Original Research Article

Response of different levels of plant growth regulators~~PGR~~ on gerbera (*Gerbera jamesonii*) cv. Pink elegance under protected cultivation

Abstract

An experiment was conducted to evaluate the influence of plant growth regulators on the growth, flower quality and yield of gerbera (*Gerbera jamesonii* Adlam~~L.~~) cv. Pink Elegance under a naturally ventilated polyhouse in the Department of Horticulture at SHUATS, Allahabad, Uttar ~~.~~Pradesh~~.,~~ India, during 2023-24. The experiment followed a Randomized Block Design with three replications and ten treatments. Gerbera plants were sprayed with GA_3, Cycocel and NAA at different concentrations of 50, 100 and 150 ppm along with control. The results from the study concluded that the treatment GA_3 @150 ppm was found in superior among other treatments in terms of plant height (33.30 cm), number of leaves per plant (30.96), plant spread (49.68), leaf area (152.34m^2), leaf area index (3.77), number of flowers per plant (12.00), flower weight (40.12g), flower diameter (12.31cm), root length (26.80cm), stalk length (47.88cm), shelf life (9.95), flower yield per m^2 (112.89), flower yield per 1000 polybags (12000) and minimum days to first flowering (69.33). Thus, the 150 ppm GA_3 treatment was identified as the most effective for promoting both excellent vegetative and reproductive growth. Thus, GA_3 @150 ppm can be recommended for plant growth and flowering of Gerbera proving the multifaceted role of plant growth regulator (PGR) in gerbera cultivation, helping growers optimize plant growth, flowering and~~&~~ yield while maintaining high-quality of flower production.

Keywords: growth regulators, Cycocel, gibberellic acid (GA_3), Gerbera, naphthalen acetic acid ~~growth,~~ (NAA), yield.

INTRODUCTION~~ntroduction~~

Gerbera (*Gerbera jamesonii* Adlam), a prominent cut flower, ranks fifth among the top ten cut flowers in the global market and is extensively cultivated under protected conditions in regions like Bangalore, Pune, and Uttarakhand, India. Gerbera is n~~N~~ative to tropical Asia and Africa, this species belongs to the Asteraceae family and known by others various common names such as Transvaal Daisy, Barberton Daisy~~,~~ or African Daisy and can be grown under a wide range of climatic conditions (Swarup, 1997). Discovered by Gronovious and named in honor of German naturalist Traugott Gerber, gerbera is valued for its wide range of colours, including yellow, red, orange, cream, white, and various shades in between (Prasad, 2007). These features, along with its use in floral arrangements and decorations, make it a popular choice in India.

Gerbera is a dwarf herbaceous perennial, characterized by solitary flower heads on long slender stalks, which thrive in polyhouses and shade houses (Sahu *et al.*, 2016). These environments enhance plant growth, producing larger, greener leaves with high dry matter content. The commercial production of gerbera is in high demand both nationally and internationally, especially during winter when few other flowers bloom (Darras, 2021).

Gerbera flowers are in high demand nationwide due to their enduring nature, elegant appearance, resilience, and export potential. Optimizing the application of plant growth regulatos (PGRs) can lead to increased productivity and improved quality of gerbera flowers, thus enhancing the economic viability of gerbera production. Understanding the specific effects

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Commented [u2]: According IPNI and Tropicos.org of different PGRs on gerbera growth, flowering, and fruiting can enable growers to tailor their application methods to maximize desired outcomes while minimizing costs and environmental impacts (Fawzy *et al.*, 2012). Moreover, research in this area can contribute to the development of sustainable cultivation practices by reducing the reliance on conventional chemical inputs and promoting environmentally friendly alternatives and gerbera plants can inform breeding efforts aimed at developing new cultivars with enhanced responsiveness to PGRs or intrinsic resistance to environmental stresses.

Plant growth regulators ~~(PGRs)~~ have revolutionized the floriculture industry by significantly enhancing the growth, yield, and quality of ornamental crops like gerbera. PGRs, including gibberellic acid (GA_3), cycocel and naphthalene acetic acid (NAA), are chemical substances used in small amounts to regulate plant development and stimulate desired growth responses (Wu *et al.*, 2024). They help overcome growth limitations, stimulate flowering, and extend the vase life of flowers (Thakur *et al.*, 2023). Given the significance of PGRs, the present study aimed to determine the optimal concentrations of GA_3, cycocel and NAA for improving the growth, yield, and quality of gerbera under naturally ventilated polyhouses. This research is conducted to study the effect of different levels of PGR on growth, flowering and~~&~~ yield of Gerbera.

