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Research Paper

Response of high yielding varieties of sugarcane (*Saccharum* spp. hybrid complex) to planting materials under waterlogged condition

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ABSTRACT

A 3 -years field experiment consisting of 2 planting materials viz., 3- bud setts and bud chips and 5 sugarcane (*Saccharum* spp. hybrid complex) varieties ('BO 91', 'CoP 16437', 'CoP 16438' and 'BO 156') was conducted during spring seasons of 2016-17, 2017-18 and 2018-19, to study the effect of planting materials and varieties on productivity of sugarcane under waterlogged conditions. Significantly higher plant population (157, 000/ha), plant height (292 cm), LAI (4.12), mortality percent (38.4%), length of internode (11.8 cm), millable canes (96, 300/ha) and B: C ratio (0.70) was observed with bud chip as planting material than three bud setts. However, significantly higher number of nodes having aerial roots (8.3), cane diameter (2.09 cm) and single cane weight (828 g) were observed with 3 bud setts. Among the varieties, 'BO 156' exhibited better growth performance under waterlogged conditions with higher tillers (175, 000/ha), plant height (295 cm), drymatter accumulation (29.5 t/ha) and number of internode/cane (12). The LAI (4.26) and number of nodes having aerial roots (8.9) were found higher in 'BO 91'. Higher cane diameter (2.11 cm) and single cane weight (936 g) were obtained from 'CoP 16437'. But the variety 'BO 91' recorded higher millable canes (107, 500/ha) which was statistically comparable to 'BO 156'. The data indicated that variety 'BO 156' recorded significantly higher cane yield (78.0 t/ha), gross returns (₹ 226, 200/ha), net returns (₹107, 000/ha) and B: C ratio (0.90) but it was at par 'CoP 16437' in respect to cane yield and gross returns. The quality in terms of brix (19.5%) and pol (17.11%) of 'CoP 16438' and 'CoP 16437' was better than 'CoP 092' and 'BO 156' but the sugar yield of varieties 'BO 156' (9.1 t/ha) and 'CoP 16437' (8.4 t/ha) were at par to each other. The productivity and economic parameters indicated that bud chip raised settlings and sugarcane variety 'BO 156' is economically viable options under waterlogged conditions.

Key words: Crop productivity, Economics, Planting material, Sugarcane varieties, Waterlogged conditions

Sugarcane is grown in varying climates, which cause waterlogging, drought, salt, heat and cold stresses along with varying soil conditions that generally limits cane and sugar productivity to a greater extent. Although agronomical management of crop or their environments in way that avoid stress injury can increase the crop productivity. The genetic potential of any variety cannot be fully exploited without proper agronomic management practices. A suitable agro-technique is required for newly released varieties for harnessing their potential to achieve maximum returns. Improved planting material of sugarcane is an important factor to achieve early growth and vigour of crop under waterlogged conditions. As much as 30 to 40% of the Bihar cane growing regions are affected by waterlogging, this is a serious issue. Waterlogging has a negative impact on sugarcane growth, yield and quality when it happens between July to September, the main growing season for the crop (Kumar, 2018; Kumar, 2009). Losses in cane yield and quality mainly depend on depth and duration of waterlogging and stages of crop growth. Tolerant varieties also fail to produce the desired yield if waterlogging takes place in the early grand growth phase (July–August). Kumar *et al.* (2015) in another study noticed that, waterlogged condition during July to September (grand growth phase) reduced millable cane height, millable canes, cane diameter, single cane weight and cane yield by 9.4, 13.8, 13.4, 15.7 and 23.6%, respectively, over normal condition. These losses can be overcome by adoption of bud chip raised settlings under waterlogged conditions. When one month old bud chip raised settlings transplanted in main field it directly enters in to tillering phase. As compared to the three bud setts, bud chip raised settlings showed high and synchronous tillering with thicker canes and ultimately higher cane yield (Loganandhan *et al.,* 2013). Bud chip raised settlings enable the crop to avoid waterlogging in the early stages of the crop's growth, and the plants can get off

