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Assessment of priming of cormels with plant growth substances on vegetative growth and cormel-associated traits in gladiolus

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ABSTRACT

The gladiolus is propagated commercially through its corm, an underground modified stem that provides nutrients during sprouting. Thus, the present research was carried out to evaluate the effect of growth substances on corm production cycle through priming of cormels. The cormels of two gladiolus varieties (Punjab Glad-1 and Punjab Pink Elegance) were primed in solutions of GA_3 (150 and 200 ppm), BA (100 and 125 ppm), SA (100 and 150 ppm), Thiourea (1000 and 1500 ppm), KNO_3 (1.5 and 2.5 %), Ethrel (250 ppm) and combinations of Thiourea and KNO_3 for 12 hours. The maximum sprouting percentage was recorded with 200 ppm GA_3 in Punjab Glad-1 (97.93%) and Punjab Pink Elegance (98.81 %). The maximum size of cormel was recorded in Punjab Glad-1 (2.10 cm) with 4.20 times increase over initial cormel size and Punjab Pink Elegance (2.11 cm) with 4.23 times increase over initial cormel size after priming with GA_3 200 ppm. Thus, priming of cormels with 200 ppm GA_3 could shorten the production cycle of cormels to flowering grade corm by favoring vegetative growth of plants and improving cormel associated traits.

Keywords: Gladiolus, plant growth substances, vegetative characters, corm-associated traits

INTRODUCTION

Gladiolus (*Gladiolus grandiflorus* L.) is a flower of glamour and perfection and known as the queen of bulbous flowers with majestic spikes having florets of massive form, brilliant colours, attractive shapes, varying sizes and excellent keeping quality. It is used in herbaceous borders, beddings, rockeries, pots and for cut flowers due to its highly bright, beautiful and differently coloured flowers. The propagation in gladiolus is through corms and cormels. So, improving the yield and quality of corm and cormel are very important for increasing gladiolus commercial value.

The planting material i.e. corm governs the growth and development of gladiolus. Therefore, better and quick vegetative growth is necessary to obtain long and healthy spikes with more florets and to obtain more yields of corms in terms of size and number (Amir, 2006). The growth and development could be regulated either by a single or by the interaction of several hormones. Plant growth substances are the organic chemical compounds that modify or regulate physiological processes in an appreciable measure in plants when used in small concentrations (Kumar *et al.,* 2020). The use of different plant growth substances induces early flowering, enhances plant growth in terms of plant height, flower number and corm yield in gladiolus and many other ornamentals. These substances are used as cultural practices to modify their vegetative and floral traits (Singh *et al.,* 2013).

Gibberellic acid (GA_3) has an important role in different plant processes, including seed germination, stem elongation, leaf expansion and flower development (Gao and Chu, 2020) and was found highly effective for increasing the sprouting percentage of the corm, increased cormel production and cormel size in gladiolus (Kumar *et al.,* 2020). Synthetic growth-regulating chemicals were reported to be very effective in manipulating growth and flowering. Benzyladenine (BA) is a cytokinin that is used for the multiplication of shoots and causes beneficial effects on growth and flower production (Ragini *et al.,* 2019; Shrivastava *et al.,* 2022). Ethrel is a chemical compound containing ethephon that releases ethylene (a plant growth regulator). The application of ethrel is effective in modifying different attributes of ornamental plants (Sajjad *et al.,* 2015). Salicylic acid (SA) is well known for its growth-promotive functions and induction of stress tolerance in plants. Salicylic acid application has a positive effect on chlorophyll concentration, photosynthetic rate and uptake of

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minerals in plants grown under stress conditions (Ebeed and Ali, 2022) thus enhancing the growth and plant productivity. Potassium is known for its influences on many enzymatic reactions and is associated with almost every major plant function. It improves the efficiency of plant water and sugar used for maintenance and normal growth functions. Potassium nitrate (KNO_3) is an indispensable elementary constituent of numerous organic compounds such as amino acid, protein and nucleic acids and could increase length and promote growth (Memon *et al.,* 2013). Thiourea (TU) plays several bioregulatory roles in crop plants, as the sulfhydryl group has diverse biological activities. It enhances the formation of the ternary complex, sucrose H^+ carrier, thus improving the translocation of photosynthates while increasing the photosynthetically active leaf surface during grain filling in cereals (Patade *et al.,* 2020).

