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Prospects of Use of *Ethrel* and Gibberellic acid on Sprouting, Growth and Productivity of Sugarcane cv CoPk 05191 (Pratap ganna1) in Rajasthan

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ABSTRACT: The experiment was conducted over three consecutive years (2015-16, 2016-17, and 2017-18) during the spring season at Agricultural Research Station, Kota (Rajasthan) to evaluate the impact of ethrel and Gibberellic acid (GA3) on the germination, growth, productivity, and economic aspects of sugarcane cultivar CoPk 05191 (Pratap Ganna 1). The experimental soil was classified as clay loam, with moderate organic carbon content (0.52%), medium availability of phosphorus (25.30 kg/ha), and high levels of available nitrogen (354 kg/ha) and potassium (320 kg/ha), and a pH of 8.19.
The present investigation was laid out in randomized block design with three replications. Sugarcane sets was planted in March and harvested after a 12-month at maturity. The application of growth regulators such as ethrel and gibberellic acid significantly influenced various growth and yield parameters throughout different stages of the crop. Treatments involving the planting of two budded setts soaked overnight in ethrel solutions of 50 ppm and 100 ppm (T3, T4, T7, and T8) showed marked superiority over conventional planting (T1) and soaking in water (T2) in promoting germination. Specifically, soaking setts in 50 ppm and 100 ppm ethrel resulted in comparable enhancements, significantly improving germination rates by 38.64-39.41% within the first 10 days of planting, tiller production by 28.98-29.47%, plant height by 16.13-16.62%, dry matter accumulation by 19.73-20.31%, and milleable cane yield by 22.74%-24.46% compared to the control group, for sugarcane cv CoPk 05191 (Pratap Ganna 1).

Keywords: Sugarcane, Ethrel, Gibberellic acid (GA_3), Agro-techniques, Growth regulators.

INTRODUCTION

India is projected to require approximately 520 million tonnes of sugarcane by 2030 to fulfil domestic demands for sugar and ethanol. Currently, the country's sugarcane production and productivity stand at 399.3 million tonnes and 82.3 tonnes per hectare, respectively. In Rajasthan, these figures are 3.26 million tonnes and 79 tonnes per hectare, respectively. However, cultivable land is diminishing, necessitating increased productivity per unit area.

Late planting after wheat harvest in March-April in Rajasthan leads to lower sugarcane germination due to high temperatures, resulting in reduced growth and ultimately lower millable cane yield compared to timely planting. To enhance productivity, new agro-technologies incorporating growth regulators are crucial. These regulators, organic substances applied in small quantities at low concentrations, modify plant growth and development. They belong to four recognized groups: Gibberellins, Indole derivatives, Abscisic acid, and Cytokinin, with ethylene recently added. Research by Rao *et al.* (1960); Kanwar and Kanwar (1986); Bendigeri *et al.* (1986) has demonstrated the beneficial effects of growth substances on sugarcane growth and yield. Studies indicate that ethrel enhances sugarcane sprouting (Li *et al*., 2003), while GA3 application notably increases internodal length (Moore, 1980; Pribil *et al.,* 2007). However, limited information exists on the combined application of ethrel and GA3 at different stages to improve sprouting, growth, and yield of sugarcane. Enhancing sugarcane germination, particularly under late planting conditions, is critical as it increases the population of mother shoots, thereby boosting tiller and cane yield.

MATERIALS AND METHODS

The present investigation on the "Prospects of Use of Ethrel and Gibberellic acid on Growth and Productivity of Sugarcane cv CoPk 05191 (Pratap Ganna1) in Rajasthan" spanned three consecutive years (2015-16, 2016-17, and 2017-18) during spring season. The experimental material used was an early maturing variety, 'CoPk 05191 (Pratap Ganna 1)'. Recommended agronomic practices and fertilizers doses of phosphorus and potassium were applied at planting using Single Super Phosphate (SSP) and Muriate of Potash (MOP), respectively, while nitrogen was applied through urea, with one-third as basal and two-thirds as top dressing in two equal splits up to the onset of monsoon.