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Materials and methods (in capital letters)

The experiment was conducted during the winter season of 2023-24 at the Department of Horticulture, Sam Higginbottom University of Agriculture, Technology and Sciences (SHUATS), Allahabad, Uttar Pradesh. The experimental site is located at a latitude of 20°15' North and a longitude of 60° East, at an altitude of 98 meters above mean sea level (MSL). The soil at the experimental site was sandy loam in texture with a pH of 6.87, an electrical conductivity (E.C) of 0.15 dS/m, and a carbon content of 43%. The available nitrogen, phosphorus, and potassium contents were 216.62 kg/ha, 37.34 kg/ha, and 215.86 kg/ha, respectively. The experiment was laid out in a Randomized Block Design with three replications and ten treatments. Seedlings of gerbera cv. Pink Elegance, each with 4-5 leaves, were planted on raised beds on November 13, 2023 in polybags. Three plant growth regulators, gibberellic acid (GA_3), C~~C~~ycocel and naphthalene acetic acid (NAA), were used at three concentrations 50, 100 and 150ppm along with the control. The details of the treatment combinations are as follows: T_0- Control, T_1- GA_3 50 ppm, T_2- GA_3 100 ppm, T_3- GA_3 150 ppm, T_4- Cycocel 5~~10~~0 ppm, T_5- Cycocel 100 ppm, T_6- Cycocel 150 ppm, T_7- NAA 50 ppm, T_8- NAA 100 ppm and T_9- NAA 150 ppm.

Results and Discussion (in capital letters)

Influence of plant growth regulators on g~~G~~rowth parameters

The data on growth parameters presented in Table 1 show that the maximum plant height (35.68 cm), number of leaves (30.96), plant spread (51.21 cm), leaf area (178.64m^2) and leaf area index (3.77) were observed in treatment T_3 (GA_3 @ 150 ppm). In contrast, the minimum plant height (21.12 cm), number of leaves (18.16~~30.96~~), plant spread (38.02 cm), leaf area (129.65 m^2) was at par with T4 (124.06 m2), and leaf area index (1.71) were recorded in treatment T_0 (control). The significantly greater plant height, number of leaves, plant spread, leaf area and leaf area index in T_3 can be attributed to the effect of gibberellic acid, which promotes cell division and cell elongation, leading to enhanced vegetative growth. Similar findings regarding maximum plant height were reported by Nair *et al.* (2002) and Dalal *et al.* (2009) in gerbera. The maximum plant spread at 150 ppm was observed by Patra *et al.* (2015) in gerbera. Sharma *et al.* (2004) suggested that GA_3 at 100 ppm is highly effective in promoting vegetative growth in gladiolus and Dogra *et al.* (2012) reported an increase in leaf area index due to GA_3 treatments. Similarly, Porwal *et al.* (2002) observed the impact of plant growth regulators on Damask Rose, noting that GA_3 at 250 ppm resulted in the maximum plant height, number of shoots per plant, and plant spread. Additionally, GA_3 promotes the increase in the photosynthetic area by inducing cell elongation and hyponasty of leaves, which affects their orientation and ultimately contributes to an increase in leaf area (Dutta, 2015).

Influence of plant growth regulators on flowering parameters

The data on qualitative parameters presented in Table 2 indicate that the minimum number of days to first flower bud emergence or earliness, which occurred in 69.33 days, was observed in T_3 (GA_3 @ 150 ppm), while T_0 (control) took the maximum number of days (93.11 days) to produce a visible flower bud. The m~~M~~aximum number of flowers per plant (12.00), flower weight (40.12), flower diameter (12.31), stalk length (47.88), shelf life (9.95) and root length (26.80)~~, stalk length (47.88), and shelf life (9.95)~~ was observed with T_3 - GA_3 @150 ppm. Conversely, the minimum number of flowers per plant (4.67), flower weight (26.72), flower diameter (7.24), stalk length (35.55), shelf life (5.63) and root length (14.86)~~, stalk length (35.55), and shelf life (5.63)~~ w~~ere~~as found in treatment T_0 (control).

