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Short Communication: Agronomical characteristics of sweet corn under different plant growth regulators during the dry season

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Abstract. *Mubarok S, Wicaksono FY, Nuraini A, Rahmat BPN, Budiarto R. 2022. Short Communication: Agronomical characteristics of sweet corn under different plant growth regulators during the dry season. Biodiversitas 23: 3091-3098.* Sweet corn (*Zea mays* convar. *saccharata* var. *rugosa*) is one of the important horticultural crops. Increasing sweet corn production during the dry season can be achieved by applying plant growth regulators (PGR). PGRs such as auxin, gibberellin, cytokinin, ethylene, and other phytohormones control various physiological and chemical processes in plants. The PGR is often used for the engineering process of plant cultivation technology, especially during environmental stress conditions. This study aimed to determine the effect of PGRs (auxin, gibberellic acid, salicylic acid, and paclobutrazol) on sweet corn growth and yield during the dry season. The results showed that the application of PGR significantly affected sweet corn growth, yield, and yield quality during the dry season. The auxin significantly increased plant height and leaf length, whereas paclobutrazol and salicylic acid significantly increased the number of cobs and total soluble solids of sweet corn, respectively.

Keywords: Auxin, dry season, gibberellic acid, plant growth regulator, yield, *Zea mays*

INTRODUCTION

Sweet corn (*Zea mays* convar. *saccharata* var. *rugosa*) is one of the important horticultural commodities worldwide due to its delicious taste and nutritional content (Mubarok et al. 2020a). Sweet corn has a high sugar content due to the altered alleles that disrupt endosperm starch synthesis (Tracy et al. 2020). An earlier study by Laughnan (1953) reported the effects of the *sh2 gene* on altering carbohydrate composition in corn endosperm, leading to less starch and high soluble sugar formation. Aside from a high sucrose content during its commercial maturity, sweet corn is a source of beneficial phytochemicals such as melatonin, tryptophan (Revilla et al. 2021), carotenoid (Song et al. 2016a; 2016b), anthocyanin (Hong et al. 2020), flavonoids (Zhang et al. 2018) and phenolic (Zhang et al. 2017; Das and Singh 2016). The nutrient content, such as minerals, phenolic acid, and xanthophyll, may vary among corn types, products, and uses (Prasanthi et al. 2017). Due to its importance, sweet corn production development is the main concern to meet the market's demand.

Abiotic stress is one of the plant growth limitations that directly affect plant growth and yield. One of the most common abiotic stresses is drought stress (Nezhadahmadi et al. 2013). Recently, global warming has been an important issue globally due to its effect on many aspects of life. Global warming stimulates uncertain whether (Takeda and Matsuoka 2008) and shifts the start of the rainy season (Iizumi et al. 2014). Altered agroclimatic conditions led to the prolonging dry season in certain areas, and afterward, drought stress incidence emerged to endanger the cultivated plant. Several intensification strategies that used to prevent environmental effects such as fertilizer and shading (Suradinata et al. 2019a; Nafi'ah et al. 2021). Another intensification strategy used to eliminate the negative effect of drought stress on plants is the application of a plant growth regulator (PGR).

Both PGR and phytohormone have a similar effect but are different in the way they are synthesized. Phytohormone is synthesized naturally by a plant, but PGR is an artificial phytohormone synthesized outside the plant body (Daphne and Michael 2005). Numerous studies have been reported that several PGRs, namely kinetin, chitosan, uniconazole, chlormequat chloride, gibberellic acid, ethephon, indole-butyric acid, benzyl amino purine, naphthalene acetic acid and brassinolide are used to control plant growth and the development and also effect on postharvest quality (Shekoofa and Emam 2008; Han et al. 2011; Otie et al. 2016; Suo et al. 2017; Shahniza te al. 2020; Mubarok et al. 2020b; 2020c).

