

Doi: [HTTPS://DOI.ORG/10.23910/IJBSM/2017.8.1.1750a](https://doi.org/10.23910/IJBSM/2017.8.1.1750a)

Effect of Plant Growth Regulators on Tiller Dynamics and Yield of Sugarcane (*Saccharum officinarum* L.)

Subhashisa Praharaj^{1*}, Dheer Singh¹, S. K. Guru² and Bolta Ram Meena¹¹Dept. of Agronomy, ²Dept. of Plant Physiology, G. B. Pant University of Agriculture and Technology, Pantnagar, Uttarakhand (263 145), India

Corresponding Author

Subhashisa Praharaj
e-mail: praharaj93@gmail.com

Article History

Manuscript No. AR1750a
Received in 13th Dec, 2016
Received in revised form 4th Feb, 2017
Accepted in final form 7th Feb, 2017

Abstract

A field experiment was conducted during spring 2015–16 at Pantnagar, Uttarakhand with the objective to study the effect of ethephon and gibberellic acid on tiller dynamics, millable cane production and yield of sugarcane. Ten treatments i.e. conventional planting (T_1), overnight soaking of setts in water (T_2), overnight soaking of setts in 50 ppm ethephon (T_3), overnight soaking of setts in 100 ppm ethephon (T_4), T_1 +foliar application of GA_3 @ 35 ppm at 90, 120 and 150 DAP (T_5), T_2 +foliar application of GA_3 @ 35 ppm at 90, 120 and 150 DAP (T_6), T_3 +foliar application of GA_3 @ 35 ppm at 90, 120 and 150 DAP (T_7), T_4 +foliar application of GA_3 @ 35 ppm at 90, 120 and 150 DAP (T_8), soaking of setts for six hours in 50 ppm ethephon (T_9) and six hour soaking of setts in 100 ppm ethephon (T_{10}) were laid down in a randomized block design with 3 replication. Soil of the experiment plot was silty clay loam having high organic carbon (1.04%), high available phosphorus (32.5 kg ha⁻¹), medium in available potassium (256.2 kg ha⁻¹) and low in available nitrogen (233.4 kg ha⁻¹). The soil was neutral in pH (7.2). The treatment in which setts were planted after overnight soaking with 100 ppm ethephon followed by foliar application of gibberellic acid @ 35 ppm at 90, 120 and 150 DAP was found to improve tiller production, number of millable canes and yield of the crop.

Keywords: Sugarcane, tiller dynamics, ethephon, gibberellic acid, yield

1. Introduction

Sugarcane (*Saccharum officinarum* L.) is one of the important commercial crop of India and sustains second largest agro-industry i.e. sugar industry, next to textile industry (Anonymous, 2013). Indian sugar industry contributes significantly to the economy of India and to the socio-economic development of the rural population in the country, as more than 6 million farmers are engaged in its cultivation. Besides half a million skilled and semiskilled workers, mostly from rural area are also engaged in sugar Industry (Anonymous, 2011).

Sugarcane is vegetatively propagated through stem cuttings or setts. A sugarcane clump comprises of several cane stalks arising from subsurface sprouting of the underground buds in the form of tillers which develop into millable canes. These millable canes serve as sink for sucrose accumulation (Kapur et al., 2011). Most of the tillers produced after 2–3 months usually die and hence don't contribute to cane yield. Hence for high cane productivity improvement in tiller production with less mortality holds due importance. Many factors such as weather condition during tillering, nature of genotype and hormonal concentration largely affects tiller production

as well as senescence. Variation in content of hormones like IAA, GA, and ABA in live and senescing tiller has been reported (Vasanta et al., 2012). Relation between endogenous hormone concentration and tillering behavior has also been reported by Shrivastava and Misra (1996).

