184 were planted as per treatments. The recommended dose of fertilizer (RDF;150–85, N–P_2O_5 /ha) were applied through urea and DAP, respectively. The graded doses of potassium 0, 60, 90 and 120 kg K_2O were applied as per treatments. The muriate of potash (60 % K_2O) was used as source of K-fertilizer. The half dose of the nitrogen and full dose of phosphorus and potassium were applied as basal and remaining half dose in two equal splits. The waterlogged condition

Table 1a. Effect of graded doses of potassium on yield attributes and yield of sugarcane.

Treatments K-level	Germination (%)	Tiller ($\times 10^3$/ha)	Plant height (cm)	Cane length (cm)	NMC ($\times 10^3$/ha)	Single cane weight (g)	Cane yield (t/ha)
K0 (Control)	38.70	102.11	204.6	192.5	83.11	795.8	54.25
K60	42.99	128.62	238.2	226.3	90.43	828.8	63.38
K90	38.43	137.84	246.4	232.5	96.85	860.5	71.81
K120	40.03	142.53	259.2	246.1	97.88	868.2	72.49
SEm±	1.88	7.86	11.2	10.2	4.54	12.23	2.55
CD (p=0.05)	NS	20.0	27.8	25.8	10.1	35.2	7.32

was maintained in field from grand growth period (120 DAP) to maturity period (275 DAP) of the crop. The water level range from 5.0- 85 cm throughout the crop season. At maturity soil was wet and no surface water was present before one month of harvesting. Soil samples were collected before planting and after harvest of crop. The processed surface soil samples (0-30 cm) were collected and analyzed using standard procedure. The available K was determined flame photometrically (Jackson 1973). The cane juice quality viz. brix, pol and purity were determined as per method given by Spencer and Meade (1964). The data were analyzed statistically.

RESULTS AND DISCUSSION

Yield attributes and yield of sugarcane

The graded doses of mineral potassium fertilizer (K_2O) up to K @120 kg /ha as basal dose was found significantly superior for improving yield attributes and yield of sugarcane grown under waterlogged condition (Table1a). The application of K_2O up to 120 kg/ha significantly enhanced plant population, plant height, cane length, number of millable cane (NMC) and single cane weight which implies that the higher doses of K might have increased these parameters. However, the effect of level of K on cane germination was found non-significant. The results indicated that yield attributes and cane yield increased significantly due to application of graded dose of K_2O up to 120 kg /ha over recommended dose of K60 (K_2O @60 kg/ha). The mean cane yield varied from 54.25- 72.49 t/ha among treatments. The highest cane yield was recorded in the treatment receiving K_2O @ 120 kg/ha which was found at par with treatment receiving K_2O @ 90 kg/ha. The significant reduction in cane yield was observed in plots treated with recommended dose of potassium (K_2O @ 60 kg/ha). The increased cane yield due to graded doses of K- fertilizer attributed to the role of potassium in photosynthesis, water relationship and its requirements for various enzyme

Table 1b. Yield attributes and yield of sugarcane influenced by different sugarcane genotypes.

Genotypes	Germination (%)	Tiller ($\times 10^3$/ha)	Plant height (cm)	Cane length (cm)	NMC ($\times 10^3$/ha)	Single cane weight (g)	Cane yield (t/ha)
BO 91 (Check)	35.33	108.21	201.8	191.6	88.62	829	58.40
BO 110	31.67	106.15	208.1	197.8	85.15	863	56.84
BO 153	47.97	149.50	254.6	241.2	97.2	880	68.85
BO 154	41.92	130.24	250.2	238.3	101.23	880	74.20
COP 2061	44.44	154.83	257.3	243.2	96.45	883	72.43
COLK 94184	38.04	138.25	248.4	232.5	95.27	870	69.20
SEm±	2.91	8.86	10.89	9.01	3.90	8.75	2.96
CD (p=0.05)	7.81	23.6	28.53	25.85	9.54	25.13	8.86

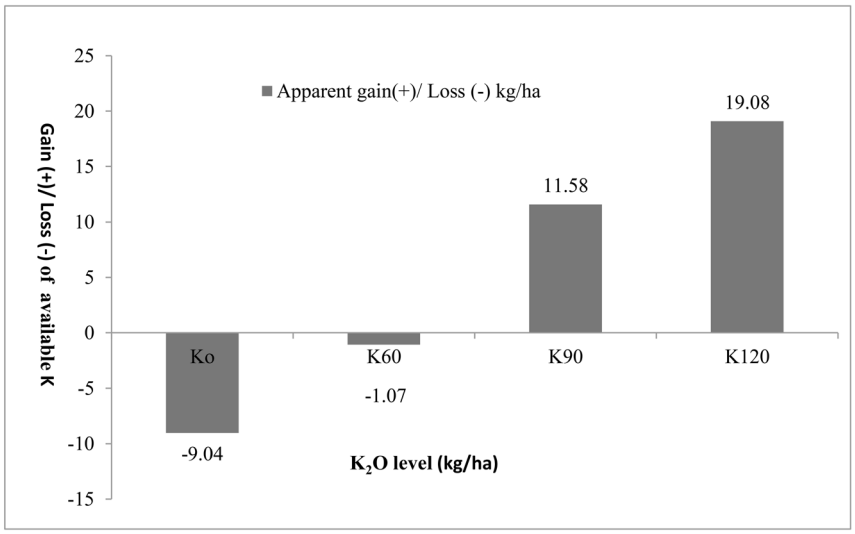

Fig. 1. 1. Balance sheet of available potassium after harvest of sugarcane (2 years) grown under waterlogged condition in calcareous soils.

systems within the plant. In general, higher doses of K establish better plant growth and minimize lodging and insect-pest damages. The similar findings have been reported by Khosa (2002), Singh *et al.* (2008) and Kumar *et al. (*2019).