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Gibberellic acid is a plant growth regulator known to play a crucial role in various physiological processes, including cell division, elongation, and differentiation. When applied exogenously, GA_3 can stimulate these processes, leading to significant changes in plant morphology and development (Ridha *et al.*, 2016). In the case of gerbera plants, the application of GA_3 at 150 ppm stimulated the cell expansion and enlargement of floral structures which have accelerated the initiation and emergence of flower buds, resulting in earlier flowering, promoted flower bud formation, enhanced floral organ development, increased flower weight and diameter (Saini and Arora, 2016). Moreover, GA_3 (150 ppm) treated plants displayed enhanced root and stalk growth, with longer root systems and taller stalks, which can support larger and more abundant flowers. It also improved the post-harvest characteristics such as shelf life, as GA_3 at 150 ppm treated flowers exhibited delayed senescence and prolonged freshness compared to untreated flowers (Zosser *et al.*, 2017). Overall, the application of GA_3 at 150 ppm effectively optimized qualitative parameters in gerbera plants, resulting in enhanced flower quality and overall plant performance.

Patel *et al.* (2013) observed similar results in gerbera, with GA_3 at 150 ppm resulting in the fewest days to first flower initiation (108.33 days), maximum flower diameter (8.76 cm), flower weight (5.93 g), and shelf life of flowers (8.00 days). GA_3 also increased the number of suckers, and foliar application of 150 ppm GA_3 was found to be the best for enhancing plant growth, yielding the maximum number of cut blooms with longer stalks and larger flower sizes, as reported by Sharifuzzaman *et al.* (2011) in chrysanthemum.~~, and~~ Jamal *et al.* (2014) in gerbera and Sainath *et al.* (2018) in chrysanthemum observed similar earliness in the full opening of flowers due to GA_3 treatments. Chauhan *et al.* (2014) found that GA_3 at 150 ppm led to the earliest appearance of the first flower bud (50.98 days) and the largest flower diameter (11.37 cm) in gerbera. Furthermore, Salem *et al.* (2016) reported that in gerbera, the highest yield and quality parameters (number of flowers per plant, stalk length, flower bud diameter, and stalk diameter), as well as the shortest time to flower bud emergence and first flowering, were observed with GA_3 at 150 ppm.

Influence of plant growth regulators on y~~Y~~ield parameters

The data on yield parameters presented in Table 3 indicate that the maximum flower yield per m^2 (112.89) and maximum flower yield per 1000 polybags (12000) was observed with T_3 - GA_3 @150 ppm. While ~~However~~, the minimum flower yield per m^2 (65.15) and flower yield per 1000 polybags (4670) were recorded in treatment T_0 (control). The increase in flower yield could be attributed to the fact that plants treated with gibberellic acid produced a greater number of leaves and ~~more~~ number of flowers. This increased leaf production likely led to the production and accumulation of more photosynthates, which were then redirected to the floral organs, resulting in a higher number of flowers and flower weight. These findings are consistent with the results reported by Dalal *et al.* (2009) in gerbera, Palei *et al.* (2016) in chrysanthemum, Tariq *et al.* (2013~~1~~) in gladiolus, Kumar *et al.* (2014); ~~and~~ Patel *et al.* (2015); Patil et al. (2016) in African marigold (*Tagetes* sp.), and~~,~~ Sainath *et al.* (2018) in chrysanthemum. ~~and Patel *et al.* (2010) in chrysanthemum, Kumar *et al.* (2014) and Patel *et al.* (2015) in African marigold.~~ .

Conclusion (in capital letters)

From the present investigation, it is concluded that among the different treatments, the treatment T_3 - GA_3 @150 ppm was found in superior among other treatments in terms of Plant height (33.30 cm), Number of leaves per plant (30.96), plant spread (49.68), leaf area (152.34m^2), leaf area index (3.77), number of flowers per plant (12.00), flower weight (40.12g), flower diameter (12.31cm), root length (26.80cm), stalk length (47.88cm), shelf life (9.95), flower yield per 1000 polybags (12000) and minimum days to first flowering (69.33). Thus, GA_3 @150 ppm can be recommended for plant growth and flowering of Gerbera proving the multifaceted role of plant growth regulator ~~PGR~~ in gerbera cultivation, helping growers optimize plant growth, flowering and~~&~~ yield while maintaining high-quality flower production.

