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THE IMPACT OF SEQUENTIAL APPLICATION OF PGR AND PGR+ NUTRIENT COMBINATION ON GROWTH, PHYSIOLOGICAL AND YIELD ATTRIBUTES OF SUGARCANE

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ABSTRACT

To study the impact of different PGR and PGR+ nutrient combinations on growth, physiological and yield attributes of sugarcane, three bud setts of variety, CoLk 94184 were primed with plant growth regulator (PGR), ethrel (@ 100 ppm) and nutrient, KCl (@0.2%) overnight and planted along with untreated control under field conditions in three replications at ICAR-IISR farm,, Lucknow in spring season (2017-18). Planted sett buds were investigated for changes in reducing sugars content and SAI activity. Foliar application of ethrel and ethrel + nutrient mixture was performed in Set-I untreated control (no sett soaking) with T1-T7 treatments; T1 – No spray (Control), T2 – ethrel spray @100 ppm (Spray 1), T3 – ethrel (100 ppm) + $ZnSO_4$ (0.5%) (Spray 2) at 60DAP, T4 – Spray 1 + GA3 spray @50 ppm (Spray 3), T5 – Spray 2 + GA3 (50 ppm) + $CaCl_2$ (1%) (Spray 4) at 110 DAP, T6 – Spray 1 + Spray 3 + Kinetin @100ppm (spray 5), T7 – Spray 2 + Spray 4 + Kinetin (100 ppm) + $MnCl_2$ (0.1%) (Spray 6) at 175 DAP. In Set-II ethrel treated (Pre-soaked setts) with T8-T14 treatments and Set-III KCl treated (Pre-soaked setts) with T15-T21) treatments, same types of treatments were given as in Set I. After 25 days of foliar application, total shoot population, fresh and dry weight of different plant parts, chlorophyll contents, and nitrate reductase (NR) activity were determined. Juice quality attributes were recorded in cane juice in each month starting from November 2017 to February 2018 and cane yield after harvesting. Findings obtained indicated higher SAI activity and reducing sugar content in treated buds. Further foliar application of ethrel and ethrel + nutrient and at elongation stage, foliar application of GA_3 and GA_3 + nutrient showed increased shoot population, chlorophyll a, b and total contents, fresh and dry weight of different plant parts and NR activity in treated sets. At harvesting, number of milliable cane (NMC/plot) in most of the treatments were higher; highest was in T11, T5 was at par followed by T13, T14 and then T8. Cane yield observed maximum in T5 (111.6 t/ha), T14 was at par (111.1 t/ha) followed by T8 (107.0 t/ha), T12 (106.4 t/ha), T11 (105.0 t/ha) and minimum in T1 (83.2 t/ha). Similarly, highest cane height and girth were observed in T11 (275.3 cm) and T8 (2.14 cm) treatments, respectively. Highest increase in sucrose % juice, CCS% and °Brix were observed in T11 treatment, while lowest reducing sugars was obtained in T17 followed by T15 treatment. Results suggested beneficial impact of PGR and PGR+ nutrient combination application on growth, yield and juice quality attributes of sugarcane when applied sequentially in whole crop duration.

Keywords: Sugarcane, PGR, Physiological and Yield attributes

Introduction

Essential nutrients in presence of growth hormones are known to enhance germination, tillering, stalk elongation, juice quality and cane yield by modulating the plant metabolism (Jain *et al*., 2019). The interaction of these hormones combined with nutrients triggers specific activities such as membrane permeability, gene expression and synthesis of new protein molecules. Literature available on effect of essential nutrients and growth promoting hormones in sugarcane as well as in other crops, arrived an idea to work on effect of nutrient –hormone combination in on sugarcane. Effect of ethrel for germination and tillering, GA_3 for shoot elongations are well established (Jain *et al*., 2011, 2013, 2014, 2018; Rai *et al*., 2017). Cell division activity could be enhanced using cytokinins. The most important hormonal groups for this process are auxins, gibberellins, abscisic acid and cytokinins (CKs) (Marschner, 1995). The gibberellic acid is the most frequently used plant harmone for the growth of sugarcane crop at the commercial level, for agronomic as well as scientific research (Resende, *et al* 2000, Gupta and Chakrabarty, 2013). GA is also known to play an important role in seed germination, stem elongation and meristematic tissue development (Gupta and Chakravarty, 2013). However, GA proved that its function in the presence of invertase (Kumar and Abbas 2014), by which sucrose is broken down into reducing sugar, further limited the phloem loading of sucrose in the sink. Along with productivity, the most important economic value of sugarcane is the sucrose concentration in the juice. Higher sucrose accumulation helps sugarcane farmers to procure a higher milling factory price and this perturbed condition can be achieved by extra chemical ripening agents (Crusciol *et al*., 2017). Plant growth regulators are being widely used to counteract the deleterious effects of adverse environmental stresses on plants. Kinetin is one of the cytokinins known to significantly improve the growth of crop plants. Physiological effects of CKs on plants are related to elongation and differentiation, capacity of division, formation and activity of apical meristems, mobilization of nutrients, break of apical dominance, germination and break of seed and dormancy, induction of parthenocarpy in fruits, flowering induction and delayed senescence (Reynolds *et al*., 1992, Davies, 2004, Rivero *et al*., 2007). Cytokinins are also involved in the development and protection of cellular structures (Chernyad, 2005) and in the enzymatic activity (Davies, 2004), regulating the induction and activation of the protein synthesis necessary for the formation of the photosynthetic system (Selivankina *et al*., 2004, Chernyad, 2005, Taiz and Zeiger, 2009). Similar to growth hormones, phosphorus, calcium, Mg and Mn are all essential nutrients for growth and improving crop productivity. Both these essential nutrients and hormones in combination will help in improving crop productivity. Seed priming is known to affect seedling characters and seed vigor of tomato using water (dH_2O), sodium chloride (2%), salicylic acid (60 ppm), acetyl salicylic acid (60 ppm), ascorbic acid (60 ppm), PEG- 6000 and potassium nitrate (5%), in darkness for 48 hours; KNO_3 showed maximum response (Mirabi and Hasanabadi , 2012). Studies on tiller initiation and emergence in sugarcane indicated interactive effect of essential nutrients like N,P,K and Zn with growth hormones and nitrogen metabolism prior to shoot differentiation. Ethephon, IBA etc have been used in inducing early tillering and each tiller needs its own rooting. Therefore, PGR application (ethrel, cytokinin and calcium) may help in inducing rooting by enhancing cell division thus suppress tiller mortality. The role of metal ions as enzyme effectors in sugarcane has been reported by Jain *et al.* (2013). Present investigation was aimed to study the impact of sequential application of PGR and PGR+ nutrient combination on physiological attributes, cane and sugar yield using sugarcane cultivar CoLk 94184 under subtropical India.

