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Response and profitability of spring planted high sugar genotypes of sugarcane (*Saccharum officinarum* L.) to phosphorous application under western Uttar Pradesh condition

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Abstract
A field experiment was conducted during spring seasons of 2017-18 and 2018-19 at sugarcane experimental farm, Titavi Sugar Complex, Titavi, Muzaffarnagar, Uttar Pradesh, to evaluate three sugarcane genotypes ('Co 118' , 'Co 238' and 'Co 239') under four phosphorous levels (0, 20, 40 and 60 kg P/ha). Genotype'Co238' recorded the higher number of tillers, millable cane, cane length and cane yield. Higher cane growth, yield components and yield viz. tillers and millable cane production, cane length, cane diameter, single cane weight and cane yield were obtained with increase P levels, however, the response was significant up to 40 kg P/ha. Genotype 'Co238' uptake maximum P from soil as compared to 'Co118' and 'Co239'. Application of P had significant influence on sucrose content in juice and P uptake. The use efficiency of P decreased with corresponding increase in its level. The maximum apparent P recovery of 14.07% was obtained with 40 kg P/ha. Genotype 'Co238' recorded higher net return and benefit: cost ratio 1.60.

Keywords: Cane yield, genotype, net return, phosphorous, sucrose content, sugarcane, uptake

Introduction
Sugarcane is a vigorous and long duration crop which produces high dry matter per unit field area. Productivity of different genotypes is greatly influenced by genetic makeup and agro-techniques. There is differential response of the genotypes to higher levels of nutrients due to differential genetic potentiality of the particular genotype (Sinha *et al*., 2005) [10]. For high yielding genotypes with high rate of biomass production and matching high rates of nutrients uptake such as sugarcane soil must be able to supply nutrients at the rate for maximum growth that should be met through combination of inherent soil fertility and externally added nutrients. The yield contributing characters like number of tillers, cane length, cane diameter and millable cane are affected if fertilizer is a limiting factor. Phosphorous is one of the most important major nutrients and is closely concerned with vital growth process of sugarcane plant. Sugarcane is an exhaustive crop that takes one year or more, in which the available P status of the soil may change during the crop-growing season (Bowen and Anderson, 1992) [1]. The requirement of sugarcane plant for P is highest during the early stages of its development. Therefore, it is affected by phosphorous nutrition and long-term available P reserves in the soil (Korndorfer *et al*., 1995) [2]. Application of P especially on P deficient soils promotes root growth, stimulates tillering and influences favourably for better growth and thereby yield and juice quality (Malie *et al*., 1982) [7]. Keeping this in view, the present investigation was carried out to study the performance of different sugarcane genotypes as affected by P application.

Materials and Methods
A field experiment was conducted during spring season of 2017-18 and 2018-19 at sugarcane experimental farm, Titavi Sugar Complex, Titavi, Muzaffarnagar, Uttar Pradesh, using three sugarcane genotypes and four phosphorous levels to identify suitable genotypes with level of P fertilization for western Uttar Pradesh. The soil was sandy loam in texture, pH 7.6, organic C 0.45%, low in available nitrogen (200 kg/ha), medium in available phosphorous (12.5 g /ha) and medium in available potassium (128 kg/ha).