Auxin regulates the incidence of apical dominance, phototropism, cell division, and meristematic formation in the plant (Woodward and Bartel 2005; Benjamins and Scheres 2008; Bielach et al. 2017; Farooq et al. 2018). Moreover, auxin is reported to increase the lateral root density of corn (Alarcón et al. 2019). Another plant phytohormone is Gibberellic acid. Gibberellic acid regulates several plant metabolisms processes, such as stem elongation, leaf expansion, seed germination, flower induction, and fruit development (Sun 2010). Specifically, in corn, gibberellic acid is reported to promote good seed germination performance (Pan et al. 2017). Unlike gibberellic acid, paclobutrazol is a gibberellin-inhibitor that inhibits cell elongation, resulting in a dwarf plant (Nuraini et al. 2020). The application of paclobutrazol has a positive effect on improvement in ear characteristics and the yield of corn (Kamran et al. 2018). Salicylic acid is reported to help the formation of salinity tolerance in corn (Gautam and Singh 2009). However, a similar study in response to drought stress is still rarely found. The present study aimed to evaluate the agronomical responses of sweet corn in response to various PGRs, namely auxin, gibberellic acid, paclobutrazol, and salicylic acid, under drought stress conditions during the dry season.

MATERIALS AND METHODS

Experimental preparation

The experiment was conducted during the dry season at the Experimental Gardens of the Faculty of Agriculture, Universitas Padjadjaran, Jatinangor, Sumedang, West Java (750 meters above sea level, 6°55'11.2" 107°46'22.0"), with a C3 rainfall type according to Oldeman classification and an Inceptisol soil type. A randomized block design was used in this experiment, which consisted of nine treatments, namely control (without PGR), paclobutrazol (200 and 400 ppm), auxin (100 and 200 mg l^{-1}), salicylic acid (10^{-5} and 10^{-2} M), GA_3 (400 and 600 ppm) and replicated thrice. In total, there were 27 experimental units and then there were 12 plants for each experimental unit. Thus, the present study involved 384 sweet corn plants.

Plant cultivation

Sweet corn land preparation used a no-tillage system by planting the seed directly in the soil with a spacing of 60 x 40 cm and a depth of 3-5 cm. Two seeds were inserted into the planting hole and then covered with soil. Embroidery was carried out seven days after planting (DAP) by replacing any unfavorable seeds (limited or abnormal growth) with new normal ones. NPK compound fertilizer at a dose of 5 g $plant^{-1}$ was applied by using the localized placement method, at a distance of 8-10 cm away from the seed. PGRs in form of paclobutrazol, auxin, salicylic acid, and GA_3, with the given concentration adjusted to the treatment, were simultaneously applied at 10 and 12 weeks after planting (WAP) by using the spraying method, with a dose of each PGR for about 50 mL $plant^{-1}$.

Plant growth and yield observation

The observation was made at 72 days after sowing on agronomical characters, such as plant height, leaf length, leaf width, number of cobs per plant, harvest age, cob weight, cob length, cob diameter, the number of kernel rows per cob, and total soluble solids of sweet corn. Total soluble solid was measured according to the methods described by Mubarok et al. (2015; 2019a; 2022).

Statistical analysis

Obtained data were represented as the mean values ± standard error (SE) of three replications. Data were subjected to a one-factor analysis of variance (ANOVA) and then followed by the Duncan Multiple Range Test (DMRT) at $p < 0.05$ in the program of Statistical Tool for Agricultural Research (STAR) version 2.0.1.

RESULTS AND DISCUSSION

Plant height

Plant height could be influenced by the genetic factor (Djarot et al. 2021; Suradinata et al. 2019b) and also exogenous auxin application. Based on statistical data analysis, the application of auxin at 100 and 200 mg L^{-1} significantly increased the plant height, resulting in the highest plant obtained. However, the application of other PGRs at a given concentration did not significantly affect plant height (Figure 1). Pramanik and Mohapatra (2017) reported that auxin promotes cell elongation and division by stimulating cell walls to be more elastic. Moreover, auxin together with cytokinin promotes xylem and phloem growth (Pramanik and Mohapatra 2017). Application of paclobutrazol at a dose of 200 mg L^{-1} produced the shortest plant, although it was not significantly different to control. Paclobutrazol is a gibberellic acid inhibitor that reduced the elongation of internodes without the reduction of the node number (Xia et al. 2018; Hütsch and Schubert 2021). The present study found that the GA_3 at 400 and 600 ppm produced a significantly higher plant than paclobutrazol-treated plants. Paclobutrazol also diverted photosynthates into the root system, leading to the limitation of canopy growth and plant height (Bridgemohan and Bridgemohan 2014), similar to the root pruning effect (Budiarto et al. 2019a), but opposite to the canopy pruning effect (Budiarto et al. 2019b).