Different application methods of plant growth substances are priming, drenching and foliar application. Among different methods, priming i.e. soaking in the solution of desired concentration for an appropriate time is best in terms of labor and time (Roy *et al.,* 2017). This method has become commercially acceptable. Different research studies have proved that the application of these substances helps to produce good quality cut flowers and additional yield of gladiolus corms. Therefore, keeping in view the role of plant growth substances, the present experiment was undertaken to evaluate plant growth substances for obtaining better growth and cormel production of gladiolus in cost effective way.

MATERIAL AND METHODS

Plant Material and Treatments

The present study was conducted at the Research Farm of the Department of Floriculture and Landscaping, Punjab Agricultural University, Ludhiana. The cormels (0.5 cm) of two varieties of gladiolus namely Punjab Glad-1 and Punjab Pink Elegance were used. The cormels of both varieties were soaked overnight in distilled water and then soaked in Bavistin (0.2%) for half an hour. The cormels were then soaked in freshly prepared priming solutions of growth substances at different concentrations for 12 hours before planting. Different priming solutions were GA_3 (150 and 200ppm), BA (100 and 125ppm), SA (100 and 150 ppm), TU (1000-1500ppm), KNO_3 (1.5% and 2.5%), Ethrel (250ppm) and combinations of TU and KNO_3 (TU 1000 ppm and KNO_3 1.5%, TU 1000 ppm and KNO_3 2.5%, TU 1500 ppm and KNO_3 1.5% and TU 1500 ppm and KNO_3 2.5%). The control corms were dipped in distilled water for the same time. The treated cormels of both varieties were planted in the first week of November and plants were raised following all the recommended practices. Data Collection

The plants raised from cormels were tagged and observations were recorded from five plants per replication and three replications per treatment. The vegetative parameters viz., plant height, leaf length, leaf width and leaf area were recorded after two months of planting. After the lifting of cormels from the field, the data for corm-related attributes were recorded. The following parameters were recorded: Days to sprouting (total number of days for the cormels to sprout from the date of planting), Sprouting percentage (percentage sprouting of the cormels was calculated by dividing the number of cormels sprouted by the number of cormels planted), Plant height (cm) (height was taken from the ground level to tip of leaf), Leaf length (cm) (from the emergence of leaf to the top of the leaf), Leaf width (cm) (recorded from the middle of the leaf horizontally with the help of scale), Leaf area (cm^2) (multiplying leaf length and leaf width), Size of cormel (cm) (length of circumference and spread), Cormel weight (g) (weight of cormels per plant), Increase in size of cormel (increase in size of cormel after harvesting).

Statistical Analysis: Statistical analysis was carried out for the observations recorded in the experiment to find out whether there were significant variations for various parameters among different treatments. Data were subjected to statistical analysis (using SPSS), using the standard technique of analysis of variance (ANOVA).

RESULTS AND DISCUSSION

Days to sprouting

The priming of cormels with growth substances showed wide variation from 16.38 to 9.53 in the number of days to sprouting (Table 1). In Punjab Glad-1, the maximum number of days to sprouting was taken when the cormels were treated with TU 1000 ppm (15.40 days) followed by TU 1500 ppm (14.60 days) which was statistically at par with KNO_3 -1.5% (14.63 days). The least number of days were taken to sprout by cormels treated with GA_3 150 ppm (9.53 days) which was at par with $GA_3$200 ppm (9.56 days) followed by SA 100 ppm (10.03 days) and SA 150 ppm (9.83 days). In Punjab Pink Elegance, treatment with TU 1000 ppm took maximum time to sprout(16.38 days) whereas least days were taken by SA 150 ppm (10.14 days) which was statistically at par with GA_3 150 ppm (10.44 days), GA_3 200 ppm (10.54 days) and SA 100 ppm (10.73 days). Both concentrations of GA_3 had a significant effect on sprouting. The early sprouting in treated cormels could account for the inductive effect of GA_3 on the activity of hydrolytic enzymes that regulate the mobilization of reserves in the cormel resulting in sprouting. Our findings are concomitant with those of Sajjad *et al.,* (2015) and Shaji *et al.,* (2022) in gladiolus.