Observations were made on germination, shoot growth, millable cane yield, cane weight, leaf area index (LAI), and overall cane yield. The experiment comprised eight treatments:

T1: Conventional planting/farmers practice (3 budded setts)

T2: Planting of setts after overnight soaking in water

T3: Planting of setts after overnight soaking in 50 ppm ethrel solution

T4: Planting of setts after overnight soaking in 100 ppm ethrel solution

T5: T1 + Gibberellic acid (GA3) spray (35 ppm) at 90, 120, and 150 days after planting (DAP)

T6: T2 + Gibberellic acid (GA3) spray (35 ppm) at 90, 120, and 150 DAP

T7: T3 + Gibberellic acid (GA3) spray (35 ppm) at 90, 120, and 150 DAP

T8: T4 + Gibberellic acid (GA3) spray (35 ppm) at 90, 120, and 150 DAP

Statistical analysis of germination, growth characteristics, and productivity followed the methods suggested by Gomez and Gomez (1984). Economic analysis, including cost of cultivation, gross returns, and net returns, was based on prevailing sugarcane prices and input costs.

RESULTS AND DISCUSSION

Germination: Sugarcane germination varied significantly across different treatments observed from 10 days after planting (DAP) to 50 DAP. Planting setts after overnight soaking in 50 ppm and 100 ppm ethrel solutions (T3, T4, T7, and T8) proved equally effective in enhancing germination compared to conventional planting (T1) or soaking in water (T2). This trend persisted throughout the observation period (Table 1). The improved germination rates can be attributed to the effects of ethrel, which likely increased enzyme activities such as acid invertase and ATPase during bud sprouting induced by growth-promoting hormones (Jain *et al.,* 2007). Rai *et al*. (2008), indicated that ethrel-treated cane setts promoted bud sprouting by altering membrane permeability, increasing moisture content, electrolyte uptake in buds, and stimulating activities of nitrate reductase, acid invertase, and peroxidase in sugarcane. Similarly, studies by Li and Solomon (2003); Jain *et al*. (2011) also highlighted improved germination due to ethrel treatments. Yangrui and Solomon (2003) reported that the application of growth-regulating chemicals like ethephon (ethrel or 2-chloroethyl phosphoric acid) enhances seed cane sprouting under both normal and late planting conditions.

Tillers (000 ha^{-1}): The highest number of tillers per hectare at 90, 120, 150, and 180 days after planting (DAP) was observed in plots where setts were planted after overnight soaking in 100 ppm ethrel solution followed by GA3 (35 ppm) spray at 90, 120, and 150 DAP (T8). This treatment significantly outperformed conventional planting (T1), planting of setts soaked overnight in water (T2), and conventional planting followed by soaking setts in 50 or 100 ppm ethrel solution followed by GA3 (35 ppm) spray at 90, 120, and 150 DAP (T5 and T6). Interestingly, planting setts soaked in 50 or 100 ppm ethrel solution followed by GA3 (35 ppm) spray (T3, T4, T7, and T8) showed comparable results in terms of tiller production per hectare (Table 1).

Gibberellic acid stimulates cane growth when applied during the vegetative phase up to the actively growing period. The increased number of tillers observed in ethrel-soaked setts with foliar application of GA3 can be attributed to higher germination rates, reduced shoot mortality, and the development of a robust root system. These findings align with previous studies by Rai *et al*. (2017); Patel and Chaudhary (2018); Gouri *et al*. (2021).