Leaf length and width

Leaf was an important variable to be an appropriate proxy of plant growth (Salazar et al. 2018; Hamdani et al. 2022), morphological feature (Efendi and Budiarto 2022; Budiarto et al. 2021a; 2021b; Djarot et al. 2021), phytochemical content (Efendi et al. 2021), and physiological condition (Budiarto et al. 2018; Budiarto et al. 2019b). Leaf size, in terms of leaf length and width, of sweet corn at present proved to be significantly affected by the application of PGR.In theory, the application of GA_3 was able to increase leaf length by increasing plant cell division and elongation, but higher doses of gibberellic acid inhibited leaf growth yielding shorter leaves (De Souza and MacAdam 2001; Utami et al. 2018). Paclobutrazol is also reported to be an inhibitor effect on canopy leaf development, and it could divert plant photosynthates into the root (Bridgemohan and Bridgemohan 2014; Cregg and Ellison-Smith 2020).

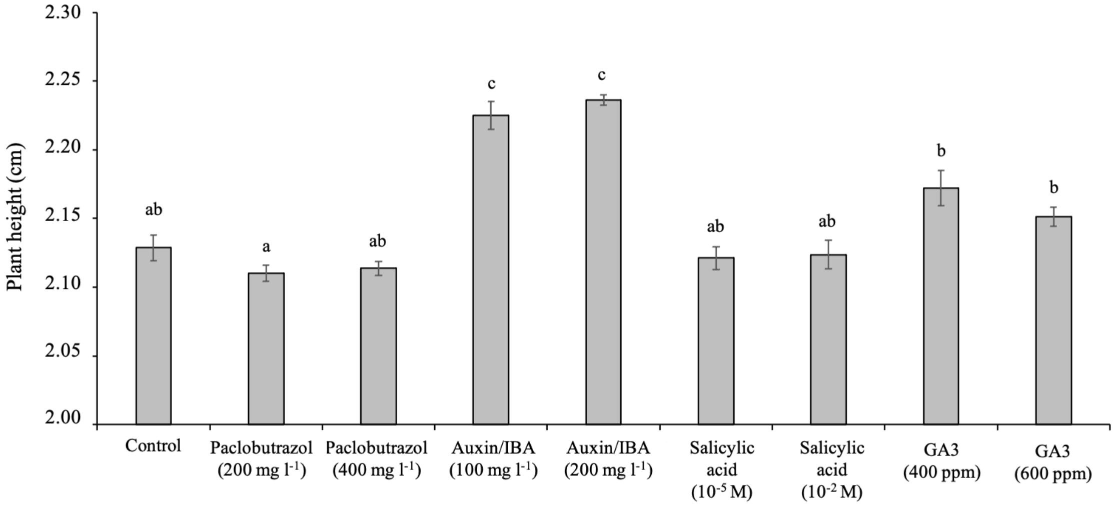

Figure 1. Sweet corn plant height in response to various PGRs applications. Note: The same lowercase letter above the bar was not significantly different based on the Duncan's Multiple Range Test at *p*<0.0