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to hardy before negative effects of waterlogging. It can help to maintain full plant population and achieve the maximum yield advantage under waterlogged conditions. Non availability of recently released variety in adequate quantity, high transportation expenses and seed rate (5-6 t/ha) cultivation of sugarcane with three bud setts is becoming uneconomical. To mitigate this problem many cane growers are switching to bud chips. Transplanting of sugarcane crop using bud chip raised settlings in place of three bud setts could save about 80% by weight of stalk material (Kumar, 2020). It is the good idea for availability of the good quality sugarcane seed (Budi *et al.* 2016; Gill and Kaur, 2015). Bud chip raised settlings can reduce the seed cost, enhance the duration of crop by 25- 30 days and provide comparable yield with 3- bud setts. Considering these facts there is a need to identify appropriate sugarcane varieties, especially suited for waterlogged conditions and also to modify the existing planting material in waterlogged condition. No much information is on planting material and suitable varieties for waterlogged conditions hence this trial was initiated.

MATERIALS AND METHODS

Field experiments were conducted at Sugarcane Research Institute, Dr. Rajendra Prasad Central Agricultural University, Pusa, Bihar (25^0 59' N latitude and 85^0 40' east longitude) for three consecutive years in spring seasons of 2016–17, 2017–18 and 2018–19 under waterlogged condition. The soil of the experimental plot was poorly drained, sandy loam in texture and alkaline (*p*H 8.2) in reaction. The soil of the site was low in organic carbon (0.47%) and nitrogen (208 kg/ha), medium in phosphorus (16.2 kg/ha) and poor in potassium (105 kg/ha) content. The experiment comprised 2 planting materials, viz. 3- bud setts and bud chips and 5 sugarcane varieties (‘BO 91’, ‘CoP 092’, ‘CoP 16437’, ‘CoP 16438’ and ‘BO 156’). The experiment was laid out in randomized block design with 3 replications. Three bud setts and bud chip raised settlings placed in main field in the first week of February at 90 cm row spacing and harvested in the fourth week of January during all the years. As per recommendation for the zone 150: 37.1: 49.8 kg NPK/ha were applied. The sources of nitrogen, phosphorus and potassium were urea, diammonium phosphate and muriate of potash, respectively. Out of the total amount of respective doses, half of N was applied as basal along with full doses of P and K whereas rest N was top dressed in two equal splits, at 45 and 120 DAP. The total rainfall recorded during the crop growth from February to January in 2016–17, 2017–18 and 2018–19 was 1016.2, 1166.1 and 871.0 mm in 59, 67 and 60 rainy days, respectively. The experiment was carried out under irrigated condition with recommended packages of practice. The average depth of water in the crop field during the month of July, August, September and October was 40, 70, 95 and 20 cm, respectively, during 2016–17, 2017–18 and 2018–19. Data on growth, yield attributes, cane yield and economics were recorded using standard techniques. When the cane was harvested, whole samples were taken, the juice was extracted using a power crusher, and the quality of the juice was determined using the procedure outlined by Spencer and Meade (1955). The formula used to determine sugar yield as; sugar yield (t/ha) = [S - 0.4 (B - S) × 0.73] × cane yield (t/ha)/100; where S and B are sucrose and brix in cane juice, respectively. Fibre content cane was estimated by rapi- pol extractor. Based on pooled yield data and taking into account the cost of input and output of the last year of study, economic analysis was done. The net realization was computed by taking the gross realization and subtracting the total cost of cultivation. The ratio of net realization to cost of cultivation was used to compute the benefit: cost ratio. Finally, the data were analysed using accepted statistical techniques.

RESULTS AND DISCUSSION

Growth performances

Planting materials significantly influenced the tillers, plant height, LAI, tiller mortality, length of internodes and number of nodes having aerial roots of sugarcane (Table 1). Significantly higher tillers (157, 000/ha), plant height (292 cm), LAI (4.12) and length of internode (11.8 cm) was noted with bud chip raised settlings, but the dry matter accumulation and number of internode/cane was not significant. The percentage increase in tillers, plant height, LAI and length of internode with bud chips raised settlings was 14.9, 11.5, 10.2 and 12.4%, respectively, over 3- bud setts. Such beneficial effect of bud chip raised settlings might be due to its early establishment and vigour, which have helped the crop to compete with the crop planted with three -bud setts. The maximum tiller mortality (38.4%) was recorded with bud- chip raised settlings, being 7.5% higher than three -bud setts. This difference in mortality per cent of tillers was mainly attributed to higher number of tillers with no extra nutrient supplied under bud chip raised settlings. Number of nodes having aerial roots was 16.9% higher in three bud setts than bud chip raised settlings.

