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Evaluation of plant growth regulators effect on growth and yield in ginger transplants under polyhouse

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ABSTRACT

The study evaluates plant growth regulators (PGRs) stimulus on growth and yield attributes in ginger transplants under polyhouse conditions. In this study, PGRs including CCC, GA_3, NAA and BAP at three concentration levels (50ppm, 100ppm, and 150ppm) with water as control were given at 90, 120 days after transplanting. All the growth regulators proved effective in improving growth and yield attributes as compared with control. The findings revealed that NAA application at 150 ppm gave the highest plant height (114.0 cm), while CCC 150 ppm recorded the lowest plant height (54.89 cm). BAP application at 100 ppm produced the highest number of pseudostems per clump (19.59). The highest rhizome yield (304 g/plant) was obtained at 150 ppm of CCC. The highest rhizome diameter (2.49 cm) and number of primary rhizome (14.52) were noted with CCC 100 ppm. The longest rhizome length was observed with CCC 50 ppm. Application of NAA 100 ppm produced maximum number of secondary rhizomes (13.99). Number of tertiary rhizomes was the highest in GA_3 150 ppm (10.59). According to this experimental findings, foliar application of cycocel improved the yield in ginger transplants grown in polyhouse conditions. Therefore, the study confirmed that polyhouse cultivation combined with application of plant growth regulators could enhance ginger productivity.

Key words: *Zingiber officinale*, cycocel, naphthalene acetic acid, gibberellic acid, 6-benzyl amino purine.

INTRODUCTION

Zingiber officinale Rosc., commonly known as ginger, is a perennial herb of the Zingiberaceae family, represents a critical component of global trade in spice and has been used in culinary and medicinal applications for centuries. Moreover, it is a valuable export crop for its powder, oil and oleoresin. Its major active compounds include gingerols, shogaols and paradols, which contribute to its medicinal efficacy and flavour profile. India remains the largest producer of ginger, but its productivity is severely affected by disease pressures and climatic vagaries in open field systems now a days. Major production limitations in ginger include soil-borne pathogens such as *Ralstonia solanacearum* (bacterial wilt), *Pythium* spp. (rhizome rot) and infestations by nematodes. Successive monocropping and soft rot disease leads to drastic decline in yield (Rai *et al.*, 9). Additionally, abiotic stresses including altered rainfall, temperature shifts, drought and soil fertility depletion, frequently exacerbate yield losses and compromise the overall quality of rhizomes. Ginger is propagated vegetatively using rhizome. In conventional method, seed rhizomes weighing 20-25 g are used for planting, resulting in a higher planting material requirement of 1500 -2500 kg ha^{-1} and this accounts for a major share in the total production cost. Forty per cent of the total cost is utilised for the purchase of seed rhizomes. Around 17-20 % of harvested ginger is annually retained for seed purpose. From the harvesting stage (Jan to Feb) upto next season (May to June), harvested rhizomes are to be kept for three months in viable as well as healthy stage for its use as planting material (Rai and Hossain, 10). In order to overcome these issues, ginger can also be propagated through transplanting of rhizome seedling raised in pro-trays (IISR, 5). The yield and quality level of ginger transplants made from single-bud sprouts are comparable to those produced using conventional planting strategy (Prasath *et al.*, 8).

The rising demand for quality produce and year-round availability has shifted attention towards protected cultivation systems particularly polyhouses. Polyhouses offer regulated environment that allow precise management of temperature, humidity and pathogen exposure, thus ensuring favourable growth conditions year-round. The controlled conditions in polyhouses significantly reduce disease incidence, enhance resource efficiency (e.g., water and fertilizer), improve rhizome yield and ensure consistent quality compared to traditional open-field practices.