Table 1: Effects of priming of cormels with different growth substances on growth parameters in gladiolus (pooled data of 2 years)

Treatments	Days to sprouting		Sprouting %		Plant height (cm)	
	Punjab Glad-1	Punjab Pink Elegance	Punjab Glad-1	Punjab Pink Elegance	Punjab Glad-1	Punjab Pink Elegance
T_1 (GA_3 150 ppm)	9.53^{h}	10.44^{f}	94.50^{b}	94.39^{b}	26.76^{a}	25.47^{a}
T_2 (GA_3 200 ppm)	9.56^{h}	10.54^{f}	97.93^{a}	98.81^{a}	24.32^{b}	27.38^{a}
T_3 (BA 100 ppm)	12.66^{e}	12.90^{de}	86.19^{d}	85.95^{fg}	12.58^{l}	13.01^{e}
T_4 (BA 125 ppm)	12.90^{de}	12.91^{de}	87.48^{d}	93.77^{b}	15.20^{k}	16.76^{d}
T_5 (SA 100 ppm)	10.03^{gh}	10.73^{f}	90.84^{c}	89.66^{de}	20.58^{ef}	20.21^{cb}
T_6 (SA 150 ppm)	9.83^{gh}	10.14^{f}	92.30^{cb}	91.46^{c}	23.42^{cb}	22.07^{b}
T_7 (Thiourea 1000 ppm)	15.40^{a}	16.38^{a}	86.12^{d}	84.54^{gh}	20.08^{hfg}	19.38^{cbd}
T_8 (Thiourea 1500 ppm)	14.60^{abc}	15.24^{b}	82.73^{e}	83.02^{h}	22.63^{cd}	21.83^{b}
T_9 (KNO_3 1.5%)	14.63^{abc}	14.49^{bc}	86.60^{d}	87.12^{f}	17.43^{j}	18.66^{de}
T_{10} (KNO_3 2.5%)	14.30^{bc}	13.87^{cd}	90.96^{c}	90.60^{cde}	18.94^{hi}	19.52^{bcd}
T_{11} (Ethrel 250 ppm)	10.51^{fg}	10.74^{f}	90.89^{c}	89.05^{e}	21.39^{de}	21.35^{bc}
T_{12} (Thiourea 1000 ppm+ $KNO_3$1.5%)	13.38^{cd}	14.05^{c}	87.32^{d}	86.57^{f}	17.74^{ij}	18.74^{cd}
T_{13} (Thiourea 1000 ppm+ KNO_3 2.5%)	11.12^{f}	12.27^{e}	91.08^{c}	90.69^{cd}	20.49^{efg}	19.80^{bcd}
T_{14} (Thiourea 1500 ppm+ KNO_3 1.5%)	12.76^{e}	14.14^{bc}	87.24^{d}	90.22^{cde}	19.32^{gh}	19.38^{bcd}
T_{15} (Thiourea 1500 ppm+ KNO_3 2.5%)	12.43^{e}	12.73^{e}	87.50^{d}	89.22^{de}	22.74^{c}	21.5^{1cb}
T_{16} (Control)	14.96^{ab}	14.73^{bc}	82.93^{e}	84.46^{gh}	19.93^{fgh}	20.89^{bc}
CD (p=0.05)	0.93	1.12	2.57	1.62	1.46	3.06

**Different lowercase letters represent significant differences among different growth substances*

Sprouting percentage

Sprouting percentage showed significant differences among different treatments (Table 1). Both the varieties i.e. Punjab Glad-1 and Punjab Pink Elegance showed maximum cormel sprouting due to GA_3 treatments. The maximum sprouting of 97.93 % and 98.81% was recorded with the application of GA_3 200 ppm followed by GA_3 150 ppm (94.50 % and 94.39%) in Punjab Glad-1 and Punjab Pink Elegance, respectively. In Punjab Pink Elegance, the minimum sprouting percentage was observed from TU 1500 ppm (83.02%) followed by control (84.46%) which was statistically at par with TU 1000 ppm (84.54%). The per cent sprouting of corms increased with increased concentrations of GA_3 that could be accounted for its role in breaking dormancy (Khan *et al.,* 2013).