Materials and Methods

A field experiment was conducted to study the impact of sequential application of PGR and PGR+ nutrient combination on physiological attributes, cane and sugar yield at ICAR-IISR, Lucknow. Three bud setts of variety, CoLk 94184 were soaked in growth promoting hormone, ethrel (@ 100 ppm), and nutrient, KCl (@ 0.2%) over night and planted along with untreated control under field conditions in three replications in randomized block design in February 2017. At about 60 DAP, foliar application of ethrel and ethrel + nutrient mixture was performed in control, ethrel and KCl treated sets. After 25 days of foliar application, total shoot population, fresh and dry weight of different plant parts were determined. Chlorophyll contents and nitrate reductase (NR) activity were determined in fresh green leaves. At about 110 DAP, foliar application of GA_3 and GA_3 + nutrient mixture was performed in control, ethrel and KCl treated sets. After 25 days of foliar application, total shoot population and growth parameters were determined. At about 175 DAP, foliar application of Kinetin and Kinetin + nutrient mixture was performed in all three sets. Juice quality attributes viz., ^{o}Brix, sucrose% juice, juice purity, commercial cane sugar (CCS %) was recorded after cane crushing in each month starting from November, 2017 to February, 2018 by the method described earlier (Jain *et al*., 2019). Cane yield attributes were recorded at harvesting. Treatment detail is given in Table A.

Table A: Detail of treatments and mode of application

	Treatment detail	**Treatment**
Set I: Untreated Control (No sett soaking)	T1 – No spray	Control
	T2 – Ethrel spray (100 ppm) at 60 DAP	Spray 1
	T3 – Ethrel (100 ppm) + $ZnSO_4$ (0.5%) spray at 60 DAP	Spray 2
	T4 – Spray 1 + GA_3 spray (50 ppm) at 110 DAP	Spray 3
	T5 – Spray 2 + GA_3 (50 ppm) + $CaCl_2$ (1%) spray at 110 DAP	Spray 4
	T6 – Spray 1 + Spray 3 + Kinetin (100ppm) spray at 175 DAP	Spray 5
	T7 – Spray 2 + Spray 4 + Kinetin (100 ppm) + $MnCl_2$ (0.1%) spray at 175 DAP	Spray 6
Set II: Ethrel Treated (Pre-soaked setts)	T8 – No spray	Control
	T9 – Ethrel spray (100 ppm) at 60 DAP	Spray 1
	T10 – Ethrel (100ppm) + $ZnSO_4$ (0.5%) spray at 60 DAP	Spray 2
	T11 – Spray 1 + GA_3 spray (50 ppm) at 110 DAP	Spray 3
	T12 – Spray 2 + GA_3 (50ppm) + $CaCl_2$ (1%) spray at 110 DAP	Spray 4
	T13 – Spray 1 + Spray 3 + Kinetin (100ppm) spray at 175 DAP	Spray 5
	T14 –Spray 2 + Spray 4 + Kinetin (100 ppm) + $MnCl_2$ (0.1%) spray at 175 DAP	Spray 6
Set III: KCl Treated (Pre-soaked setts)	T15 – No spray	Control
	T16 – Ethrel spray (100 ppm) at 60 DAP	Spray 1
	T17 – Ethrel (100ppm) + $ZnSO_4$ (0.5%) spray at 60 DAP	Spray 2
	T18 – Spray 1 + GA_3 spray (50 ppm) at 110 DAP	Spray 3
	T19 – Spray 2 + GA_3 (50ppm) + $CaCl_2$ (1%) spray at 110 DAP	Spray 4
	T20 – Spray 1 + Spray 3 + Kinetin (100ppm) spray at 175 DAP	Spray 5
	T21 – Spray 2 + Spray 4 + Kinetin (100 ppm) + $MnCl_2$ (0.1%) spray at 175 DAP	Spray 6

Chlorophyll Content

Chlorophyll content was determined in 0.05 gm fresh leaf tissues of control and treated plants in all three sets according to Arnon (1949). Leaf tissues were ground in 10 ml acetone (80%, v/v) and add a pinch of $CaCO_3$. The homogenate was centrifuged at 10,000 rpm at room temperature for 10 min. Then supernatant was collected and absorbance was measured at 663, 645 and 470 nm. The Chlorophyll a, b and total chlorophyll contents were calculated using the formula given below, and the amounts were expressed as mg/g fresh weight:

(1) Chlorophyll a (mg/g fwt) = $((12.7 \times A_{663}) - (2.69 \times A_{645})) \times 0.2$

(2) Chlorophyll b (mg/g fwt) = $((22.9 \times A_{645}) - (4.68 \times A_{663})) \times 0.2$

(3) Total chlorophyll (mg/g fwt)= Chlorophyll a+ Chlorophyll b

Nitrate Reductase Activity

Nitrate reductase (NR) activity *in vivo* was determined by the method of Harley (1993) in fresh leaf discs fixed in 5ml 0.005 M phosphate buffer (pH 7.0) containing 0.1% isopropyl alcohol and 0.1M KNO_3 and kept in dark for 1 h. After 1 h reaction, 1 ml reaction mixture was mixed with 1 ml sulphanilamide (1% in 25% HCl) and 1ml Naphthyl ethylenediamine dihydrochloride (0.02% NDD) solution and measured at 540 nm within 15 min. NR activity was expressed as µg nitrite formed/100 mg fresh weight.