Varieties differed significantly for observations recorded on growth attributes. Significantly higher number of tillers (175, 000/ha) was recorded with ‘BO 156’ and minimum with ‘CoP 16437’ (122,700/ha), owing to its tillering capacity. Maximum plant height was recorded with the variety ‘BO 156’ (295 cm) which was significantly higher over ‘CoP 16438’ (254 cm). Similarly, higher dry matter accumulation (29.5 t/ha) was obtained with ‘BO 156’ was statistically similar to ‘CoP 16437’ (26.7 t/ha) and signifi-

Table 1. Effect of planting materials and varieties on growth of sugarcane under waterlogged condition (pooled data of 3 years)

Treatment	Plant population at 120 DAP ($\times 10^3$/ha)	Plant height at harvest (cm)	Total DMA* at harvest (t/ha)	LAI at 240 DAP	Tillers mortality (%)	Number of internode/ cane	Length of internode (cm)	Number of nodes having aerial roots
Planting material								
3- bud setts	136.7	262	26.3	3.74	35.7	19	10.5	8.3
Bud chips	157.0	292	24.7	4.12	38.4	21	11.8	7.1
SEm±	3.41	5.9	0.59	0.096	0.85	0.4	0.22	0.15
CD (P=0.05)	9.6	18	NS	0.28	2.5	NS	0.6	0.4
Variety								
'BO 91'	152.5	285	22.0	4.26	29.3	20	11.8	8.9
'CoP 092'	150.8	281	24.2	3.87	43.3	21	11.3	7.7
'CoP 16437'	122.7	270	26.7	3.56	37.1	19	10.5	7.0
'CoP 16438'	133.4	254	25.1	3.94	32.1	18	10.4	6.7
'BO 156'	175.0	295	29.5	4.02	43.7	22	12.0	8.2
SEm±	5.39	9.4	0.94	0.152	1.38	0.6	0.34	0.23
CD (P=0.05)	15.2	28	2.8	0.45	4.1	3	1.0	0.7

*DMA, Dry matter accumulation

cantly superior over other varieties. However, variety 'BO 91' noticed higher LAI (4.26) and number of nodes having aerial roots (8.9) followed by 'BO 156' (43.7%) and 'CoP 092' (43.3%) were almost similar but significantly higher over other varieties. Variety 'BO 156' also showed the highest number of internodes/cane (22) and length of internode (12.0 cm) and minimum with 'CoP 16438'. Similar observations were made by Kumar *et al.* (2012) and Kumar (2018).

Yield attributes, cane yield and economics

Significantly higher cane diameter (2.09 cm) and single cane weight (828 g) were observed with three bud setts (Table 2). This is because of higher availability of food material during initial stages of crop in three -bud setts planting than bud chips under similar nutrition condition. Kumar and Kumar (2020) also reported similar results. Significantly higher number of millable canes (96, 300/ha) was recorded with bud -chips, due to its higher tillers. Cane yield, gross returns and net returns obtained from three bud setts and bud chips were statistically similar that exhibiting the better competition of bud chips with three bud setts. It was observed that sugarcane yield with bud chips was as good as with three bud setts. The cost of cultivation in three bud setts was Rs. 124, 500/ha whereas in bud chips it was only 114, 000/ha. This shows that bud chips are cost effective, since the amount of seed used in bud chips is less. The reduced cost of cultivation significantly increased the B: C ratio (0.70) under bud chip raised settlings.

Variety 'CoP 16437' recorded higher cane diameter (2.11 cm) which was significantly superior to 'CoP 16438' and 'BO 91'. As a result, 'CoP 16437' recorded significantly higher single cane weight (935 g). Lowest cane diameter (1.75 cm) and single cane weight (590 g) as noticed with 'BO 91' which was statistically similar to 'BO 156' and significantly superior over rest of the varieties. Variety 'BO 156' recorded higher cane yield (78.0 t/ha) which was statistically comparable to 'CoP 16437' (70.7 t/ha). Variety 'BO 156' exhibited significantly higher gross returns (226,200/ha), net returns (107,000/ha) and B: C ratio (0.90) than the other varieties. This may be due to higher cane yield. Similar results were also reported by Kumar *et al.* (2023a and 2023b).

