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Impact of Exogenously Applied Plant Growth Regulators on Yield Attributes and Yield of Sugarcane (*Saccharum* spp. Hybrid Complex)

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A B S T R A C T

A field experiment was conducted during the spring season of 2017 at Research farm of Sugarcane Research Institute, Dr. Rajendra Prasad Central Agricultural University, Pusa (Samastipur), Bihar to study the "Impact of exogenously applied plant growth regulators on yield attributes and yield of sugarcane (*Saccharum* spp. hybrid complex)". The experiment was laid out in randomized block design and replicated thrice. The treatment comprised of ten treatments *viz*., conventional planting/farmers practice (T_1), planting of setts after overnight soaking in water (T_2), planting of setts after overnight soaking in cattle dung, cattle urine and water slurry in 1: 2: 5 ratios (T_3), planting of setts after overnight soaking in 50 ppm ethrel solution (T_4), planting of setts after overnight soaking in 100 ppm ethrel solution (T_5), T_1 + GA_3 spray @ 35 ppm at 90, 120 and 150 DAP (T_6), T_2 + GA_3 spray @ 35 ppm at 90, 120 and 150 DAP (T_7), T_3 + GA_3 spray @ 35 ppm at 90, 120 and 150 DAP (T_8), T_4 + GA_3 spray @ 35 ppm at 90, 120 and 150 DAP (T_9) and T_5 + GA_3 spray @ 35 ppm at 90, 120 and 150 DAP (T_{10}). Planting of setts after overnight soaking in 50 ppm ethrel solution followed by foliar spray of GA_3 @ 35 ppm at 90, 120 and 150 DAP showed significantly higher cane and sugar yield as compared to rest of the treatments which was due to improvement in yield attributes like number of tillers, number of millable canes, internodal length, number of nodes/cane, cane diameter, single cane weight and cane: top ratio.

Introduction

Sugarcane (*Saccharum* spp. hybrid complex) is a tropical, perennial grass that forms lateral shoots at the base to produce multiple stems, typically three to four metre high and about 5 centimetre in diameter. The stems grow into cane stalk, which when mature constitutes around 75% of the entire plant. All sugarcane species interbreed and the major commercial cultivars are complex hybrids. Sugarcane belongs to the grass family Gramineae, an economically important seed plant family that includes maize, wheat, rice, and sorghum, and many forage crops. Sugarcane farming is mainly done for the sugar production. However, apart from producing sugar, this crop is also used for manufacturing numbers

of by-products from it. On worldwide basis, sugarcane is cultivated in more than 100 countries, producing 178 million tonnes of sugar, nearly 80% of which is contributed by cane sugar. In India, it occupies about 2.53% (4.9 million ha) of the gross cropped area of the country with an annual production of 303.6 million tonnes. In Bihar, it occupies an area of 0.3 million ha with the production of 14.7 million tonnes (ISMA, 2017). India is the second largest producer after Brazil producing nearly 15 and 25% of global sugar and sugarcane, respectively. In India, sugarcane is cultivated in tropical zone and sub-tropical zone.

Sub-tropical zone comprising of 60% of total cane acreage contributes only 48% of total cane and 37% to total white sugar production in the country. The productivity of sugarcane in sub-tropical states like Bihar is far below (50.0 t/ha) as compared to tropical states *i.e.* Tamil Nadu (88.0 t/ha). Extremes of climate and use of sub-optimal agro-technologies are the main characteristics which lead to lower sugarcane productivity in sub-tropical India. In sub-tropical India, 60-70% of millable canes are comprised of tillers, whereas in tropical regions only 20-30% of millable canes are formed from tillers. Though, higher sugarcane yield can be achieved by increasing the number of mother shoots instead of tillers (Chand *et al.*, 2011) and higher mother shoots can be achievable by rate and speed of germination of planted setts, which is largely dictated by initial soil moisture content. To improve the sugarcane productivity, it is necessary to enhance the yield attributing characters like cane length, cane girth, single cane weight, number of tillers and millable canes. In this direction, plant growth regulators like ethrel and gibberellic acid have been found useful to reduce these constraints and thus have been effective in improving productivity in sugarcane. Therefore, to investigate the combined effects of ethrel and gibberellic acid on yield attributing characters and yield of sugarcane, the present experiment was aimed.