Statistical Analysis

All data were determined in three replications and analyzed statistically for coefficient of variance (CV %) and Critical Difference (CD). Different letters indicate significant difference between treatments.

Results and Discussion

Growth, physiological, yield and quality attributes:

At Germination Stage

- **Germination percent**

Pre-soaking of setts in ethrel solution (@ 100 ppm) and KCl solution (0.2%) over night resulted in early and higher rate of bud germination than untreated control. Increase in germination percent in ethrel and KCl soaked setts was recorded and reported earlier in our first publication (Singh *et al*., 2018). Increase in SAI activity and sugar content in relation to bud germination was observed due to soaking treatments which help in higher sugars availability to growing bud and causes early germination (Rai *et al*., 2017).

CONTROL ETHREL TREATED

Plate 1: Effect of setts soaking on germination and early growth of sugarcane

At Tillering Stage

Shoot population: Initial shoot population was relatively higher in ethrel soaking (415/plot) and KCl soaking (419/plot) sets than untreated control (255/plot). Foliar application of ethrel and ethrel + nutrient increased total shoot population in all the sets as compared to untreated control. Highest increase in shoot population was observed in Set II with ethrel spray as compared to untreated control (Table 1, Plate 1).

Biomass analysis: Foliar application of ethrel and ethrel + nutrient showed increase in fresh weight and dry weight of different plant parts in all three sets as compared to untreated control. Highest increase in fresh and dry weight was observed in Set III with ethrel spray (Table 2&3).

Chlorophyll Content: Foliar application of ethrel and ethrel + nutrient mixture in control, ethrel and KCl sets showed increase in chlorophyll a, b and total chlorophyll contents as compared to untreated control; highest increase in chlorophyll content was observed with ethrel spray in all sets as compared to respective control (Table 4).

Nitrate Reductase (NR) activity: NR activity increased in all three sets due to foliar application of ethrel and ethrel + nutrient mixture; highest increase was observed in Set II with ethrel + nutrient mixture spray (Table 5). Increased shoot population due to PGR application indicates stimulatory effect of ethrel on tiller formation (Jain and Solomon 2010) and higher rate of nitrate assimilation (Singh *et al*., 2018).

At Grand Growth Stage

Shoot population: At grand growth stage, initial shoot population was relatively higher in ethrel and KCl soaking sets than untreated control. Foliar application of GA_3 and GA_3 + nutrient spray increased total shoot population in all the sets as compared to respective control. Highest increase in shoot population was observed in Set II as compared to untreated control (Table 6).

Plant height, leaf number and leaf area: Plant height increased in all treatments in all sets as compared to untreated control due to GA_3 application. Highest increase in Set I, Set II and Set III was observed with ethrel + nutrient spray along with GA_3 + nutrient spray. Leaf number and leaf area were increased due to foliar application of GA_3 and GA_3 + nutrient spray in ethrel and KCl soaked sets. Leaf area ranged from 286.8 to 375.0 cm^2, highest increase was observed in Set II with ethrel + nutrient spray along with GA_3 + nutrient spray (T12) (Table 7).

Biomass analysis: Foliar application of ethrel, ethrel + nutrient, GA_3 and GA_3 + nutrient spray showed increase in fresh weight and dry weight of different plant parts; maximum increase was observed in Set II with ethrel + nutrient spray. Fresh and dry weight of stalk and root showed highest increase in Set II with ethrel + nutrient spray along with GA_3 + nutrient spray (Table 8&9).

Chlorophyll Content: Chlorophyll a, b and total chlorophyll contents was relatively higher in all three sets with ethrel, ethrel + nutrient, GA_3 and GA_3 + nutrient mixture as compared to untreated control. Highest increase in chlorophyll content was observed in Set III with ethrel spray along with GA_3 spray as compared to untreated control (Table 11).

NR activity: Foliar application of GA_3 and GA_3 + nutrient mixture showed increased NR activity in control, ethrel and KCl sets; highest increase was observed in Set II with ethrel spray along with GA_3 spray (Table 12). Earlier reports also showed similar results of increased internode length and fresh weight in response to GA treatment (Moore and Buren 1978, Jain *et al*., 2019). GA stimulates physiological growth which causes higher shoot population and dry matter production (Rai *et al*., 2017).

At maturity

- **Juice Quality attributes**

Juice quality attributes viz., Brix, sucrose percent juice, juice purity and CCS%, was determined periodically from October till harvesting. Foliar application of GA_3, GA_3 + nutrient, Kinetin and Kinetin + nutrient increased juice quality attributes as compared to respective controls. Brix and juice purity showed gradually increase in all treatments from the month of November 2017 to February 2018. At harvesting, highest increase in ºBrix and juice purity was observed in T17 and T21 respectively (Table 12 &13); while lowest reducing sugar % was obtained in T7. Sucrose % juice and CCS% gradually increased in all treatments from the month of November 2017 to February 2018 (Fig 1 & 2). Sucrose content varied from 14.17 to 19.53% from the month of November 2017 to February 2018. Highest increase in sucrose and CCS was obtained in T7 at harvesting. Rai *et al.* (2017) also reported stimulated physiological growth of sugarcane due to PGR application which augumented dry matter production and juice quality attributes. Increase in juice quality attributes indicates higher sugar transport and accumulation by source sink manipulation through PGR application (Tripathi *et al*., 2019).

- **Cane Yield Attributes**

PGR and PGR + nutrient combination treatment increased cane height and girth as compared to untreated control; it ranged from 199.3 to 275.3 cm and 1.68 to 2.14 cm, respectively (Table 14). Highest increase in cane height and girth was observed in T11 and T8 treatments, respectively. Number of milliable cane (NMC) increased in all the treatments (Table 14). Highest increase was obtained in T10. Cane yield increased in all treatments over control. Cane yield ranged from 83.2 to 111.6 t/ha. Highest yield was observed in T5 (Control set Ethrel + nutrient spray along with GA+ Nutrient spray), T14 was at par (111.1 t/ha) (ethrel set with Ethrel + Nutrient, GA + Nutrient and Kinetin + Nutrient spray), then T8 (107.0 t/ha), followed by T12 (106.4 t/ha), T11 (105.0 t/ha) (Table 14). Increased cane yield by GA application was also reported earlier by several workers (Rai *et al*., 2017; Moore and Buren , 1978, Moore *et al*., 1982; Bull 1964; Coleman *et al*., 1959 ; Tanimoto and Nickell 1968, Rademacher, 2016).