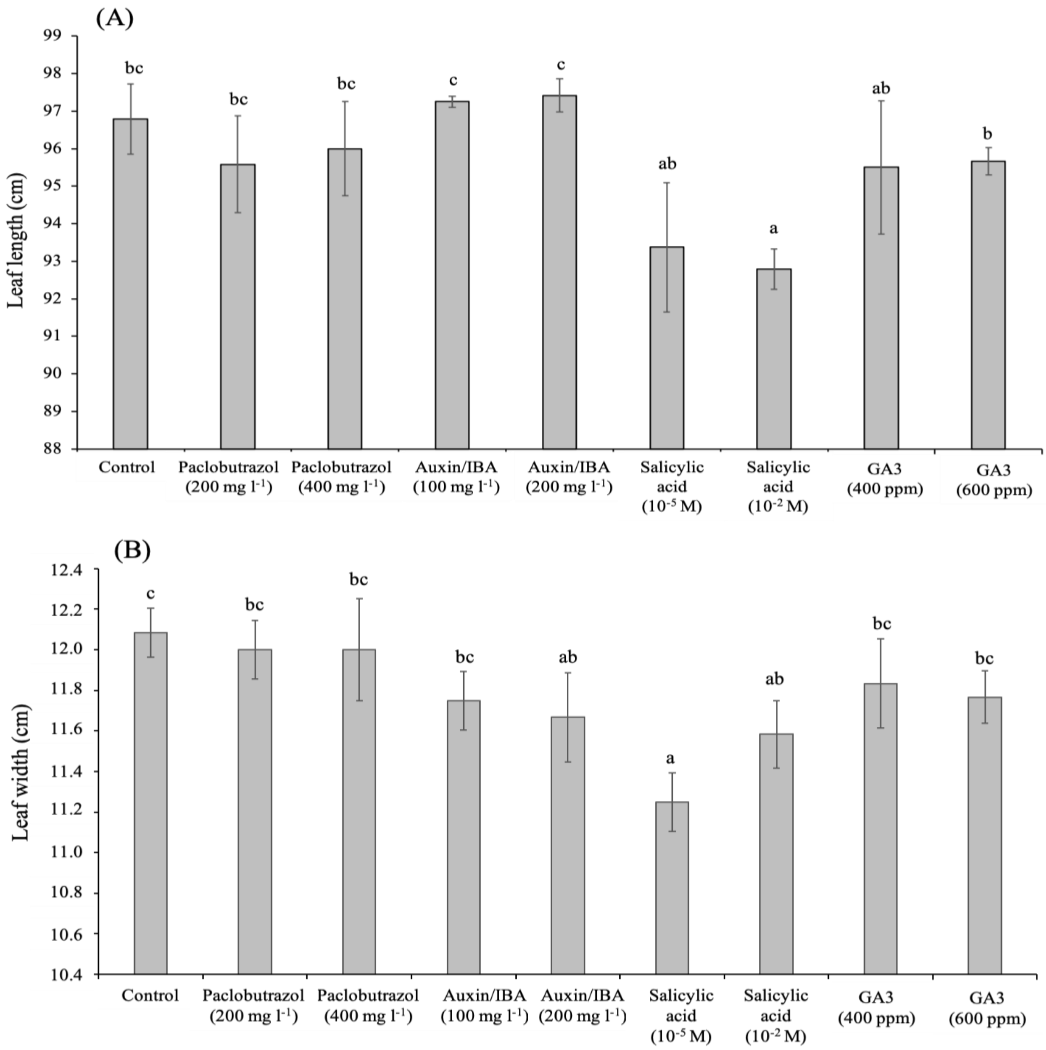

Figure 2. Sweet corn in response to various PGRs applications. A. sweet corn leaf length. B. sweet corn leaf width. Note: The same lowercase letter above the bar was not significantly different based on the Duncan's Multiple Range Test at $p < 0.05$

However, the present finding stated that the leaf size of paclobutrazol, and GA_3 treated plant was not significantly different than control. The auxin-treated sweet corn, at a dose of 200 mg L^{-1}, displayed a narrower leaf than the control, similar to the earlier finding by Chaudhary et al. (2019). However, the application of salicylic acid (10^{-2} M) produced significantly lower leaf size (length and width) than control (Figure 2A and 2B). This finding was in accordance with an earlier report (Youssef et al. 2017).

The number of cobs per plant and harvesting time

The application of PGR significantly affected the number of cobs per plant. Recent finding highlighted the significantly higher number of cobs per plant on paclobutrazol 400 mg L^{-1} treated plant than control (Figure 3A). Kozlowski and Pallardy (1997) stated that paclobutrazol could increase the number of cornflowers set, which affected the increase in the number of cob per plant. A similar study was reported by Urfan et al. (2021) who reported the increase in the number of flowers per plant and the number of cobs per plant as the effect of the paclobutrazol application. This condition might be caused by the increased water use capacity in a paclobutrazol-treated plant (Hütsch and Schubert 2021). Statistical analysis showed no significant variation in sweet corn harvesting time, with a range of 70-72 days after sowing (Figure 3B). Surtinah (2008) reported that sweet corn was harvested after 70 days after showing to achieve the highest sugar content. The harvesting time of sweet corn uld is altered by the presence of ethylene through an exogenous application (Shekoofa and Emam 2008).