Materials and Methods

The field study was conducted during the spring season of 2017 at Research farm of Sugarcane Research Institute, Dr. Rajendra Prasad Central Agricultural University, Bihar which falls in sub-humid and sub-tropical climate with moderate rainfall. Total rainfall during the period of investigation was 1,134.6 mm. The soil of the experimental plot was low in organic carbon (0.41%), low in available nitrogen (220 kg/ha) and medium in phosphorus (28.3 kg/ha) and potassium content (141.5 kg/ha). The experiment was laid out in randomized block design, comprising ten treatments, *viz.*, conventional planting/farmers practice (T_1), planting of setts after overnight soaking in water (T_2), planting of setts after overnight soaking in cattle dung, cattle urine and water slurry in 1: 2: 5 ratios (T_3), planting of setts after overnight soaking in 50 ppm ethrel solution (T_4), planting of setts after overnight soaking in 100 ppm ethrel solution (T_5), T_1 + GA_3 spray @ 35 ppm at 90, 120 & 150 DAP (T_6), T_2 + GA_3 spray @ 35 ppm at 90, 120 & 150 DAP (T_7), T_3 + GA_3 spray @ 35 ppm at 90, 120 & 150 DAP (T_8), T_4 + GA_3 spray @ 35 ppm at 90, 120 & 150 DAP (T_9) and T_5 + GA_3 spray @ 35 ppm at 90, 120 & 150 DAP (T_{10}). Setts of variety 'BO 153' were used as planting material. Ridges and furrows were laid out at 90 cm spacing with Bihar senior ridger. The opened furrows were treated with Thimet 10 G to control insects-pests.

In case of plant population count, total number of plants (mother shoots + tillers) were recorded from 60 days after planting to 120 days after planting and number of millable canes (NMC) at the time of harvesting from net plot area of each plot and expressed as

thousands per hectare and expressed in thousands per hectare.

The length of internode was computed by the formula:-

$$\text{Internodal length (cm)} = \frac{\text{Average length of cane (cm)}}{\text{Average number of nodes per cane}}$$

The commercial cane sugar per cent was calculated with the help of brix and pol readings recorded in laboratory on the basis of the formula as described by Parthasarthy (1979).

$$CCS\ \% = [S\text{-}0.4\ (B\text{-}S)] \times 0.73$$

Where,

S = Sucrose per cent in juice
B = Brix per cent in juice

Cane yield was recorded with the help of spring balance from net plot area of each plot and converted into tonnes per hectare.

In order to obtained commercial cane sugar yield, the commercial cane sugar per cent was multiplied with cane yield (tonnes/ha).

$$\text{CCS (t/ha)} = \frac{\text{CCS\% at harvest x Cane yield (t/ha)}}{100}$$

Results and Discussion

Yield attributing characters

Number of tillers per hectare was counted at different growth stages starting from 60 DAP to 120 DAP. The data presented in Table 1 revealed that planting of setts after overnight soaking in 50 ppm ethrel solution followed by foliar spray of GA_3 @ 35 ppm at 90, 120 & 150 DAP (T_9) recorded significantly higher number of tillers *viz.*, 142.6, 210.6 and 229.7 × 10^3/ha at 60, 90 and 120 DAP, respectively. It might be due to ethrel treatment that strengthen the root activity and effectively utilized the nitrate- nitrogen for proper tiller growth. Higher tiller production due to ethrel treatment has also been reported by several workers (Li and Solomon, 2003). It also might be attributed that phasic application of gibberellic acid led to an increase in tiilers number against control, due to a significant decrease in shoot mortality. Jain *et al.*, (2011) also reported that ethrel treatment increases tiller formation under field condition; increase was about 9.7-18.6% in spring planting and 9.7-58.5% in late planting conditions over control.