GA_3 and BA application under *in vitro* condition improved shoot and root development in sugarcane (Mustafa and Khan 2016). Kinetin @ 75 ppm was found to mitigate the negative effect of water scarcity on photosynthesis, growth and yield of wheat grain (Lalarukh *et al*., 2014). Kannan in 1980 earlier stated that the above groung parts and plant leaves are able to absorb chemicals and essential nutrients. Sugarcane setts treated with 0.3% K-rich biostimulant and sequentially applied further at tillering and ripening stage indicated >20% increase in cane yield and juice quality attributes (Karthikeyan and Shanmungam, 2017). Findings obtained indicated stimulatory effect of PGR and PGR+ nutrient combination on sugarcane germination, growth, yield and juice quality attributes when applied in a sequential manner at different growth stages.

Table 1: Effect of foliar spray of PGR and PGR + Nutrient on shoot population/plot at tillering

Treatment	Set I	Set II	Set III	CV (%)	CD (0.05)
Control	255 (b)	415 (a)	419 (a)	6.70	42.79
Ethrel	291 (b)	422 (a)	413 (a)		
Ethrel+Nutrient	291 (b)	404 (a)	412 (a)		

Different letters indicate significant difference between treatments.

Table 2: Effect of foliar spray of PGR and PGR + Nutrient on fresh weight (Kg/m^2) of different plant parts at tillering stage

Treatments	Set I	Set II	Set III	CV (%)	CD (0.05)
Leaf Lamina					
Control	0.0948 (g)	0.2478 (e)	0.3033 (c)	1.05	0.009
Ethrel	0.1240 (f)	0.3116 (b)	0.4080 (a)		
Ethrel+ Nutrient	0.1245 (f)	0.2790 (d)	0.3088 (bc)		
Leaf Sheath					
Control	0.1188 (h)	0.2785 (f)	0.4167 (b)	2.19	0.005
Ethrel	0.1590 (g)	0.3602 (d)	0.4692 (a)		
Ethrel+ Nutrient	0.1589 (g)	0.3263 (e)	0.3906 (c)		
Stalk					
Control	0.0948 (i)	0.2096 (f)	0.3943 (c)	1.49	0.010
Ethrel	0.1279 (h)	0.3336 (d)	0.4871 (a)		
Ethrel+ Nutrient	0.1399 (g)	0.2816 (e)	0.4366 (b)		
Root					
Control	0.0072 (d)	0.0197 (b)	0.0224 (b)	9.56	0.004
Ethrel	0.0107 (c)	0.0315 (a)	0.0321 (a)		
Ethrel+ Nutrient	0.0088 (d)	0.0200 (b)	0.0224 (b)		
Total					
Control	0.3156 (h)	0.7556 (f)	1.1368 (c)	0.69	0.020
Ethrel	0.4216 (g)	1.0370 (d)	1.3964 (a)		
Ethrel+ Nutrient	0.4321 (g)	0.9069 (e)	1.1584 (b)		

Different letters indicate significant difference between treatments.

Table 3: Effect of foliar spray of Ethrel and Ethrel +Nutrient on dry weight (Kg/m^2) of different plant parts at tillering stage

Treatments	Set I	Set II	Set III	CV (%)	CD (0.05)
Leaf Lamina					
Control	0.0324 (f)	0.0779 (d)	0.0910 (c)	3.433	0.008
Ethrel	0.0392 (e)	0.0988 (b)	0.1137 (a)		
Ethrel+ Nutrient	0.0398 (e)	0.0883 (c)	0.0787 (d)		
Leaf Sheath					
Control	0.0204 (f)	0.0503 (d)	0.0714 (b)	5.95	0.007
Ethrel	0.0270 (ef)	0.0638 (c)	0.0791 (a)		
Ethrel+ Nutrient	0.0281 (e)	0.0574 (c)	0.0641 (c)		
Stalk					
Control	0.0120 (e)	0.0334 (c)	0.0350 (bc)	10.38	0.009
Ethrel	0.0190 (de)	0.0429 (b)	0.0510 (a)		
Ethrel+ Nutrient	0.0208 (d)	0.0374 (bc)	0.0523 (a)		
Root					
Control	0.0036 (c)	0.0090 (b)	0.0093 (a)	17.19	0.003
Ethrel	0.0056 (c)	0.0099 (b)	0.0143 (a)		
Ethrel+ Nutrient	0.0044 (c)	0.0098 (b)	0.0130 (a)		
Total					
Control	0.0684 (f)	0.1707 (d)	0.2067 (bc)	3.84	0.015
Ethrel	0.0908 (e)	0.2155 (b)	0.2581 (a)		
Ethrel+ Nutrient	0.0931 (e)	0.1929 (c)	0.2081 (b)		

Different letters indicate significant difference between treatments.

Table 4: Effect of foliar spray of PGR and PGR + Nutrient on Chlorophyll a, b and total contents (mg/g fwt) in sugarcane leaves at tillering stage

Treatment	Set I	Set II	Set III	CV (%)	CD (0.05)
	Chlorophyll a				
Control	(e)	(bcd)	(d)	7.13	0.276
Ethrel	(abcd)	(ab)	(a)		
Ethrel + Nutrient	(b)	(cd)	(abc)		
	Chlorophyll b				
Control	(ef)	(bcd)	(de)	7.88	0.076
Ethrel	(abc)	(ab)	(a)		
Ethrel + Nutrient	(f)	(cd)	(abc)		
	Total Chlorophyll				
Control	(e)	(bcd)	(d)	6.96	0.336
Ethrel	(abc)	(ab)	(a)		
Ethrel + Nutrient	(e)	(cd)	(abc)		

Different letters indicate significant difference between treatments.