Hence exogenous application of plant growth regulators may be a useful option in improving tillering and reducing tiller mortality or senescence in sugarcane Diaz et al. (1995) reported a significant increase in stalk population of two poorly germinating sugarcane varieties, when setts were dipped in ethephon solution prior to planting. Increase in tiller population due to ethephon treatment was also reported by Millhollon and Legendre (1995). El-Lattief and Bekheet (2012) reported that foliar spray of GA_3 in sugarcane improved the stalk population ha⁻¹. In addition to this, PGRs like ethephon and gibberellic acid has immense potential to improve productivity and sugar recovery in sugarcane (Li and Solomon, 2003; Jain et al., 2011; El Latieff and Bekheet, 2012). Keeping these facts in view a field experiment was conducted with an objective to improve tiller population and produce higher no. of millable canes, thus producing higher yield.



2. Materials and Methods

A field experiment was conducted during spring 2015–2016 in the N.E. Borlaug Crop Research Centre of Govind Ballabh Pant University of Agriculture and Technology, Pantnagar, Uttarakhand, India. The soil of the experiment plot was silty clay loam, rich in organic carbon (1.04%), high in available phosphorus (32.5 kg P₂O₅ ha⁻¹) and medium in available potassium (256.2 kg K₂O ha⁻¹). pH of the soil was 7.2. Ten treatments i.e. conventional planting (T₁), overnight soaking of setts in water (T₂), overnight soaking of setts in 50 ppm ethephon (T₃), overnight soaking of setts in 100 ppm ethephon (T₄), T₁+foliar application of GA₃ @ 35 ppm at 90, 120 and 150 DAP (T₅), T₂+foliar application of GA₃ @ 35 ppm at 90, 120 and 150 DAP (T₆), T₃+foliar application of GA₃ @ 35 ppm at 90, 120 and 150 DAP (T₇), T₄+foliar application of GA₃ @ 35 ppm at 90, 120 and 150 DAP (T₈), soaking of setts for six hours in 50 ppm ethephon (T₉) and six hour soaking of setts in 100 ppm ethephon (T₁₀) were laid down in a randomized block design with replications. Three budded sugarcane setts of variety Co pant-3220 were planted in flat bed method at a row to row spacing of 75 cm. A dose of 120 kg nitrogen, 60 kg P₂O₅ and 40 kg K₂O ha⁻¹ was applied through urea (46% N), single super phosphate (16% P₂O₅) and muriate of potash (60% K₂O). Half dose of nitrogen was applied as basal in furrows at the time of planting and remaining was top dressed in two equal splits in the month of last week of May and third week of June. However, full dose of phosphorus and potassium was applied at the time of planting. To control weeds atrazine was sprayed @ 2 kg a.i. ha⁻¹ two days after planting by tractor operated power sprayer. Before planting setts were either soaked with water or ethephon. For water soaking treatment, setts were soaked overnight in tubewell water. Setts were soaked in 50 and 100 ppm ethephon solution for two different duration i.e. 6 hours and overnight. Ethephon treated setts were used for planting immediately after completion of soaking duration. Gibberellic acid was sprayed @ 35 ppm at 90, 120 and 150 DAP. In conventional planting setts were planted without any sett soaking treatment.

The no. of tillers (shoots) per net plot was counted at 90, 120, 150 and 180 DAP from all plots and the data was presented as no of shoots per hectare. For measuring shoot height, Five randomly selected shoots in each net plot were tagged. The height of all five shoots was measured from base of the stem to tip of the top most leaf with the help of meter scale at monthly interval starting from 90 days till 180 DAP. The average height of shoot was calculated on the basis of five shoots. The millable canes from each net plot were counted at the time of harvest and their number was calculated on hectare basis. The crop was harvested during February, 2016. The weight of millable canes from each net plot was recorded separately with the help of platform balance and the cane yield ha⁻¹ was computed on the basis of net plot area and expressed in t ha⁻¹.

The data obtained during the course of investigation were

subjected to statistical analysis using analysis of variance technique prescribed for randomized block design, to test difference among treatments means by the 'F-test' (Gomez and Gomez, 1984).