The data presented in Table 1 revealed that planting of setts after overnight soaking in 50 ppm ethrel solution followed by foliar spray of GA_3 @ 35 ppm at 90, 120 & 150 DAP (T_9) recorded significantly higher number of millable canes (153.1×10^3/ha) at harvest over rest of the treatments. The higher number of millable canes in the corresponding treatments might be attributed to higher number of tiller production. Early and higher emergence due to setts treatment with ethrel solution and better photosynthetic efficiency due to foliar application of gibberellic acid resulted in the production of higher number of tillers and their subsequent conversion to millable canes. Similar result has also been reported by Kumar (2016).

The results on yield attributing characters of sugarcane are shown in Table 2. No significant effect of different treatments was observed on cane diameter. However, the maximum cane diameter was recorded in conventional planting (2.21 cm). Of the different treatments, number of nodes/cane was registered maximum under conventional planting and planting of setts after overnight soaking in water (26 nodes/cane) but did not

affect the number of nodes significantly. The length of internode was significantly higher (13.4 cm) in planting of setts after overnight soaking in 50 ppm ethrel solution followed by foliar spray of GA_3 @ 35 ppm at 90, 120 & 150 DAP (T_9) over rest of the treatments except in treatment T_7, T_8 and T_{10} where it was on par with T_9. It might be due to increase in the length of the stalk. Foliar application of GA_3 increased the leaf area index enhancing the photosynthetic activity and assimilates production in the leaves which later on translocated into internodes, thus increased internodal elongation and also internodal numbers as reported by Rai *et al.*, (2017). As a result, the number of nodes/cane is minimum in this treatment. Pribil *et al.*, (2007) also found that external application of GA_3 remarkably increased internodal length in sugarcane. Single cane weight did not produced significant impact on single cane weight, though maximum was recorded in treatment T_8 (684.0 g/plant) and the minimum was recorded under conventional planting (615.0 g/plant). Like single cane weight, different treatments failed to have any significant influence on cane: top ratio. However, maximum cane: top ratio (4.0) was recorded in planting of setts after overnight soaking in 50 ppm ethrel solution followed by GA_3 spray @ 35 ppm at 90, 120 and 150 DAP.

Table.1 Plant population (x 10^3/ha) of sugarcane as affected by different treatments

Treatment	60 DAP	90 DAP	120 DAP
Conventional planting/farmers practice	87.3	141.1	151.6
Planting of setts after overnight soaking in water	90.0	147.0	158.6
Planting of setts after overnight soaking in cattle dung, cattle urine and water slurry in 1: 2: 5 ratios	94.2	175.2	187.0
Planting of setts after overnight soaking in 50 ppm ethrel solution	137.1	201.7	218.4
Planting of setts after overnight soaking in 100 ppm ethrel solution	131.0	199.3	214.9
T_1 + GA_3 spray @ 35 ppm at 90, 120 & 150 DAP	93.7	160.2	171.6
T_2 + GA_3 spray @ 35 ppm at 90, 120 & 150 DAP	101.0	165.1	176.7
T_3 + GA_3 spray @ 35 ppm at 90, 120 & 150 DAP	103.4	180.0	196.5
T_4 + GA_3 spray @ 35 ppm at 90, 120 & 150 DAP	142.6	210.6	229.7
T_5 + GA_3 spray @ 35 ppm at 90, 120 & 150 DAP	135.0	205.5	224.8
SEm (±)	6.30	10.2	10.5
CD (P=0.05)	18.7	29.7	31.1
Mean	**111.5**	**178.6**	**193.0**

Table.2 Cane diameter, number of nodes/cane, length of internode, cane: top ratio, number of millable canes and single cane weight as affected by different treatments