The transfer of assimilates to the rhizomes is reduced in ginger due to the dense canopy. The distribution of assimilates among different plant organs might be an issue. It can be solved by the

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use of PGRs by modifying plant physiological and morphological attributes. Though some reports on application of PGRs under polyhouse conditions on ginger rhizomes (Maruthi *et al.*, 7; Arif *et al.*, 1) are available, there is lack of specific information of applicability of PGRs for improving growth as well as yield of ginger transplants grown in polyhouse. Therefore, current investigation was undertaken to examine the impact on various concentrations of PGRs in increasing the productivity of ginger transplants in polyhouse condition.

MATERIALS AND METHODS

During the 2024–2025 cropping cycle, a pot culture study was implemented at Horticulture nursery of KVK Palakkad, Pattambi (Longitude 76.1904° E, Latitude 10.8114° N) in polyhouse. Average temperature, RH, intensity of light inside the polyhouse were maintained at 20 to 30ºC, 60-70% and 200 - 800 k lux respectively throughout crop duration. Athira, KAU released ginger variety, was used for this experiment. The ginger transplants were developed from single-bud hydro-primed rhizomes. These transplants were planted in polybags (4 × 4 inch) filled with a potting mixture prepared in a 2:1:1 ratio of soil, sand, and FYM. Kerala Agricultural University POP recommendations were followed for crop maintenance (KAU, 6).

The study was done in Factorial Completely Randomised Design of twelve treatment combinations and three replications. Four different PGRs (Factor A) were used in the experiment viz; Naphthalene acetic acid (NAA), Cycocel (CCC), Gibberellic acid (GA) and 6-benzyl amino purine (BAP) each at three concentration levels (Factor B) 50ppm, 100 ppm & 150 ppm given as foliar sprays along with control (water spray). The foliar applications were given to ginger transplants at 90 and 120 days after transplanting (DAT).

The evaluation of growth related characters like plant height and pseudostem number per clump in transplants of ginger were observed during the harvest. The yield parameters were recorded at harvest by uprooting the plants. Harvested rhizomes were thoroughly cleaned and observations on rhizome yield, rhizome length, rhizome diameter, primary, secondary and tertiary rhizomes were recorded. The collected data on growth and yield attributes were subjected to statistical analysis and analysed using ANOVA to evaluate the significance differences among the treatment effects.

RESULTS AND DISCUSSION

The growth attributes of ginger transplants under polyhouse condition are significantly impacted by foliar application of different PGRs at various concentrations as per data depicted in Table 1. Application of NAA at 150ppm produced maximum value of 114.0 cm for the growth attribute plant height, while BAP at 100 ppm produced maximum number of pseudostem per clump (19.59). NAA being an auxin promotes stem elongation process. Higher auxin synthesis in the meristematic region leads to higher mitotic activity. Moreover, NAA helps in osmotic upward transport of water and nutrients in crops due to its stimulatory effect on absorption of available nutrients present in the soil (Campanoni and Nick, 3). Bezabih *et al.* (2) reported similar results stating that exogenous application of BAP enhanced plant height in ginger, reinforcing the cytokinin's role in vegetative growth promotion.

Application of BAP100 ppm drastically increased the pseudostems number per clump (19.59), GA_3 50 ppm exhibited a slightly lower value of 18.76, while CCC100 ppm recorded the lowest (9.79). Saljuna *et al.* (12) reported that BAP increased the pseudostem production in polyhouse ginger transplants due cytokinin effects on cells. It induces the cell division and increases number of cells by promoting lateral bud outgrowth. Saljuna *et al.* (11) also demonstrated increased shoot proliferation in ginger rhizomes with BAP (100–150ppm) in polyhouse condition. Similarly, CCC's negative effect on pseudostem proliferation

Table 1. Effects of PGRs on growth attributes of ginger transplants in polyhouse.