The treatments consisted of combinations of three genotypes of sugarcane viz., 'Co118', 'Co238' and 'Co239' and four levels of P viz., 0, 20, 40 and 60 kg/ha. Each treatment was replicated four times in randomized block design. The crop received recommended dose of nitrogen (150 kg N/ha) and potassium (50 kg K/ha) through urea and muriate of potash, respectively. Phosphorous as per treatment was applied in the form of di-ammonium phosphate. Half of the N after adjusting the N applied through di-ammonium phosphate and full dose of P and K were applied at planting, and the remaining N was top dressed in two equal splits after the first irrigation and at the time of earthing-up (early July). The sugarcane was planted on 25 February 2018 and 24 February 2019, and harvested on 15 February 2019 and 18 February 2020, respectively. The total rainfall during the crop season was 1215.6 mm in 2017-18 and 1012,3 mm in 2018-19. Whole sugarcane samples were taken at the time of harvest and analysed for sucrose content in juice and P content in plant by vanado-molybdate-yellow colour method. The P uptake in sugarcane was calculated by multiplying the percent content of P with dry matter. Net returns was calculated by deducting the total cost of cultivation from the gross returns and expressed as Rs/ha on the basis of cost of inputs and prices of outputs in experimental year. The benefit cost ratio was calculated as ratio of gross return to cost of cultivation.

Results and Discussion

Effect of variety

Growth, yield attributes and yield

Mean data of two cropping seasons indicated that genotype 'Co238' showed higher number of tillers at 120 days after planting than 'Co118' and 'Co239' (Table 1). Maximum number of millable canes were found with 'Co238', owing to its higher tillering capacity. 'Co238' gave the longer cane of 248.50 cm was significantly superior by 14.8% to genotypes 'Co118' which may be attributed to its growth habit governed by genetic traits. Cane diameter of all the three genotypes were at par. The genotype 'Co239' obtained significantly highest individual cane weight (715.0) which was statistically at par with 'Co118'. Higher cane yield was harvested with genotype 'Co238' owing to higher number of millable canes and differential genetic potentiality of particular genotype. These findings are similar with those reported by Shukla and Singh (2011) [9].

Effect of phosphorous levels

Growth, yield attributes and yield of cane

Application of P had positive and significant influences on the growth, yield attributes and yield of cane (Table 1). Higher cane growth, yield components and yields viz., tillers and millable cane production, cane length, cane diameter, single cane weight and cane yield were obtained with increase P level, however, the response was significant up to 40 kg P/ha only. Moreover, increasing doses of P also reduced the tillers mortality. This indicated that besides tiller production, P nutrition also helped in maintaining the retention of tillers. Phosphorous, being integral participant of photosynthetic activities and constituent of the sugar phosphate and adenosine di- and tri-phosphates recorded significant increase in tillers production. It eventually resulted in higher number of mature stalks, probably through production of new meristems and improvement in overall metabolic activities in the plants. Kumar and Verma (1999) [4] and Mistry *et al*. (2018) [8] also reported significant influence of P fertilization on tillers and millable canes. Application of P registered significant increase in single cane weight i.e. 60 kg P/ha increased it by 21.3% as compared with control. Significant increase in cane diameter in the P fertilized plots might have helped the plant attain full capacity of sink size, which manifested into bolder and thicker canes. Similar results were also reported by Kumar and Sinha (2008) [3].

Application of P significantly improved the cane yield and the response to P in terms of cane yield which was recorded 0.61, 0.28 and 0.06 t/kg P at 20, 40 and 60 kg P /ha, respectively (Table 1). High P content in the plant tissues due to P nutrition enabled the plant to maintain high rate of metabolic and physiological activities, increase the sink size and utilize the photosynthate at a faster rate, which laid down the foundation of higher yield. These results are in agreement with the findings of Kumar *et al*. (2004) [5], kumar *et al*. (2014) [6] and Yadav *et al*. (2016) [11].

Sucrose content, P uptake and P-use efficiency

Phosphorous uptake by cane determined (Table 2) at harvest stage showed that 'Co238' absorbed the maximum P as compared to 'Co118' and 'Co239' cultivars due to higher tonnage harvested.

Application of P had significant effect on sucrose content in juice and P uptake (Table 2). The highest sucrose content in juice of 16.82% was recorded at 60 kg P /ha and minimum of 14.72% under the control. Uptake of P indicated a significant and progressive increase up to 40 kg /ha. The highest P uptake of 20.18 kg P/ ha was recorded at 60 kg P / ha and the lowest of 13.16 kg P / ha under the control. Improved and prolonged availability of nutrient resulted in higher P concentration in the plants, which markedly increased the P uptake. These results are similar with those obtained by Yadav *et al*. (2016) [11].