Table 5: Effect of foliar spray of PGR and PGR + Nutrient on Nitrate reductase activity (µg nitrite formed/100mg fwt) in sugarcane leaves at tillering stage

Treatment	Set I	Set II	Set III	CV (%)	CD (0.05)
Control	3.460 (f)	4.720 (de)	3.900 (ef)	11.69	1.22
Ethrel	5.499 (cd)	6.706 (bc)	5.599 (cd)		
Ethrel + Nutrient	7.328 (b)	9.705 (a)	7.117 (b)		

Table 6: Effect of foliar spray of PGR and PGR + Nutrient on shoot population/plot at grand growth stage

Treatment	Set I	Set II	Set III	CV (%)	CD (0.05)
Control	530 (fgh)	522 (gh)	511 (h)	3.34	33.46
Ethrel	640 (c)	593 (de)	563 (ef)		
Ethrel + Nutrient	683 (b)	719 (a)	505 (h)		
GA_3	632 (c)	714 (ab)	545 (fg)		
GA_3 + Nutrient	620 (cd)	696 (ab)	527 (gh)		

Different letters indicate significant difference between treatments.

Table 7: Effect of foliar spray of PGR and PGR + Nutrient on leaf number, leaf area and plant height at grand growth stage

Treatment	Set I	Set II	Set III	CV (%)	CD (0.05)
Leaf number/clump					
Control	63 (a)	56 (abcd)	59 (abc)	6.47	7.80
Ethrel	63 (a)	49 (d)	55 (bcd)		
Ethrel + Nutrient	57 (abc)	62 (ab)	54 (cd)		
GA_3	53 (cd)	55 (bcd)	53 (cd)		
GA_3 + Nutrient	54 (cd)	57 (abc)	52 (cd)		
Leaf Area (cm^2)					
Control	286.8 (d)	344.9 (ab)	364.9 (ab)	6.02	44.35
Ethrel	362.9 (ab)	363.7 (ab)	343.4 (ab)		
Ethrel + Nutrient	357.4 (ab)	364.9 (ab)	352.9 (ab)		
GA_3	296.4 (cd)	333.6 (abc)	330.8 (abcd)		
GA_3 + Nutrient	321.8 (bcd)	375.0 (a)	355.2 (ab)		
Stalk height (cm)					
Control	118.2 (e)	129.9 (de)	143.3 (abc)	5.73	13.35
Ethrel	130.5 (cde)	139.4 (abcd)	148.7 (ab)		
Ethrel + Nutrient	135.5 (bcd)	145.0 (ab)	140.1 (abcd)		
GA_3	130.8 (cde)	135.4 (bcd)	148.2 (ab)		
GA_3 + Nutrient	140.8 (abcd)	150.6 (a)	152.3 (a)		

Different letters indicate significant difference between treatments.

Table 8: Effect of foliar spray of PGR and PGR + Nutrient on fresh weight (Kg/m^2) of different plant parts at grand growth stage

Treatments	Set I	Set II	Set III	CV (%)	CD (0.05)
Leaf Lamina					
Control	1.0988 (o)	1.4647 (n)	1.7170 (j)	0.220	0.009
Ethrel	1.7013 (k)	1.5649 (l)	1.8445 (i)		
Ethrel+ Nutrient	1.9633 (f)	2.4990 (a)	1.5403 (m)		
GA_3	2.3793 (b)	2.0388 (e)	1.9039 (h)		
GA_3+ Nutrient	2.0849 (d)	2.3283 (c)	1.9338 (g)		
Leaf Sheath					
Control	1.0018 (n)	1.2324 (m)	1.3814 (k)	0.177	0.006
Ethrel	1.4213 (j)	1.3050 (e)	1.4341 (i)		
Ethrel+ Nutrient	1.6203 (g)	2.1148 (a)	1.4527 (h)		
GA_3	1.7640 (d)	1.7736 (c)	1.6786 (f)		
GA_3+ Nutrient	1.6208 (g)	1.8047 (b)	1.7098 (e)		
Stalk					
Control	2.5953 (n)	4.1201 (m)	5.5063 (i)	0.116	0.015
Ethrel	4.5957 (l)	5.0218 (k)	5.4546 (j)		
Ethrel+ Nutrient	5.7102 (h)	6.7487 (c)	6.3984 (e)		
GA_3	6.6709 (d)	7.9603 (b)	6.1948 (g)		
GA_3+ Nutrient	6.7367 (c)	9.3871 (a)	6.3473 (f)		
Root					
Control	0.0506 (j)	0.0537 (i)	0.0595 (hi)	7.608	0.013
Ethrel	0.0660 (ghi)	0.0635 (ghi)	0.0656 (ghi)		
Ethrel+ Nutrient	0.0951 (cd)	0.1061 (bc)	0.0724 (fgh)		
GA_3	0.0798 (ef)	0.1118 (b)	0.0890 (de)		
GA_3+ Nutrient	0.0746 (fg)	0.1436 (a)	0.0840 (def)		
Total					
Control	4.7464 (o)	6.8709 (n)	8.6642 (k)	0.101	0.021
Ethrel	7.7843 (m)	7.9552 (l)	8.7989 (j)		
Ethrel+Nutrient	9.3889 (i)	11.4686 (c)	9.4637 (h)		
GA_3	10.8940 (d)	11.8846 (b)	9.8663 (g)		
GA_3+ Nutrient	10.5169 (e)	13.6637 (a)	10.0748 (f)		

Different letters indicate significant difference between treatments.