Treatment	Cane diameter (cm)	Number of nodes/cane	Length of internode (cm)	Cane: top ratio	Number of millable canes (x 10^3/ha)	Single cane weight (g/plant)
Conventional planting/farmers practice	2.21	26	8.9	3.1	117.1	615.0
Planting of setts after overnight soaking in water	2.17	26	9.3	3.2	122.0	657.0
Planting of setts after overnight soaking in cattle dung, cattle urine and water slurry in 1: 2: 5 ratios	2.10	25	9.8	3.4	129.0	659.0
Planting of setts after overnight soaking in 50 ppm ethrel solution	2.01	24	10.7	3.7	148.6	663.0
Planting of setts after overnight soaking in 100 ppm ethrel solution	2.02	25	10.0	3.6	146.2	660.0
T_1 + GA_3 spray @ 35 ppm at 90, 120 & 150 DAP	2.16	24	11.2	3.3	123.3	645.0
T_2 + GA_3 spray @ 35 ppm at 90, 120 & 150 DAP	2.15	24	11.6	3.4	126.2	682.0
T_3 + GA_3 spray @ 35 ppm at 90, 120 & 150 DAP	2.08	23	12.6	3.5	135.5	684.0
T_4 + GA_3 spray @ 35 ppm at 90, 120 & 150 DAP	1.98	22	13.4	4.0	153.1	675.0
T_5 + GA_3 spray @ 35 ppm at 90, 120 & 150 DAP	1.98	23	12.6	3.8	150.5	670.0
SEm (±)	0.106	1.57	0.71	0.20	7.15	42.90
CD (P=0.05)	NS	NS	2.1	NS	21.3	NS
Mean	**2.09**	**24**	**10.9**	**3.5**	**135.2**	**66.1**

Table.3 Cane yield and sugar yield as affected due to different treatments

Treatment	Cane yield (t/ha)	Sugar yield (t/ha)
Conventional planting/farmers practice	71.4	8.55
Planting of setts after overnight soaking in water	78.9	9.33
Planting of setts after overnight soaking in cattle dung, cattle urine and water slurry in 1: 2: 5 ratios	81.5	9.58
Planting of setts after overnight soaking in 50 ppm ethrel solution	96.3	11.70
Planting of setts after overnight soaking in 100 ppm ethrel solution	94.5	11.47
T_1 + GA_3 spray @ 35 ppm at 90, 120 & 150 DAP	77.6	9.23
T_2 + GA_3 spray @ 35 ppm at 90, 120 & 150 DAP	83.5	9.84
T_3 + GA_3 spray @ 35 ppm at 90, 120 & 150 DAP	87.2	10.29
T_4 + GA_3 spray @ 35 ppm at 90, 120 & 150 DAP	101.8	12.40
T_5 + GA_3 spray @ 35 ppm at 90, 120 & 150 DAP	98.7	11.93
SEm (±)	5.08	0.58
CD (P=0.05)	15.1	1.7
Mean	**87.1**	**10.43**

Cane and sugar yield

Mean data showed that different treatments brought significant variation variation in cane and sugar yield in compared to conventional planting (Table 3). Planting of setts after overnight soaking in 50 ppm ethrel solution followed by GA_3 spray @ 35 ppm at 90, 120 and 150 DAP (T_9) resulted in highest cane yield (101.8 t/ha). However, it remained statistically at par with treatment T_4, T_5, T_8 and T_{10} and all of them significantly out yielded T_1, T_2, T_3, T_6 and T_7. It might be due to higher number of millable canes, cane length, length of internode as well as cane weight. Raji *et al.,* (1999) also reported that high leaf area index and vast canopy at the initial growth stages improved cane yield. Similar report was also obtained by Kumar (2016).

Maximum sugar yield (12.40 t/ha) was recorded under planting of setts after overnight soaking in 50 ppm ethrel solution followed by GA_3 spray @ 35 ppm at 90, 120 and 150 DAP (T_9) which was closely followed by T_4, T_5, T_8 and T_{10}. This might be due to the fact that the significant effect on sugar yield was solely due to cane yield on which the effect of different treatments was significant. Xing *et al.,* (2002) also demonstrated that ethrel promoted the differentiation and stimulated the plant growth and finally resulted in higher cane yield and thus the sugar yield.

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