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Table 1. Effect of pPlant growth regulators on growth parameters of gerbera

(*G. jamesonii* cv. Pink elegance).

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Treatments	Plant height (cm)	Number of leaves/plant	Plant spread (cm)	Leaf Area (m^2)	Leaf Area Index (cm^2)
T_0	21.12	18.16	38.02	129.65	1.71
T_1	31.66	24.86	47.02	146.40	2.78
T_2	33.30	28.79	49.68	171.19	3.19
T_3	35.68	30.96	51.21	178.64	3.77
T_4	27.43	19.25	39.72	124.06	2.04
T_5	29.77	21.67	41.35	152.34	2.46
T_6	29.33	23.56	44.85	164.18	2.53
T_7	24.04	22.24	42.02	164.48	2.36
T_8	25.49	25.91	43.35	153.13	2.94
T_9	27.04	26.73	45.35	146.58	3.12
F-Test	**S**	**S**	**S**	**S**	**S**
S.Ed (±)	**0.94**	**1.06**	**0.87**	**2.69**	**0.06**
$CD_{(0.05)}$	**2.00**	**2.24**	**1.84**	**5.70**	**0.13**

Note: T0= control; T1= GA3 50 ppm; T2= GA3 100 ppm; T3= GA3 150 ppm. T4= cycocel 50 ppm; T5= cycocel 100 ppm; T6= cycocel 150 ppm. T7= NAA 50 ppm; T8= NAA 100 ppm; T9= NAA 150 ppm.

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Table 2. Effect of pPlant growth regulators on floral parameters of gerbera

(*G. jamesonii* cv. Pink elegance)

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Treatments	Days to first flowering	Flower wWeight (g)	Flower dDiameter (cm)	Stalk lLength (cm)	Shelf life (dDays)	Root length (cm)
T_0	93.11	26.72	7.24	35.55	5.63	14.86
T_1	72.48	36.99	10.65	44.35	7.67	23.66
T_2	70.27	38.64	11.72	45.93	8.69	24.85
T_3	69.33	40.12	12.31	47.88	9.95	26.80
T_4	88.01	29.39	7.83	36.22	6.63	17.42
T_5	84.88	31.03	8.09	38.47	6.61	18.19
T_6	80.29	32.24	8.75	38.69	6.34	18.36
T_7	77.73	34.72	9.98	39.33	7.52	19.44
T_8	75.26	34.81	10.26	40.62	8.31	22.21
T_9	78.33	35.36	10.31	42.31	8.66	22.30
F-Test	**S**	**S**	**S**	**S**	**S**	**S**

S.Ed (+)	**1.78**	**0.64**	**0.21**	**1.13**	**0.44**	**0.52**
$CD_{(0.05)}$	**3.77**	**1.35**	**0.45**	**2.40**	**0.94**	**1.11**

Note: T0= control; T1= GA3 50 ppm; T2= GA3 100 ppm; T3= GA3 150 ppm. T4= cycocel 50 ppm; T5= cycocel 100 ppm; T6= cycocel 150 ppm. T7= NAA 50 ppm; T8= NAA 100 ppm; T9= NAA 150 ppm.

Table 3. Effect of p~~P~~lant growth regulators on yield parameters of gerbera

(*G. jamesonii* cv. Pink elegance).

Treatments	Flowers n~~N~~umber ~~Of Flowers~~ p~~P~~er p~~P~~lant	Flower Yield per m^2	Flower y~~Y~~ield per 1000 p~~P~~olybags
T_{10}	4.67	65.15	4670
T_1	8.23	99.39	8230
T_2	10.00	107.58	10000
T_3	12.00	112.89	12000
T_4	6.86	77.58	6860
T_5	7.00	76.11	7000
T_6	7.57	90.23	7570
T_7	7.61	82.05	7610
T_8	8.12	86.54	8120
T_9	9.20	92.15	9200
F-Test	**S**	**S**	**S**
S.Ed (+)	**0.70**	**1.55**	**180.414**
CD (5%)	**1.48**	**3.28**	**381.972**

Note: T0= control; T1= GA3 50 ppm; T2= GA3 100 ppm; T3= GA3 150 ppm. T4= cycocel 50 ppm; T5= cycocel 100 ppm; T6= cycocel 150 ppm. T7= NAA 50 ppm; T8= NAA 100 ppm; T9= NAA 150 ppm.