Table 9: Effect of foliar spray of PGR and PGR + Nutrient on dry weight (kg/m^2) of different plant parts at grand growth stage

Treatments	Set I	Set II	Set III	CV (%)	CD (0.05)
Leaf Lamina					
Control	0.3296 (l)	0.4469 (h)	0.6514 (h)	0.444	0.006
Ethrel	0.5018 (j)	0.5633 (i)	0.7126 (e)		
Ethrel+ Nutrient	0.6481 (h)	0.7642 (b)	0.5622 (i)		
GA_3	0.6783 (g)	0.7644 (ab)	0.7703 (a)		
GA_3+ Nutrient	0.6983 (f)	0.7335 (d)	0.7543 (c)		
Leaf Sheath					
Control	0.2255 (k)	0.2711 (j)	0.3703 (f)	0.502	0.004
Ethrel	0.2985 (i)	0.2674 (j)	0.3720 (f)		
Ethrel+ Nutrient	0.3728 (f)	0.4633 (a)	0.3703 (f)		
GA_3	0.3381 (g)	0.4078 (d)	0.3957 (e)		
GA_3+ Nutrient	0.3221 (h)	0.4151 (c)	0.4274 (b)		
Stalk					
Control	0.4023 (n)	0.8036 (k)	1.1179 (g)	0.294	0.007
Ethrel	0.7811 (l)	0.8790 (i)	1.0044 (h)		
Ethrel+ Nutrient	0.5712 (m)	1.3834 (c)	1.2797 (d)		
GA_3	1.2470 (e)	1.5344 (b)	1.1151 (g)		
GA_3+ Nutrient	0.8422 (j)	1.8774 (a)	1.2061 (h)		
Root					
Control	0.0219 (h)	0.0295 (fg)	0.0265 (gh)	7.260	0.005
Ethrel	0.0285 (fg)	0.0357 (cde)	0.0323 (ef)		
Ethrel+ Nutrient	0.0393 (bc)	0.0428 (b)	0.0330 (def)		
GA_3	0.0378 (bcd)	0.0325 (ef)	0.0309 (efg)		
GA_3+ Nutrient	0.0283 (fg)	0.0649 (a)	0.0350 (cde)		

Total					
Control	0.9794 (n)	1.5510 (m)	2.1661 (g)		
Ethrel	1.6100 (l)	1.7453 (j)	2.1213 (h)		
Ethrel+Nutrient	1.6314 (k)	2.6536 (c)	2.2452 (f)	0.250	0.011
GA_3	2.3012 (e)	2.7391 (b)	2.3119 (e)		
GA_3+ Nutrient	1.8909 (i)	3.0909 (a)	2.4227 (d)		

Different letters indicate significant difference between treatments.

Table 10: Effect of foliar spray of PGR and PGR + Nutrient on Chlorophyll a, b and total contents (mg/g fwt) in sugarcane leaves at grand growth stage

Treatment	Set I	Set III	Set III	CV (%)	CD (0.05)
Chlorophyll a					
Control	2.03 (e)	2.68 (bc)	2.59 (cd)		
Ethrel	2.64 (bcd)	2.95 (ab)	2.59 (cd)		
Ethrel+ Nutrient	2.66 (bcd)	3.11 (a)	2.22 (e)	5.87	0.337
GA_3	2.68 (bc)	2.94 (ab)	3.27 (a)		
GA_3 + Nutrient	2.33 (de)	2.77 (bc)	2.69 (bc)		
Chlorophyll b					
Control	0.51 (g)	0.67 (bcde)	0.66 (cdef)		
Ethrel	0.71 (abcde)	0.74 (abcd)	0.61 (defg)		
Ethrel+ Nutrient	0.73 (abcde)	0.80 (abc)	0.62 (defg)	9.82	0.144
GA_3	0.52 (efg)	0.73 (abcde)	0.84 (a)		
GA_3 + Nutrient	0.59 (efg)	0.69 (bcde)	0.81 (ab)		
Total Chlorophyll					
Control	2.54 (g)	3.35 (cd)	3.25 (de)		
Ethrel	3.35 (cd)	3.69 (bc)	3.20 (def)		
Ethrel+ Nutrient	3.39 (cd)	3.91 (a)	2.84 (fg)	5.11	0.368
GA_3	3.20 (def)	3.67 (bc)	4.11 (a)		
GA_3 + Nutrient	2.92 (ef)	3.46 (cd)	3.50 (cd)		

Different letters indicate significant difference between treatments.

Table 11: Effect of foliar spray of PGR and PGR + Nutrient on Nitrate reductase activity (µg nitrite formed/100mg fwt) in sugarcane leaves at grand growth stage

Treatment	Set I	Set II	Set III	CV (%)	CD (0.05)
Control	1.614 (i)	2.193 (h)	3.456 (fg)		
Ethrel	3.686 (fg)	2.212 (h)	4.511 (e)		
Ethrel + Nutrient	3.335 (g)	7.762 (b)	3.533 (fg)	4.89	0.456
GA_3	5.546 (c)	8.934 (a)	5.198 (cd)		
GA_3 + Nutrient	3.874 (f)	4.475 (e)	4.912 (de)		

Different letters indicate significant difference between treatments.

Table 12: Effect of foliar spray of PGR and PGR + Nutrient on ºBrix of cane juice in different months

Treatments	Nov'17	Dec'17	Jan'18	Feb'18
T1	18.11 (cdef)	19.40 (f)	20.12 (hi)	21.22 (h)
T2	17.99 (def)	20.22 (a)	20.65 (abc)	21.55 (cdef)
T3	18.29 (bcdef)	20.00 (abc)	20.26 (gh)	21.65 (cde)
T4	18.02 (cdef)	20.05 (abc)	20.35 (cdefgh)	21.68 (cde)
T5	18.20 (bcdef)	20.02 (ab)	20.67 (ab)	21.71 (bcd)
T6	17.83 (fg)	19.93 (abcd)	20.61 (abcde)	21.72 (bc)
T7	17.89 (efg)	19.74 (bcdef)	20.58 (abcdef)	21.75 (bc)
T8	18.18 (cdef)	19.64 (bcdef)	19.57 (j)	21.47 (efg)
T9	18.38 (abcdef)	19.68 (bcdef)	20.39 (bcdefgh)	21.42 (fgh)
T10	18.14 (cdef)	19.63 (cdef)	20.71 (a)	21.66 (cde)
T11	18.95 (a)	19.91 (abcd)	20.66 (ab)	21.64 (cde)
T12	17.94 (efg)	19.75 (bcdef)	20.33 (defgh)	21.47 (efg)
T13	18.30 (bcdef)	19.82 (abcde)	20.35 (cdefgh)	21.23 (h)
T14	17.37 (g)	19.55 (def)	20.28 (fgh)	21.32 (gh)
T15	18.52 (abcd)	19.42 (f)	19.90 (i)	21.50 (defg)
T16	18.41 (abcde)	19.67 (bcdef)	20.09 (hi)	21.41 (fgh)
T17	18.25 (bcdef)	19.90 (abcde)	20.31 (efgh)	22.15 (a)
T18	18.76 (ab)	19.87 (abcde)	20.46 (abcdefg)	21.92 (b)
T19	18.59 (abc)	19.74 (bcdef)	20.56 (abcdefg)	21.24 (h)

T20	18.76 (ab)	19.76 (bcdef)	20.73 (a)	21.42 (fgh)
T21	18.55 (abcd)	19.52 (ef)	20.62 (abcd)	21.35 (fgh)
CV (%)	1.91	0.93	0.72	0.47
CD (0.05)	0.575	0.383	0.305	0.213

Different letters indicate significant difference between treatments.