Cob quality

Cob quality variables in terms of cob weight, cob length, cob diameter, and the number of kernel rows per cob were analyzed in the present study. There was no significant difference in cob length under various PGRs applications, with a range of 18.63 to 19.45 cm in GA_3 400 ppm and control treatment, respectively (Figure 4). The application of auxin 200 mg L^{-1} significantly reduced the cob weight and cob diameter by 16% and 15% lower than the control, respectively (Figures 5, 6).

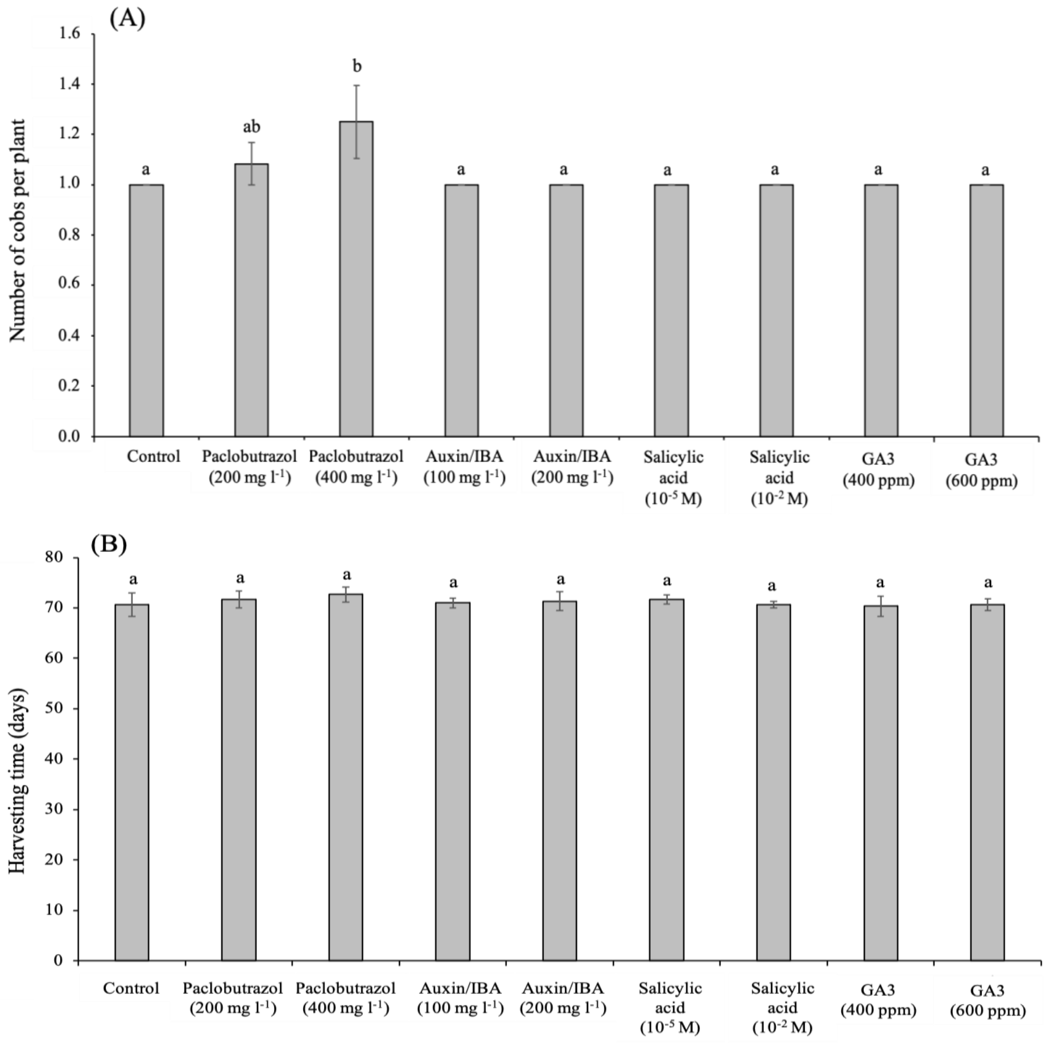

Figure 3. Response to various PGRs applications. A. The number of cob per plant. B. Sweet corn harvesting time. Note: The same lowercase letter above the bar was not significantly different based on the Duncan's Multiple Range Test at *p*<0.05