3. Results and Discussion

Tiller dynamics in terms of number of tillers (shoots) and shoot height at different growth stages was taken. No. of millable cane at harvest was counted to know how many tillers have been converted into millable canes to contribute commercial cane sugar production.

3.1. No. of tillers

No. of tillers varied significantly at all the stages of crop growth under different treatments. At 90 DAP, highest tillering (114.99 '000 ha⁻¹) was recorded in the treatment of overnight setts soaking in 100 ppm ethephon (T₄) which was significantly higher over other treatments except treatment T₆, T₈ and T₁₀.

At 120 days stage, there was continuous increase in tiller number in all the treatment irrespective of the treatments. The highest tiller count 148.10 ('000 ha⁻¹) was recorded in the treatment of overnight soaking in 100 ppm ethephon (T₄) followed by T₈ (overnight soaking with 100 ppm ethephon+GA₃ @ 35 ppm at 90, 120 and 150 DAP). Number of tillers were lowest i.e.118.49 ('000 ha⁻¹) in conventional (without any treatment) (Table 1).

At 150 days stage, the highest tiller count was recorded in T₄ (overnight soaking with 100 ppm ethephon) followed by T₈ (overnight soaking with 100 ppm ethephon+GA₃ @ 35 ppm at 90, 120 and 150 DAP), which were significantly higher over rest of the treatments. At 180 days stage, though there was some mortality in tillers in all the treatments irrespective of the treatments but the trend was the same and the highest tiller count was recorded in the treatment of overnight sett soaking in ethephon @ 100 ppm (T₄) followed by T₈. It means number of tillers per unit area could not be improved due to GA₃ application. These two treatments were at par with each other but were significantly higher over rest of the treatments. The increase in tillers was 24% higher in 100 ppm ethephon treated crop as compared to conventional (without treatment). It was evident from the observations that number of tillers were significantly higher under overnight sett soaking with 100 ppm ethephon as compared to lower concentration (50 ppm) as well as duration (6 hour) of ethephon soaking. Higher tiller production due to ethephon treatment has also been reported by many workers (Li and Solomon, 2003). Diaz et al. (1995) also reported a significant increase in stalk population of two poorly germinating sugarcane varieties, when setts were dipped in 120 ppm ethephon solution prior to planting. Increase in tiller population was also reported by Millhollon and Legendre (1995) from Louisiana when ethephon (250 ppm) was applied as a whole stalk treatment.

3.2. Shoot height

Shoot height varied significantly at all the growth stages due



Table 1: No. of tillers ('000 ha⁻¹), shoot height (cm), No. of millable canes ('000 ha⁻¹), cane yield (t ha⁻¹), green top yield (t ha⁻¹), trash yield (t ha⁻¹), and economics as influenced by different treatments

Treat- ments	No. of tillers ('000 ha ⁻¹)				Shoot height (cm)				At harvest				Net return (₹ ha ⁻¹)	B:C ratio
	90 DAP	120 DAP	150 DAP	180 DAP	90 DAP	120 DAP	150 DAP	180 DAP	NMC	CY (t ha ⁻¹)	GTY (t ha ⁻¹)	TY (t ha ⁻¹)		
T ₁	83.66	118.49	128.10	118.88	166	183	253	273	73.33	67.95	18.14	5.92	134873	1.74
T ₂	105.92	141.44	151.66	136.66	185	206	280	308	82.21	87.10	20.36	6.66	190535	2.42
T ₃	105.73	137.77	146.99	131.99	201	223	303	314	79.25	84.07	18.70	6.29	172354	2.00
T ₄	114.99	148.10	159.99	147.22	223	238	313	332	90.73	104.06	22.40	7.03	224548	2.37
T ₅	84.62	120.55	131.44	121.66	163	180	290	303	78.32	71.10	19.25	6.47	134566	1.53
T ₆	107.38	141.10	152.38	136.44	186	206	296	319	79.07	89.43	20.55	7.95	186653	2.09
T ₇	105.72	138.88	149.05	136.66	183	198	286	331	82.40	89.62	21.29	6.84	180378	1.86
T ₈	113.49	144.99	155.33	146.99	218	236	323	353	92.77	114.06	23.51	8.14	243762	2.32
T ₉	102.38	132.77	140.72	131.43	175	190	266	293	79.99	74.99	18.32	6.84	146112	1.69
T ₁₀	109.05	139.44	149.77	135.55	178	190	270	298	81.10	81.29	19.06	7.03	155807	1.63
SEm±	2.76	2.8	2.16	1.82	5.69	5.29	4.98	5.38	1.14	2.04	0.41	0.23	5763	0.06
CD*	8.2	8.34	6.41	5.43	16.92	15.72	14.79	15.98	3.40	6.06	1.21	0.70	17122	0.19