Plant height (cm): Table 2 showed that, plant height increased as the crop aged. Among the treatments observed throughout the study period, planting setts after overnight soaking in 100 ppm ethrel followed by GA3 (35 ppm) spray at 90, 120, and 150 days after planting (DAP) (T8) showed the tallest plants and significantly outperformed other treatments, except for planting setts after overnight soaking in 100 ppm ethrel followed by GA3 (35 ppm) spray at 90, 120, and 150 DAP (T7). Planting setts soaked in 50 ppm and 100 ppm ethrel solutions (T3, T4) also resulted in significantly taller plants compared to conventional planting (T1) and soaking setts in water (T2). El Lattief and Bekheet (2012); Jain *et al*. (2013) have reported that foliar application of GA3 promotes stem elongation by enhancing invertase activity in the apical portion of sugarcane, thereby improving plant height.

Dry matter accumulation (gplant^{-1}): Dry matter accumulation per plant was increased with advancement in age of sugarcane (Table 2). Planting of setts after overnight soaking in 100 ppm followed by GA_3 (35 ppm) spray at 90, 120 and 150 DAP (T_8) produced the maximum dry matter accumulation of sugarcane throughout the period of observations (T8). It was proved significantly superior to rest of the treatments except planting of setts after overnight soaking in 50 ppm followed by GA_3 (35 ppm) spray at 90, 120 and 150 DAP (T_7), planting of setts after overnight soaking in 50 as well as 100 ppm ethrel solution (T_3, T_4) which were found comparable to planting of setts after overnight soaking in 100 ppm followed by GA_3 (35 ppm) spray at 90, 120 and 150 DAP (T_8). Rai *et al.* (2017) reported that the positive effect of GA_3 application on growth characters and thereby increased dry matter of sugarcane.

Millable cane yield (tha^{-1}): Planting setts after overnight soaking in 50 ppm and 100 ppm ethrel solution alone or in combination with GA3 spray (35 ppm) at 90, 120, and 150 days after planting (DAP), as well as conventional planting or planting setts after overnight soaking in water followed by foliar spray of GA3 (35 ppm) at the same intervals, resulted in significantly higher millable cane yields compared to conventional planting (T1) and soaking setts in water (T2). Among all treatments, planting setts soaked in 100 ppm ethrel solution combined with GA3 spray (35 ppm) at 90, 120, and 150 DAP (T8) demonstrated the highest millable cane yield, reaching 98.88 tonnes per hectare (t/ha^{-1}). However, comparable millable cane yields were also achieved with planting setts soaked in 50 ppm ethrel solution combined with GA3 spray (35 ppm) at 90, 120, and 150 DAP (T7), and planting setts soaked in 100 ppm ethrel solution alone (T4) (Table 3). The use of ethrel and GA3 in late-planted sugarcane crops shows promising potential to enhance cane yield (Rai *et al.,* 2017). These findings are consistent with previous studies by Yadav *et al*. (2016); Patel and Chaudhary (2018); Patnaik and Nayak (2020); Gouri *et al.* (2021).

Economics: The economic analysis of sugarcane production under various treatments is summarized in Table 3. The treatment where setts were planted after overnight soaking in 100 ppm ethrel solution combined with GA3 spray (35 ppm) at 90, 120, and 150 days after planting (DAP) (T8) resulted in the highest gross return (₹247,200 per hectare), net return (₹131,750 per hectare), and additional return (₹48,580 per hectare) over the control. Following closely was planting setts soaked in 50 ppm ethrel solution combined with GA3 spray (35 ppm) at 90, 120, and 150 DAP (T7), planting setts soaked in 100 ppm ethrel solution alone (T4), planting setts soaked in 50 ppm ethrel solution alone (T3), and planting setts soaked in water (T2), in descending order. Conventional planting (T1) yielded the lowest gross return. The maximum net return was also achieved with planting setts soaked in 100 ppm ethrel solution combined with GA3 spray (35 ppm) at 90, 120, and 150 DAP (T8), followed by planting setts soaked in 50 ppm ethrel solution (T3) and planting setts soaked in 50 ppm ethrel solution combined with GA3 spray (35 ppm) at 90, 120, and 150 DAP (T7), in descending order. Conventional planting (T1) resulted in the minimum net return.