An increase of P level by 40 and 60 kg/ha led to corresponding decrease in P use efficiency (Table 2), probably because the cane yield did not increase proportionately. The maximum apparent P recovery of 14.07% was obtained with 40 kg P /ha. In this study the increase in P recovery with 40 kg P / ha as compared to lower and higher levels of P indicates that the applied P was nearly sufficient up to 40 kg P /ha, beyond which the absorbed P was less effective in increasing cane yield.

Economics

Sugarcane 'Co238' recorded higher net return (Rs 106420) and benefit : cost ratio was 1.60. Net returns and benefit : cost ratio was influenced by various levels of P fertilization (Table 2). Net returns increased with each successive increase in P level from 20 to 60 kg P /ha. The differences in net returns and benefit : cost ratio of different genotypes and P levels were primarily due to variation in cane yield.

Table 1: Influence of genotypes and phosphorous levels on growth, yield attributes and yield of sugarcane (Pooled data of two years)

Treatment	Tillers at 120 DAP (x 10^3/ha)	Millable canes (x 10^3/ha)	Tillars mortality (%)	Cane length (cm)	Cane diameter (cm)	Single cane weigth (g)	Cane yield (t/ha)
Genotype							
Co118	143.86	99.74	24.27	216.50	1.93	682.87	72.25
Co238	177.88	139.87	20.68	248.50	1.86	630.19	87.18
Co239	150.79	115.39	24.39	230.25	1.95	715.00	80.91
SEm±	0.29	3.87	1.37	2.31	0.07	26.64	2.72
CD at 5%	0.87	11.6	NS	6.92	NS	79.93	8.17
P levels (kg/ha)							
0	149.13	101.8	25.44	227.00	1.75	592.08	64.52
20	158.11	117.17	25.00	230.00	1.88	691.58	76.79
40	161.15	125.85	21.54	234.00	2.00	702.08	87.82
60	161.64	128.51	20.42	235.67	2.02	718.33	91.31
SEm±	0.03	4.47	1.57	2.66	0.08	30.76	3.14
CD at 5%	1.00	13.42	4.73	7.99	0.25	92.29	9.43

Table 2: Effect of genotypes and phosphorous levels on sucrose content, P uptake and economics of sugarcane plant (Pooled data of two years)

Treatment	Sucrose content in juice (%)	P uptake (kg/ha)	P use efficiency (kg cane / kg P application)	Apparent P recovery (%)	Gross returns (x 10^3 Rs/ha)	Net returns (x 10^3 Rs/ha)	Benefit : Cost ratio*
Genotype							
Co118	15.75	15.85	-	-	234.81	57.90	1.33
Co238	15.59	18.29	-	-	283.34	106.42	1.60
Co239	16.81	16.87	-	-	262.96	86.04	1.49
SEm±	0.59	0.69	-	-	-	-	-
CD at 5%	NS	1.97	-	-	-	-	-
P levels (kg/ha)							
0	14.72	13.16	-	-	209.69	32.78	1.18
20	16.20	15.89	613.50	13.65	249.57	72.65	1.41
40	16.45	18.79	582.50	14.07	285.42	108.50	1.61
60	16.82	20.18	446.50	11.70	296.76	119.84	1.68
SEm±	0.69	0.76	-	-	-	-	-
CD at 5%	2.06	2.28	-	-	-	-	-

* Cost of cultivation Rs. 176915; Sale price : Rs. 3250/ tonne

Conclusion

Thus, it may be concluded that sugarcane variety 'Co238' can be grown and fertilized with 40 kg P along with 150 kg N and 50 kg K /ha, so as to achieve higher cane yield and quality under western Uttar Pradesh condition.

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