Treatment	Plant height (cm)			Pseudostem per clump (in numbers)		
	50 ppm	100 ppm	150 ppm	50 ppm	100 pm	150 ppm
Cycocel	64.79	60.98	54.89	12.70	9.79	12.01
Gibberellin	65.61	79.94	80.98	18.76	14.99	18.03
Naphthalene acetic acid	95.81	107.85	114.00	14.21	15.75	17.29
6-benzyl amino purine	65.29	98.67	104.60	16.51	19.59	11.25
PGR (p=0.05)		2.20			0.45	
ppm (p=0.05)		1.90			0.39	
PGR*ppm (p=0.05)		3.81			0.77	

confirms its inhibitory role in cell elongation and shoot emergence (Velayutham and Parthiban, 14).

However, cycocel inhibited the elongation of shoot irrespective of concentrations. Moreover, its intensity of inhibition progressively increased with escalation of concentration of CCC. At higher concentration of CCC (150ppm), maximum reduction of plant height occurred (54.89 cm). Plant height reduction by foliar application of CCC may be due to its retardant effect resulting in internodal shortening caused by reducing cell division in turn cell numbers. Application of Cycocel 150 ppm results in antagonization of GAs, which leads to retard plant height over control plants by suppressing the apical dominance. These results show conformity with early study (Thanopoulos *et al*., 13).

The yield attributing characters like number [primary, secondary, tertiary rhizome], length, diameter and yield of rhizome responded significantly different due to the foliar application of PGRs (Table 2). At harvest, it was clear that rhizome yield was maximum (304g/plant) when foliar spray of CCC at 150 ppm was done to ginger transplants at polyhouse condition as comparison with lowest (183 g/plant) in BAP 100ppm. Increased yield under CCC treatments may be attributed to its antigibberellin effect which redirects the photoassimilates from vegetative growth to underground rhizomes (Velayutham and Parthiban, 14). Choudhuri *et al*. (4) used CCC in potato to reduce excessive vegetative growth and to enhance yield.

In ginger transplants, application of CCC outperformed control under protected conditions with increased rhizome number, rhizome length as well as diameter, which could have increased the final yield. Significantly higher values for rhizome length (18.32 cm) was noted with CCC 50ppm whereas CCC at 100ppm exhibited a slightly lower value of 16.99 cm. The lowest measure for rhizome length was recorded in BAP 150ppm (9.45 cm). Foliar application of different concentration of CCC exhibited significant results for rhizome diameter in ginger transplants under polyhouse condition. The higher values for rhizome diameter (2.49 cm) were obtained with CCC 100 ppm followed by CCC 50 ppm (2.29 cm), whereas the NAA 50ppm recorded the least value of 1.10cm. The foliar spray of Cycocel retards cell elongation, resulting in an increase in rhizome diameter.

From Table 3, it was clear that higher number of primary rhizomes was recorded for application of CCC 100ppm (14.52) followed by CCC 50 ppm (13.85) and the lowest was recorded in NAA 150 ppm (3.74). The highest number of secondary rhizomes obtained in NAA 100 ppm (13.99) which was on

Table 2. Effect of PGRs on yield attributes of ginger plantlets under polyhouse.

Treatment (ppm)	Rhizome yield (g/plant)			Rhizome length (cm)			Rhizome diameter (cm)		
	50	100	150	50	100	150	50	100	150
Cycocel	209	251	304	18.32	16.99	14.96	2.29	2.49	1.19
Gibberellin	265	239	257	10.30	13.00	12.00	1.90	1.65	1.42
Naphthalene acetic acid	222	241	235	13.00	11.00	9.45	1.10	1.35	1.72
6-benzyl amino purine	196	183	202	11.60	14.00	9.00	1.60	1.30	1.22
PGR (p= 0.05)		5.676			0.24			0.05	
ppm (p= 0.05)		4.915			0.21			0.04	
PGR*ppm (p= 0.05)		9.831			0.42			0.08	

Table 3. Effect of PGRs on primary, secondary and tertiary numbers of ginger rhizome in polyhouse.