NMC: No. of millable canes ('000 ha⁻¹); CY: Cane yield; GTY: Green top yield; TY: Trash yield; CD*: CD ($p=0.05$)

to different treatments. Soaking of setts with ethephon was found to be effective in improving shoot height, however the response was both time and concentration dependent. At both the concentration (i.e. 50 and 100 ppm) of ethephon, overnight soaking of setts with ethephon was found to be more efficient as compared to 6 hour soaking.

It was very interesting to observe that the increase in shoot height due to application of gibberellic acid at 90 DAP was initially slow but the subsequent application of gibberellic acid at 120 DAP resulted in much higher increase in shoot height and the response of GA₃ application again decreased when sprayed at 150 DAP.

Final shoot height was taken at 180 days after planting. The highest shoot height was recorded in the treatment in which setts were soaked overnight in 100 ppm ethephon followed by foliar application of Gibberellic acid (35 ppm) at 90, 120 and 150 DAP. It might be due to combined effect of overnight sett soaking with 100 ppm ethephon and foliar application of Gibberellic acid.

Improvement in stalk height due to foliar application of gibberellic acid was also reported by El-lattief and Bekheet (2012).

3.3. No. of millable canes

Data pertaining to number of millable canes revealed that number of millable cane (NMC) were recovered significantly higher in the treatment T₈ (overnight soaking with 100 ppm ethephon followed by GA₃ application @ 35 ppm applied at 90, 120 and 150 DAP) over rest of the treatments except T₄ (overnight soaking of setts with 100 ppm ethephon without

GA₃ @ 35 ppm at 90, 120 and 150 DAP). The higher number of millable cane production might be attributed to higher number of tiller production in the corresponding treatments. All the treatments could significantly improve no. of millable canes over control. El-Lattief and Bekheet (2012) from Egypt reported that foliar spray of GA₃ in sugarcane improved the stalk population ha⁻¹.

3.4. Cane yield

Highest cane yield (114.06 t ha⁻¹) was obtained from the treatment of overnight soaking of cane setts in 100 ppm ethephon followed by three spraying of GA₃ @ 35 ppm at 90, 120 and 150 days after planting. Corresponding cane yield in this treatment (T₈) was 67.85% higher than conventional method (no treatment). The highest cane yield in this treatment was due to higher no. of millable canes as well as high cane weight. Cane yield was increased in all the treatments over conventional, though the response was different in different treatments. Even overnight soaking of setts in water before planting produced 28.18% higher cane yield over conventional. Sett treatment with ethephon improved germination and hence plant stand in all the treatments though the response was different for different duration (6 hour or overnight) as well as concentration (50 or 100 ppm) of sett soaking with ethephon. Ethephon soaking also improved tiller formation as has been elaborated earlier. Hence it ensured an optimum tiller count and ultimately higher no. of millable cane formation. Further application of Gibberellic acid again improved the growth which further improved cane growth and hence yield. Alexander (1968) also reported increase in yield of sugarcane due to foliar



application of gibberellic acid.