The highest benefit-to-cost (B) ratio was observed under planting setts soaked in 100 ppm ethrel solution alone (T4) with a ratio of 1.24, followed by planting setts soaked in 50 ppm ethrel solution alone (T3) with a ratio of 1.21, planting setts soaked in 100 ppm ethrel solution combined with GA3 spray (35 ppm) at 90, 120, and 150 DAP (T8) with a ratio of 1.14, and planting setts soaked in 50 ppm ethrel solution combined with GA3 spray (35 ppm) at 90, 120, and 150 DAP (T7) with a ratio of 1.11, in descending order. The higher Bratio under planting setts soaked in 100 ppm ethrel solution alone (T4) was attributed to comparatively higher millable cane yield and lower cost of cultivation. Conversely, the lower Bratio under planting setts soaked in 100 ppm ethrel solution combined with GA3 spray (35 ppm) at 90, 120, and 150 DAP (T8) and planting setts soaked in 50 ppm ethrel solution combined with GA3 spray (35 ppm) at 90, 120, and 150 DAP (T7) was due to higher cultivation costs, resulting in a less favourable Bratio. The minimum Bratio (0.94) was observed under planting setts soaked in water (T2) (Table 3).

Table 1: Effect of plant growth regulators on germination and tillering of sugarcane (mean of three years).

Treatment	Germination (%)					Tillers (000 ha^{-1})			
	10 DAP	20 DAP	30 DAP	40 DAP	50 DAP	90 DAP	120 DAP	150 DAP	180 DAP
T_1 : Conventional planting / Farmers' practice (3-bud setts)	5.15	17.96	37.46	43.08	46.99	71.93	133.62	145.24	157.83
T_2 : Planting of setts after overnight soaking in water	5.56	18.49	39.11	43.74	47.21	74.04	135.05	145.70	159.89
T_3 : Planting of setts after overnight soaking in 50 ppm ethrel solution	6.42	20.17	43.39	47.74	53.58	87.29	148.40	189.18	195.17
T_4 : Planting of setts after overnight soaking in 100 ppm ethrel Solution	6.91	20.18	43.49	47.38	52.65	90.58	148.42	188.39	197.58
T_5 : T1+GA$_3$ spray (35 ppm) at 90, 120 and 150 DAP	5.78	19.31	38.92	43.65	47.90	77.63	140.63	155.64	167.88
T_6 : T2+ GA$_3$ spray (35 ppm) at 90, 120 and 150 DAP	5.83	19.48	39.01	43.41	47.87	78.56	142.29	157.69	169.58
T_7 : T3 + GA$_3$ (35 ppm) spray at 90, 120 and 150 DAP	7.18	21.68	44.15	49.12	55.51	92.19	155.90	194.91	203.57
T_8 : T4 + GA$_3$ (35 ppm) spray at 90, 120 and 150 DAP	6.99	21.74	44.04	48.68	54.83	94.55	157.58	196.24	204.34
SEm ±	0.31	0.43	1.03	0.90	1.21	2.61	3.19	4.82	5.08
CD (P=0.05)	0.94	1.31	3.12	2.73	3.68	7.93	9.67	14.61	15.41

DAP = Days After Planting.

Table 2: Effect of plant growth regulators on dry matter accumulation and plant height at different growth stages of sugarcane(mean of three years).