Table 13: Effect of foliar spray of PGR and PGR + Nutrient on Juice Purity in different months

Treatments	**Nov'17**	**Dec'17**	**Jan'18**	**Feb'18**
T1	83.96 (cde)	87.64 (f)	88.23 (jk)	88.51(k)
T2	84.31 (c)	88.81 (ab)	89.24 (cde)	89.46 (fghi)
T3	84.19 (cd)	88.10 (cde)	89.68 (ab)	89.80 (efg)
T4	83.00 (g)	87.65 (f)	88.08 (k)	89.20 (hij)
T5	81.10 (h)	87.83 (ef)	88.92 (efgh)	89.07 (hij)
T6	83.25 (fg)	87.92 (def)	89.77 (a)	89.04 (ij)
T7	82.91 (g)	86.80 (g)	88.54 (hij)	90.28 (cde)
T8	84.75 (ab)	86.33 (h)	88.98 (cdefg)	89.55 (fgh)
T9	84.12 (cd)	88.17 (cde)	88.52 (ij)	89.18 (hij)
T10	84.21 (cd)	88.42 (bc)	88.82 (fghi)	88.93 (jk)
T11	84.10 (cd)	88.19 (cde)	89.00 (cdefg)	90.13 (cde)
T12	84.24 (cd)	88.26 (cd)	88.74 (ghi)	89.38 (ghij)
T13	84.30 (c)	88.93 (a)	89.34 (bc)	89.85 (efg)
T14	83.85 (de)	87.17 (g)	88.52 (ij)	89.89 (def)
T15	84.80 (a)	87.88 (ef)	88.42 (ijk)	89.36 (ghij)
T16	84.80 (a)	88.87 (a)	89.19 (cdef)	90.80 (ab)
T17	83.61 (ef)	88.93 (a)	89.11 (cdefg)	90.48 (bc)
T18	85.05 (a)	88.74 (ab)	89.01 (cdefg)	91.10 (a)
T19	84.30 (cd)	88.70 (ab)	89.33 (cd)	90.16 (cde)
T20	84.33 (bc)	88.17 (cde)	89.18 (cdef)	90.38 (bcd)
T21	84.36 (bc)	87.90 (def)	88.94 (defg)	90.42 (bc)
CV (%)	0.243	0.213	0.214	0.270
CD (0.05)	0.426	0.392	0.398	0.505

Different letters indicate significant difference between treatments.

Table 14: Effect of foliar spray of PGR and PGR + Nutrient on yield attributes at harvesting

Treatment	**NMC (lakh/ha)**	**Yield (t/ha)**	**Cane height (cm)**	**Cane girth (cm)**
T1	1.58 (e)	83.2 (i)	199.3 (i)	1.68 (g)
T2	1.60 (e)	92.4 (efghi)	216.0 (hi)	1.95 (abcde)
T3	1.62 (de)	87.4 (hi)	242.3 (defg)	1.99 (abcd)
T4	1.60 (e)	96.1 (cdefgh)	240.0 (efg)	2.01 (abcd)
T5	1.73 (bcd)	111.6 (a)	254.0 (bcdef)	2.12 (a)
T6	1.62 (cde)	92.5 (efghi)	260.0 (abcd)	2.05 (abc)
T7	1.61 (e)	100.6 (bcdef)	269.3 (ab)	2.07 (abc)
T8	1.62 (de)	107.0 (ab)	244.3 (defg)	2.14 (a)
T9	1.65 (cde)	97.3 (bcdefg)	249.0 (cdefg)	2.09 (ab)
T10	1.85 (a)	103.5 (abcd)	253.7 (bcdef)	2.11 (ab)
T11	1.73 (bc)	105.0 (abcd)	275.3 (a)	2.12 (a)
T12	1.66 (cde)	106.4 (abc)	257.3 (abcde)	2.07 (abc)
T13	1.80 (ab)	102.6 (abcde)	258.3 (abcde)	2.04 (abc)
T14	1.74 (abc)	111.1 (a)	265.3 (abc)	1.91 (bcde)
T15	1.68 (cde)	101.7 (abcde)	232.3 (gh)	2.08 (ab)
T16	1.63 (cde)	98.0 (bcdefg)	236.0 (fg)	1.71 (fg)
T17	1.62 (de)	90.9 (fghi)	232.7 (gh)	2.00 (abcd)
T18	1.66 (cde)	88.8 (ghi)	250.0 (bcdefg)	1.88 (cdef)
T19	1.58 (e)	92.3 (efghi)	251.0 (bcdefg)	1.75 (efg)
T20	1.66 (cde)	95.8 (defgh)	254.3 (bcdef)	1.84 (defg)
T21	1.66 (cde)	98.5 (bcdefg)	267.3 (abc)	1.77 (efg)
CV (%)	3.25	6.38	4.70	6.15
CD (0.05)	33.80	10.34	19.16	0.20

Different letters indicate significant difference between treatments.