3.5. Green top and trash yield

The highest green top yield was recorded in the treatment T₈ (overnight soaking of setts in 100 ppm ethephon followed by GA₃ spray @ 35 ppm at 90, 120 and 150 DAP which was significantly higher over rest of the treatments except T₄ (overnight soaking of setts in 100 ppm ethephon). The highest green top yield was due to high leaf area index observed in this treatment. Highest dry leaves (trash) yield were recorded in the treatment T₈, which was significantly higher over rest of the treatments except T₆ (overnight soaking of setts in water followed by GA₃ spraying at 90, 120 and 150 DAP).

3.6. Economics

Net return and benefit cost ratio was calculated as the indices of acceptability or economic feasibility of the new technology. In the present study maximum net return was obtained in T₈ which was ₹ 243762 with a B:C ratio of 2.32. It is noteworthy that water soaking treatment showed highest B:C ratio (2.42) as it improved yield without involving much additional input cost, however the net return in this treatment was significantly lower as compared to T₈. In terms of B:C ratio, all the treatments performed well economically except T₅, T₉ and T₁₀ as the additional input cost over control could not bring a notable increase in net return.

4. Conclusion

Application of plant growth regulators was found to have a role in tiller dynamics of sugarcane. Sett soaking with 100 ppm ethephon followed by foliar application of Gibberellic acid @ 35 ppm at 90, 120 and 150 ppm was found to be the best proposition for improving tiller count, no. of millable cane production and cane yield.

5. Reference

Anonymous, 2011. Vision 2030. Indian institute of sugarcane research, Lucknow-226002, Uttar Pradesh, India, 1–4.
Anonymous, 2013. Status paper on sugarcane. Directorate of sugarcane development, Ministry of agriculture,

Department of agriculture and cooperation, Lucknow, Uttar Pradesh, India, 2–3.

- Alexander, A.G., 1968. Interrelationship of GA and nitrate in sugar production and enzyme activity of sugarcane. *Journal of Agriculture of the University of Puerto Rico* 52(1), 19–28.
- Diaz, J.C., Gonzalez-Tellez, F., Perez, L., Guevara, H., Zuaznaber, R., 1995. Effects of seedcane treatment with ethephon on germination, population and yields of sugarcane. *International Sugar Journal* 44, 69–72.
- El-Lattief, E.A.A., Bekheet, M.A., 2012. Quantitative and qualitative attributes of three sugarcane varieties as influenced by foliar spray of some growth regulators under upper Egypt conditions. *Sugar Technology* 14(4), 345–350.
- Gomez, K.A., Gomez, A.A., 1984. *Statistical procedure for agricultural research*. John Wiley and Sons, New York. 20–27.
- Jain, R., Solomon, S., Chandra, A., 2011. Some discernible Physio-biochemical changes associated with improved sprouting of sugarcane setts treated with Ethephon. *Sugar Technology* 13(2), 123–128.
- Kapur, R., Duttamajumder, S.K., Rao, K.K., 2011. A breeder's perspective on the tiller dynamics in sugarcane. *Current Science* 100(2), 183–189.
- Li, Y., Solomon, S., 2003. Ethephon: a versatile growth regulator for sugarcane industry. *Sugar Technology* 5(4), 213–223.
- Millhollon, R.W., Legendre, B.L., 1995. Influence of ethephon on plant population and yield of sugarcane (*Saccharum* spp. hybrids). *Quarterly Plant Growth Regulator Society of America* 23, 17–30.
- Shrivastava, A.K., Misra, S.R., 1996. Tillering in sugarcane. *Technical Bulletin No 35, Indian Institute of Sugarcane Research, Lucknow*, 10.
- Vasantha, S., Shekinah, D.E., Gupta, C., Rakkiyappan, P., 2012. Tiller production, regulation and senescence in sugarcane (*Saccharum* species hybrid) genotypes. *Sugar Technology* 14(2), 156–160.