Treatment	Dry matter accumulation, g plant-^{1}					Plant height (cm)				
	90 DAP	120 DAP	150 DAP	180 DAP	At harvest	90 DAP	120 DAP	150 DAP	180 DAP	At harvest
T_1 : Conventional planting (3-bud setts)	52.79	89.34	142.43	186.71	283.06	83.76	125.79	148.24	167.39	222.18
T_2 : Planting of setts after overnight soaking in water	55.08	93.75	141.66	188.26	287.93	84.43	127.78	150.92	172.41	224.41
T_3 : Planting of setts after overnight soaking in 50 ppm ethrel solution	60.44	101.42	155.54	206.86	325.36	94.01	135.76	159.04	179.49	238.94
T_4 : Planting of setts after overnight soaking in 100 ppm ethrel solution	65.05	104.33	157.94	210.09	331.30	96.27	137.11	162.38	181.68	245.26
T_5 : T1+GA$_3$ spray (35 ppm) at 90, 120 and 150 DAP	56.55	105.51	158.64	214.82	301.34	88.60	135.52	157.09	178.19	246.35
T_6 : T2+ GA$_3$ spray (35 ppm) at 90, 120 and 150 DAP	57.55	108.21	160.26	215.79	295.50	89.46	136.26	158.14	178.93	248.45
T_7 : T3 + GA$_3$ (35 ppm) spray at 90, 120 and 150 DAP	67.24	113.68	171.96	227.65	338.89	97.62	148.89	172.30	195.86	258.01
T_8 : T4 + GA$_3$ (35 ppm) spray at 90, 120 and 150 DAP	68.88	115.84	173.30	228.58	340.57	100.46	151.42	172.52	197.14	259.11
SEm ±	0.87	2.41	3.20	4.65	7.21	2.03	2.85	3.74	3.55	4.91
CD (P=0.05)	2.63	7.32	9.71	14.12	21.87	6.14	8.65	11.35	10.76	14.90

DAP = Days After Planting

Table 3: Effect of plant growth regulators on cane yield, production cost and economics in sugarcane (mean of three years).

Treatment	Cane yield (t ha^{-1})	Treatment cost (₹ ha^{-1})	Production cost (₹ ha^{-1})	Gross returns (₹ ha^{-1})	Net returns (₹ ha^{-1})	B: C ratio
T_1 : Conventional planting/ Farmers' practice (3-bud setts)	79.45	0	1,01,804	198617	96813	0.95
T_2 : Planting of setts after overnight soaking in water	80.57	1,970	1,03,774	201425	97651	0.94
T_3 : Planting of setts after overnight soaking in 50 ppm ethrel solution	91.98	2,123	1,03,927	229942	126015	1.21
T_4 : Planting of setts after overnight soaking in 100 ppm ethrel solution	93.33	2,276	1,04,080	233325	129245	1.24
T_5 : T1+GA_3 spray (35 ppm) at 90, 120 and 150 DAP	90.52	11,370	1,13,170	226309	113135	1.00
T_7 : T3 + GA_3 (35 ppm) spray at 90, 120 and 150 DAP	97.52	13,493	1,15,297	243808	128511	1.11
T_8 : T4 + GA_3 (35 ppm) spray at 90, 120 and 150 DAP	98.88	13,646	1,15,450	247200	131750	1.14
SEm ±	2.10	-	-	-	-	-
CD (P=0.05)	6.38	-	-	-	-	-

CONCLUSIONS

The mean data of three years on growth and yield of cane indicted that, germination, tillers, plant height and dry matter accumulation recorded at different stages under overnight soaking in 100 ppm ethrel solution was significantly superior to conventional and overnight soaking in water. Planting of two budded setts after overnightsoaking in *ethrel* solution (100 ppm) + spraying of GA_3 (35 ppm) at 90,120 and 150 DAP exhibited significantly higher germination (38.64%), higher number of tillers (204.34 thousand ha^{-1}), cane height (259.11cm), dry matter accumulation (340.57 g plant^{-1}) and millable cane yield (98.88 t/ha^{-1}) as compared to conventional planting.

FUTURE SCOPE

In our country there appears ample scope of use of ethrel in planting of setts after overnight soaking in 100 ppm ethrel with subsequent foliar application of GA_3 (35 PPM)at 90,120 and 150 DAP for increasing germination, growth and millable cane yield and economics in late planted sugarcane where yields are low due to production of shorter millable canes.

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