Treatment (ppm)	Primary rhizome (in numbers)			Secondary rhizome (in numbers)			Tertiary rhizome (in numbers)		
	50	100	150	50	100	150	50	100	150
Cycocel	13.85	14.52	12.95	13.87	11.97	9.66	8.54	8.33	8.53
Gibberellin	10.76	5.33	12.42	10.50	10.99	9.80	7.33	10.50	10.59
Naphthalene acetic acid	8.69	10.42	3.74	8.86	13.99	7.94	7.38	7.00	8.10
6-benzyl amino purine	6.50	8.32	6.66	10.53	10.41	8.94	9.33	6.66	7.50
PGR (p=0.05)		0.22			0.24			0.22	
ppm (p=0.05)		0.19			0.21			0.19	
PGR*ppm (p=0.05)		0.38			0.42			0.37	

par with CCC 50 ppm (13.87) and the lowest was recorded in NAA 150 ppm (7.94). Tertiary rhizome was recorded highest with GA_3 150 ppm (10.59) followed by GA_3 100 ppm and the lowest was in BAP 100 ppm. Efficient use and transport of carbohydrates led to more primary & secondary rhizomes per plant due to CCC's effect on inhibiting vegetative development.

The influence of various treatments on the vegetative growth & yield parameters on ginger were statistically compared (one sample t – test) with the control population attributes and following results were obtained.

As pointed out earlier, the dwarfing effect on ginger plants was found to be the greatest under CCC 150 ppm treatment. The mean height (54.89 cm) of the CCC 150 ppm treated plants was found to be significantly lower than the mean height of control population (59.06 cm, t (2) = 22, *p* = 0.001). So, it could be inferred that, although CCC 150 ppm treated plants experienced dwarfing, overall vegetative growth was retarded beyond a point less than that of control population and mean height (114 cm) of NAA 150ppm is found to be higher than the mean value of control population (t test= -5.034, *p* =0.018). Similarly, when the other growth attribute, i.e., pseudostem number per clump was evaluated, it became evident that the plants sprayed with 100 ppm of BAP produced the highest pseudostem number (19.59 numbers per clump) and this was found to be drastically higher than that of check population (11.06 numbers per clump, t (2) = 17.424, *p* = 0.0016).

As far as yield attributes are concerned, CCC was the plant growth regulator which produced significantly superior results in terms of most of the characters. Similarly, NAA and GA_3 had the greatest influence on characters like the number of secondary rhizome and tertiary rhizome respectively. Also, in one tailed t- test, effects of all the superior treatments on yield attributes were found to be significantly higher than that of control. The highest rhizome yield (304 gram per plant, t (2) = 30.146, *p* = 0.000054) and rhizomes with largest diameter (2.49 cm, t (2) = 33.51, *p* = 0.00044) were produced under CCC 150 ppm treatment whereas mean values of the same in control populations were 44.66 gram per plant and 1.14 cm respectively. Rhizome length was found to be the highest (18.32 cm, t (2) = 92.74, *p* =0.000058) under CCC 50 ppm while the control values for the same was 5.77 cm. The number of primary rhizome (14.52, t (2) = 81.97, *p* = 0.000074), secondary rhizome (13.99, t (2) =53.061, *p* =0.000177) and tertiary rhizome (10.59, t (2) = 62.6, *p* = 0.000128) were the highest under CCC 100ppm, NAA 100ppm and GA_3 150ppm respectively. Here also the respective control means (4.62, 6.65 and 8.52) were significantly lower than treatment means.

Since all the superior measured values of the growth and yield attributes were found to be significantly different from their respective control population means, one could safely infer that the best results observed in this experiment are not due to environmental influence but rather due to difference in the effects of treatments.

To conclude, experimental findings revealed that foliar treatment of cycocel improved morphological and yield characteristics of ginger transplants under polyhouse condition. Cycocel assimilates photosynthates from vegetative portions to the rhizomes, resulting in the maximum production of ginger by retarding plant height and vegetative development under polyhouse cultivation.