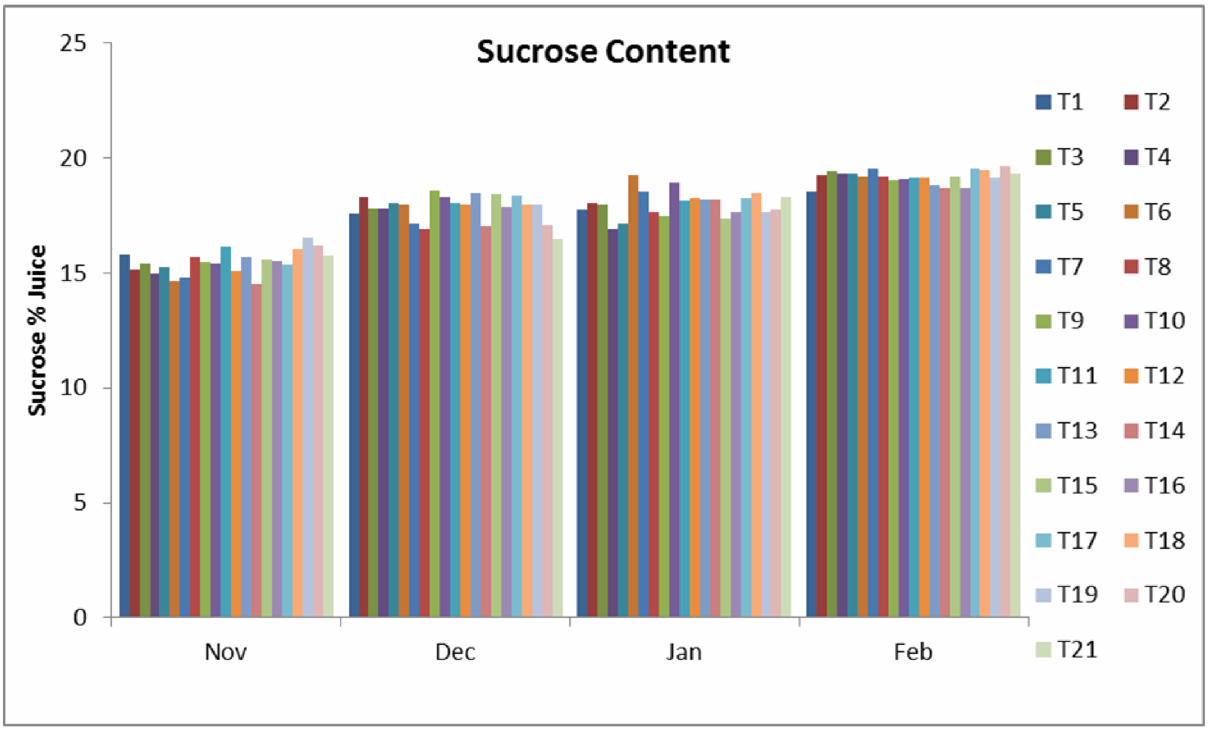

Fig. 1: Effect of PGR and PGR + Nutrient spray on Sucrose% Juice of sugarcane

	Nov	Dec	Jan	Feb
CV (%)	3.838	3.518	3.284	2.097
CD (0.05)	0.272	0.284	0.270	0.184

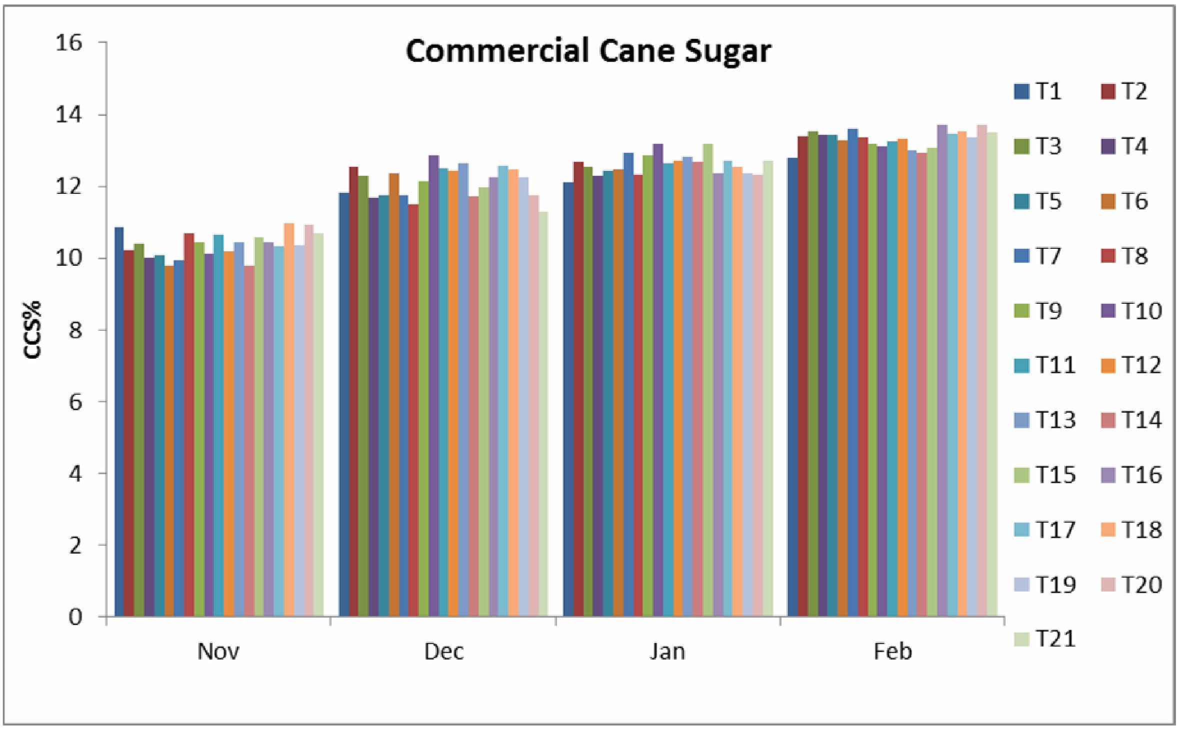

Fig. 2: Effect of PGR and PGR + Nutrient spray on CCS% Juice

	Nov	Dec	Jan	Feb
CV (5%)	4.675	4.198	3.943	3.297
CD (0.05)	0.219	0.234	0.228	0.199

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