However, the application of low concentration paclobutrazol (200 mg L^{-1}) and GA_3 significantly increased the cob diameter than control (Figure 4C). The present finding was similar to the previous study by Mishra et al. (2020), who reported that the application of GA_3 combined with fertilizer became an effective strategy to increase cob diameter and the number of the kernel. In terms of the number of kernel rows per cob, the application of 10^{-2} M salicylic acid and 400 ppm GA_3 significantly increases the result over the control (Figure 7). This result was in accordance with an earlier study by Zamaninejad et al. (2013) who reported that the application of salicylic acid in high concentrations under drought conditions effectively increased the number of kernel rows per cob.

Total Soluble Solid (TSS)

The carbohydrate and sugar content of plants could be affected by the maturity stage (Khanduri et al. 2011; Mubarok et al. 2016) and also the presence of drought stress conditions (Almodares et al. 2013). Total soluble solid could be used to preliminary evaluate the carbohydrate status, especially the sweetness level (Mubarok et al. 2019b; 2021). By applying suitable PGRs during the dry season, the TSS of sweet corn was proportionally increased. Statistical analysis found that PGRs in form of salicylic acid and gibberellic acid significantly increase TSS content than control under drought stress conditions during the dry season (Figure 8). This result was similar to Tayyab et al. (2020), who reported that drought-stressed maize has 28 % higher sugar content and 38% in carbohydrate content after being treated with salicylic acid. Dawood et al. (2012) also reported that salicylic acid diverted photoassimilate into sink organs during the vegetative stage, affecting the accumulation of carbohydrates and sugar.

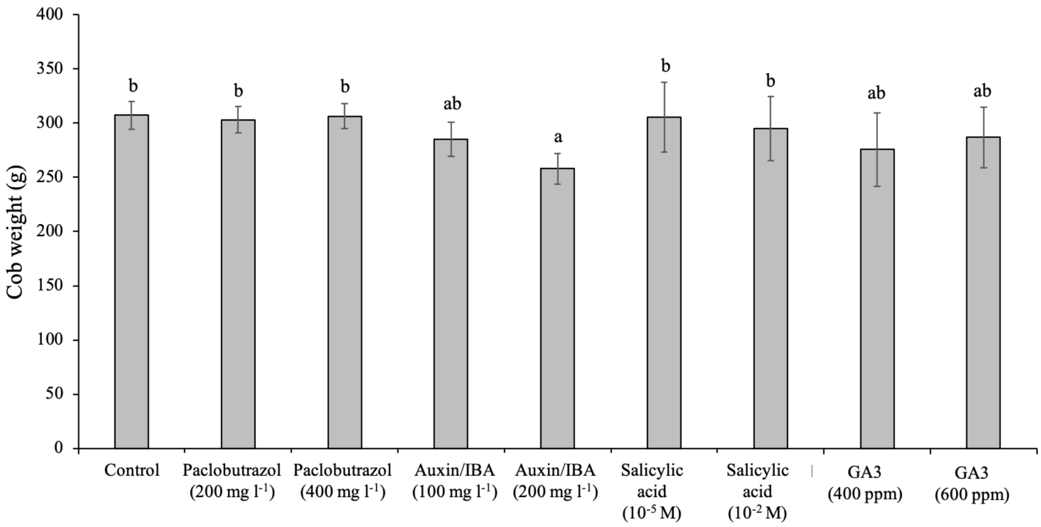

Figure 4. Sweet corn cob weight in response to various PGRs applications. Note: The same lowercase letter above the bar was not significantly different based on the Duncan's Multiple Range Test at $p<0.05$