Quality

Quality parameter of sugarcane was not significantly influenced by planting materials. Overall, higher brix (19.0), pol (16.86%) and CCS per cent (11.69%) were recorded with bud chip raised settlings while, the lowest with three -bud setts. Comparatively higher purity (89.5%) and fibre (13.3%) were recorded with three bud setts. Among the varieties, 'CoP 16438' showed higher brix (19.5%) and pol (17.11%) in juice, which was statistically comparable to 'CoP 16437' with respect to brix percent and 'CoP 16437' and 'BO 91' in case of pol per cent juice. Varieties caused non-significant variations in purity and CCS per cent juice. It varied from 88.2 to 89.7% in case of purity percent and 11.49 to 11.84% in case of CCS percent. But there was a wide range of variation in fibre per cent and sugar yield of sugarcane varieties. Varieties, 'CoP 092' and 'CoP 16437' produced lowest fibre per cent which was significantly lower than 'BO 91', 'CoP 16437' and 'BO 156'. As cane yield, the trend in sugar yield indicates that varieties 'BO 156' (9.1 t/ha) and 'CoP 16437' (8.4) exhibited superiority over 'CoP 092' and 'BO 91'. The findings are in corroboration with the results of Tayade *et al.* (2017)

Table 2. Effect of planting materials and varieties on yield attributes, cane yield and economics of sugarcane under waterlogged condition (pooled data of 3 years)

Treatment	Cane diameter (cm)	Millable canes (× 10³/ha)	Single cane weight (g)	Cane yield (t/ha)	Gross returns (× 10³ ₹/ha)	Cost of cultivation (× 10³ ₹/ha)	Net returns (× 10³ ₹/ha)	Benefit: cost ratio
Planting material								
3- bud setts	2.09	87.3	828	69.8	202.5	124.5	78.0	0.63
Bud chips	1.87	96.3	718	66.7	193.4	114.0	79.4	0.70
SEm±	0.042	2.29	19.7	1.48	4.87	-	1.92	0.017
CD (P=0.05)	0.12	6.5	57	NS	NS	-	NS	0.05
Variety								
‘BO 91’	1.75	107.5	590	60.8	176.4	119.3	57.1	0.48
‘CoP 092’	2.06	85.7	778	64.8	187.8	119.3	68.6	0.58
‘CoP 16437’	2.11	76.9	936	70.7	205.1	119.3	85.8	0.73
‘CoP 16438’	1.88	90.5	758	67.0	194.3	119.3	75.1	0.63
‘BO 156’	2.10	98.5	805	78.0	226.2	119.3	107.0	0.90
SEm±	0.066	3.62	31.2	2.34	7.70	-	3.04	0.28
CD (P=0.05)	0.20	10.2	88	6.6	22.9	-	9.0	0.08

Table 3. Quality parameters of sugarcane as influenced by planting materials and varieties under waterlogged condition (pooled data of 3 years)

Treatment	Brix (%)	Pol (%)	Purity (%)	CCS (%)	Fibre in cane (%)	Sugar yield (t/ha)
Planting material						
3- bud setts	18.7	16.74	89.5	11.64	13.3	8.1
Bud chips	19.0	16.86	88.7	11.69	13.1	7.8
SEm±	0.10	0.11	0.45	0.062	0.24	0.18
CD (P=0.05)	NS	NS	NS	NS	NS	NS
Variety						
‘BO 91’	18.6	16.68	89.7	11.62	13.2	7.1
‘CoP 092’	18.5	16.53	89.4	11.49	12.2	7.5
‘CoP 16437’	19.3	17.10	88.6	11.84	12.2	8.4
‘CoP 16438’	19.5	17.11	88.2	11.81	14.2	8.0
‘BO 156’	18.5	16.61	89.7	11.58	14.3	9.1
SEm±	0.13	0.14	0.71	0.097	0.39	0.28
CD (P=0.05)	0.38	0.43	NS	NS	1.1	0.8

and Bakshi Ram (2017).

Based on the experimental results, it can be concluded that planting sugarcane with bud chip raised settlings recorded statistically similar cane yield as compared to three bud setts. Bud chip raised settlings showed reduction in cost of cultivation due to saving on cost of seed, resulting in significantly higher benefit: cost ratio, indicated that the bud chip raised settlings is economically viable. Among the varieties tested, ‘BO 156’ was found more promising under waterlogged conditions and can be recommended.

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