AUTHORS' CONTRIBUTION

Formulation of research (RU & RJ); Development of the experimental design (RU, RJ & DSN); Provision of experimental materials (RJ, DSN, SGS & MRV); Conducting of field/lab experiments and data collection (RU & RJ); Analysis and interpretation of data (RU, RJ, DSN, SGS & MRV); Writing original draft and editing (RU, RJ, DSN, SGS & MRV).

DECLARATION

The authors declare that they do not have any conflict of interest.

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REFERENCES

1. Arif, T., H.R. Bhoomika, Ganapathi, M., Nataraj, S. K. and Nadukeri, S. 2022. Influence of growth retardant and nutrient level on ginger in soil-less culture under protected structure. *Mod. Phytomorphol*. **15**:134-140.

2. Bezabih, M., N.M. Chauhan, Hajare, S.T. and Gezahegn, G. 2017. Effect of foliar application of 6 - benzyl amino-purine on *Zingiber officinale* Rosc. boziab variety growth and rhizome production in Ethiopia. *J. Sci. Res. Rep.* **17**(2): 1-8.

3. Campanoni, P. and Nick, P. 2005. Auxin - dependent cell division and cell elongation : 1-Naphthalene acetic acid and 2, 4 -

dichlorophenoxy acetic acid activate different pathways. *Pl. Physiol.* **137**(3): 939 – 948.

4. Choudhuri, R.S., P.K.R. Choudhori and Veeraraghavan, P.A. 1976. Response of potato crop to treatment with ascorbic acid and cycocel. *Ind. J. Plant. Physiol.* **19:** 15 - 19.
5. IISR. 2014. Research highlights 2013 - 2014. Indian Institute of Spice Research, Kozhikode, Kerala, p. 15.
6. KAU. 2024. Package of Practices Recommendations : Crops (16th ed.). Kerala Agricultural University, Thrissur, p. 141-43.
7. Maruthi, M., Gowda, M. C. and Gowda, A. M. 2003. Influence of growth regulator on growth of ginger *cv.* Himachal Pradesh at different stages. *Natl. Sem. New Prospective in Spices Med. Aromat. Pl.* p.342-44.
8. Prasath, D., Kandiannan, K., Chitra, R., Nissar, V. A. M., Suresh, J. and Babu, K. N. 2017. Quality seed production in ginger and turmeric: present status and future prospects. *Shodh Chintan* **9**: 163 - 170.
9. Rai, M., A. P. Ingle, Paralikar, P., Anasane, N., Gade, R. and Ingle, P. 2018. Effective management of soft rot of ginger caused by *Pythium* spp. and *Fusarium* spp. *Appl. Microbiol. Biotechnol*. **102**: 6827 – 6839.
10. Rai, S. and Hossain, M. 1998. Comparative studies of three traditional methods of seed rhizome storage of ginger practiced in Sikkim and Darjeeling hills. *Environ. Ecol.* **16**: 34-36.
11. Saljuna, K. P., Thankamani, C. K., Alagupalamuthirsolai, M., Krishnamurthy, K. S. and Pavithran, G. 2023. Effect of plant growth regulators on the growth and yield of ginger (*Zingiber officinale* R.) under polyhouse. *J. Plant. Crops* **51**(2): 71-76.
12. Saljuna K. P., Thankamani, C. K. and Pavithran, G. 2024. Application of growth regulators in ginger & turmeric: A review. *Int. J. Res. Agron.* **7**(3): 321-28.
13. Thanopoulos, C., Petropoulos, S.A., Alexopoulos, A. and Karapanos, I. 2013. A comparison of the effectiveness of chlormequat chloride application and terminal apex excision to restrict plant height in okra and optimize yield. *J. Agric. Sci.* **5**(9): 44-50
14. Velayutham, T. and Parthiban, S. 2013. Role of growth regulators and chemicals on growth, yield and quality traits of ginger (*Zingiber officinale* R.). *Int. J. Hortic.* **3**(16): 91-95.

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