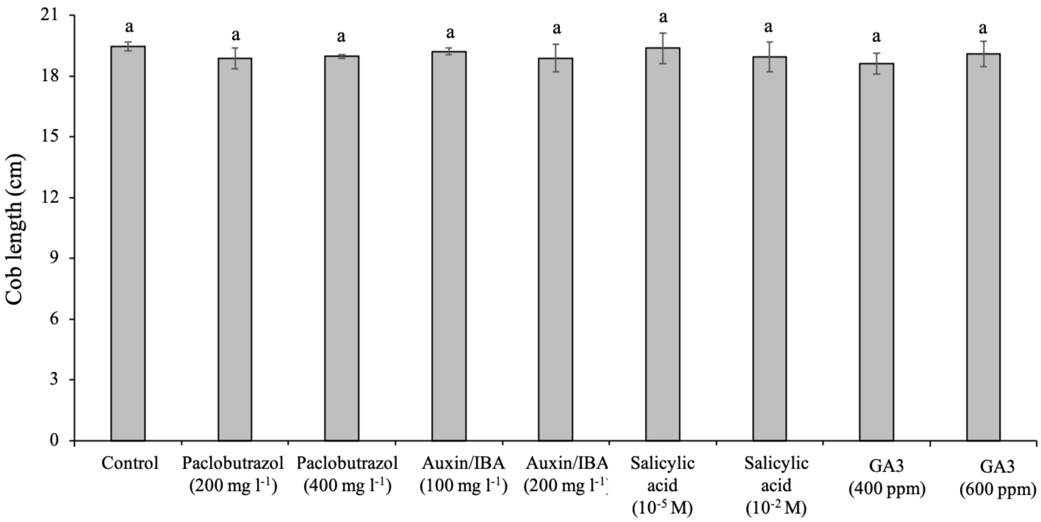

Figure 5. Sweet corn cob length in response to various PGRs applications. Note: The same lowercase letter above the bar was not significantly different based on the Duncan's Multiple Range Test at $p<0.05$

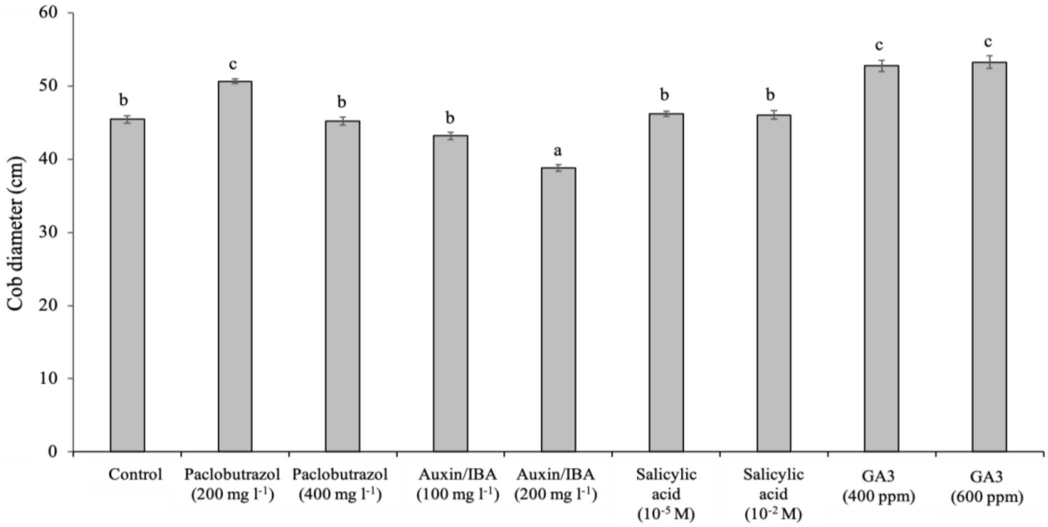

Figure 6. Sweet corn cob diameter in response to various PGRs applications. Note: The same lowercase letter above the bar was not significantly different based on the Duncan's Multiple Range Test at $p<0.05$