The germination plant population and plant height of sugarcane elite varieties BO153, BO 154, CoP 2061 and COLK 94184 increased significantly over BO 91 and BO 110 (Table1b). Among sugarcane varieties highest germination (47.97%) and number of tillers (149.50 × 10^3/ha) were recorded in BO153. In case of plant height maximum was recorded in COP 2061. The significant increase in cane length was recorded in BO153, BO 154, CoP 2061 and COLK 94184 as compared to BO 91 and BO 110. The number of millable cane (NMC) increased significantly ranged from 85.15-101.23 × 10^3/ha in BO153, BO 154, CoP 2061 and COLK 94184 over BO 110 grown under waterlogged condition. All the varieties were superior in terms of cane weight over BO 91 (Check). Among sugarcane genotypes BO 154 (74.20 t/ha) and COP 2061 (72.40 t/ha) were fighting fit under water logged condition in terms of cane yield. The specific K-nutrition through inorganic fertilizer and varietal characteristics resulted in higher yield of crop under

Table 2a. Effect of graded doses of potassium on juice quality and sugar yield.

Treatments	Juice quality (%)			Sugar yield
K-level	Brix	Pol	Purity	(t/ha)
K0 (Control)	19.23	16.80	87.36	6.35
K60	19.61	17.06	87.00	7.52
K90	19.57	17.30	88.40	8.71
K120	19.48	17.10	87.78	8.66
SEm±	0.39	0.65	1.01	0.53
CD (p= 0.05)	NS	NS	NS	1.48

Table 2b. Effect of graded doses of potassium on juice quality and sugar yield .

Genotypes	Juice quality (%)			Sugar yield (t/ha)
	Brix	Pol	Purity	
BO 91 (Check)	19.31	16.89	87.46	6.88
BO 110	19.29	16.54	85.74	6.49
BO 153	19.46	16.98	87.25	8.14
BO 154	19.34	17.37	89.81	9.08
COP 2061	19.27	16.85	87.44	8.51
COLK 94184	20.32	17.67	86.95	8.50
SEm±	0.30	0.41	0.98	0.88
CD (p= 0.05)	0.88	1.21	NS	2.39

waterlogged condition.

Juice quality and sugar yield

The juice quality parameters viz. brix, pol and purity coefficient remains unaffected due to application of graded doses of K, however numerical increase in these parameters' have been observed in the treatments receiving K_2O @ 60, 90 and 120 kg/ha (Table 2a). However, sugar yield increased significantly in the K treated plots over control except treatment K60. The mean sugar yield ranged from 6.35-8.71 t/ha and varied significantly. The highest sugar yield was recorded in K90 (8.71t/ha) treated plots followed by K 120 (8.66 t/ha). The performance of different sugarcane varieties on cane juice quality viz. brix and pol percent was also found significant. The purity coefficient of cane juice of different varieties was found non-significant (Table 2b). The mean value for brix (19.27-20.32%) and pol (16.54-17.67) varied significantly. COLK 94184 was found superior in terms of brix and pol. The sugar yield recorded in the increasing order of BO 110< BO 91< BO 153< COLK 94184< COP 2061< BO 154. Among sugarcane genotypes B.O. 154 recorded highest sugar yield (9.08 t/ha) which was significantly superior over BO 110 (6.49 t/ha). Sugar yield, a function of cane yield exhibited similar trend as cane yield. Bhalerao *et al.* (2006) reported similar findings. The interaction effect for the treatments was found non-significant. Kurian *et al.* (2004)) reported that soil application of K 75% of recommended dose of the as basal along with 25% of recommended dose of potassium as foliar application at 90 DAP resulted in appreciable increase in millable cane and cane yield. However, the juice quality remained unaffected with treatment effects.

Balance sheet of available -K

The balance sheet of available K was prepared after harvest of sugarcane (Fig. 1.1). The results indicated that apparent gain of the available-K increases with increase in K fertilization rate from K90 to K120 kg/ha. Availability of K of the soil was directly associated to the respective rates of their application from 0 to 120 kg K_2O /ha. The application of recommended dose of K- fertilizer (K_2O 60 kg/ha) resulted in the net negative balance of available K after harvest of sugarcane grown under waterlogged condition. The maximum loss in available K was recorded in control plot (-9.04 K_20 /ha) followed by application of K @ 60 kg/ha (-1.07 K_20 /ha). The application of K fertilizer @ 90 and 120 kg /ha resulted in the net positive balance of + 11.58 and +19.08 kg/ha available K in post harvest soil, respectively. The result clearly indicated that treatments of K90 and K 120 doses meet the demand of sugarcane crop with its positive balance in soil.

The light textured sandy-loam soil rich in free calcium carbonate and low in available K respond well up to 200% potassium applied as basal dose (120 kg K_2O /ha) over recommended dose of potassium (60 kg K_2O /ha) for accelerating productivity and maintaining juice quality of sugarcane which was on par with 150% potassium (90 kg K_2O /ha). Among sugarcane genotypes BO 153, COP 2061, COLK 94184 and BO 154 were fighting fit under waterlogged condition in terms of cane and sugar yield. Based on our findings it may be suggest that soil application of K_2O @ 90 kg/ha as basal dose was found optimum for improving productivity of sugarcane grown under waterlogged condition in calcareous soils of Bihar.

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