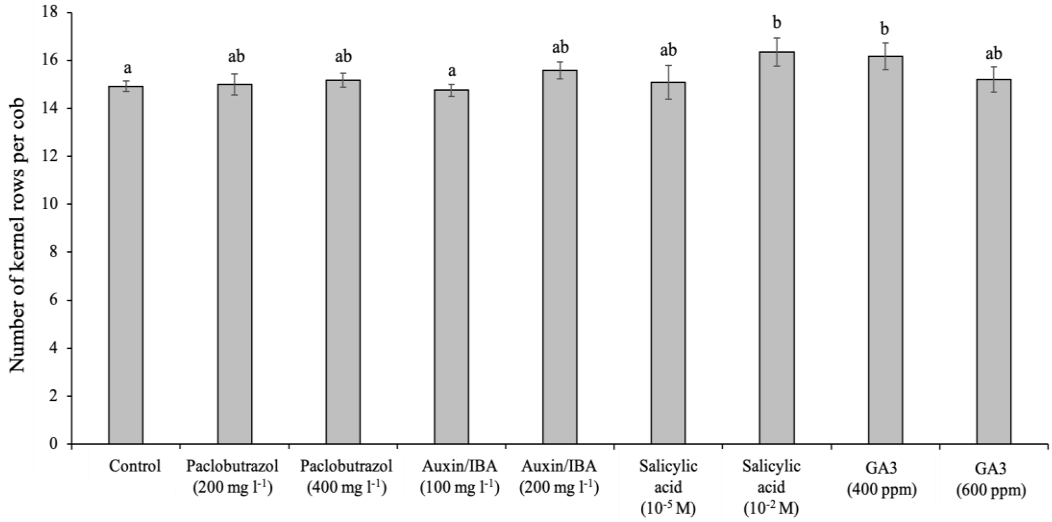

Figure 7. Sweet corn number of kernel rows per cob in response to various PGRs applications. Note: The same lowercase letter above the bar was not significantly different based on the Duncan's Multiple Range Test at $p<0.05$

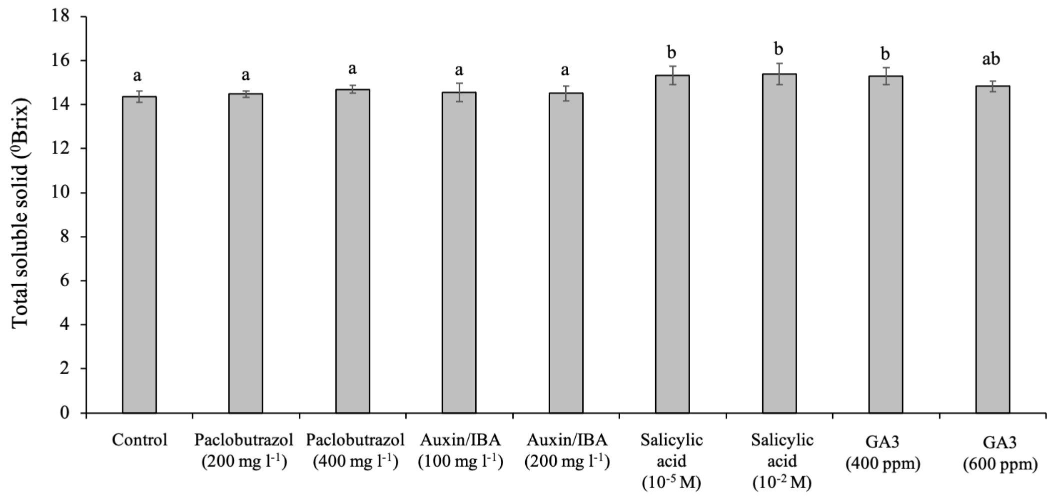

Figure 8. Total soluble solid of sweet corn in response to various PGRs applications. Note: The same lowercase letter above the bar was not significantly different based on the Duncan's Multiple Range Test at $p<0.05$

In conclusion, PGRs plays important role in regulating sweet corn growth and development during the dry season auxin was very influential in plant growth and significantly increased plant height and leaf length. The administration of paclobutrazol and salicylic acid had a significant effect on the yield and quality of crop yields, especially in increasing the number of cobs and total soluble solids of sweet corn.

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