Plant height

The maximum plant height was observed with the application of GA_3 150 ppm (26.76 cm) in Punjab Glad-1 which was significantly higher than all other treatments. Similarly in Punjab Pink Elegance, maximum plant height was observed by GA_3 200 ppm (27.38 cm) which was at par with GA3150 ppm (25.47 cm). The priming with BA 100 ppm showed significantly least plant height i.e.12.58 cm in Punjab Glad-1 and 13.01 cm in Punjab Pink Elegance as compared to other treatments. The enhancement in plant height with GA_3 could be accounted for its effect in promoting vegetative growth by inducing active cell division and cell elongation in the apical meristem and photosynthetic activity along with efficient utilization of photosynthetic products by the plants (Kumar *et al.,* 2021; Khalafalla *et al.,* 2022). However, plant height was minimum with the highest concentration of BA as it is mainly known for promoting multiple shooting rather than cell elongation (Sajjad *et al.,* 2015).

Leaf length, Leaf width and Leaf Area

The priming of cormels with different growth substances resulted in significant variations in leaf length and width (Table 2). In Punjab Glad-1, significantly highest leaf length was recorded with the application of GA_3 200 ppm (24.11cm) followed by GA_3 150 ppm (22.64 cm). The least leaf length was recorded with TU 1000 ppm+ KNO_3 1.5% (11.07 cm) which was statistically at par with TU1500 ppm+ KNO_3 1.5% (11.46 cm). In Punjab Pink Elegance, priming with GA_3 200 ppm resulted in highest leaf length (25.71cm) followed by GA_3 150 ppm (23.52 cm) whereas least leaf length was recorded with TU 1000 ppm+ KNO_3 1.5% (10.88cm). Similarly, the maximum leaf width in Punjab Glad-1 and Punjab Pink Elegance was recorded with GA_3 200 ppm and GA_3 150 ppm (0.61 cm in both varieties) whereas least was recorded when cormels were primed with TU 1000 ppm+ KNO_3 1.5% (0.31 cm in both varieties).

Table 2: Effects of priming of cormels with different growth substances on leaf traits in gladiolus (pooled data of 2 years)

Treatments	Leaf length (cm)		Leaf width (cm)		Leaf area (cm^2)	
	Punjab Glad-1	Punjab Pink Elegance	Punjab Glad-1	Punjab Pink Elegance	Punjab Glad-1	Punjab Pink Elegance
T_1 (GA_3 150 ppm)	22.64[ab]	23.52[b]	0.61[a]	0.61[a]	10.78[ab]	10.92[ab]
T_2 (GA_3 200 ppm)	24.11[a]	25.71[a]	0.61[a]	0.63[a]	12.55[a]	12.18[a]
T_3 (BA 100 ppm)	12.16[ij]	13.01[gh]	0.28[f]	0.31[ef]	3.00[e]	3.06[h]
T_4 (BA 125 ppm)	14.84[gh]	13.83[g]	0.30[ef]	0.30[f]	3.30[e]	4.79[g]
T_5 (SA 100 ppm)	17.42[ef]	17.84[de]	0.32[def]	0.32[ef]	4.41[e]	5.74[fg]
T_6 (SA 150 ppm)	18.54[cde]	18.08[de]	0.33[def]	0.34[de]	9.90[bc]	7.75[de]
T_7 (Thiourea 1000 ppm)	20.30[bcd]	21.38[c]	0.44[b]	0.45[c]	7.31[d]	6.15[fg]
T_8 (Thiourea 1500 ppm)	22.29[ab]	22.43[bc]	0.48[b]	0.50[b]	10.76[ab]	9.69[bc]
T_9 (KNO_3 1.5%)	17.39[efg]	16.90[ef]	0.43[b]	0.44[c]	8.30[dc]	7.08[ef]
T_{10} (KNO_3 2.5%)	20.91[bc]	19.28[d]	0.47[b]	0.46[bc]	9.67[bc]	9.24[cd]
T_{11} (Ethrel 250 ppm)	18.45[cde]	17.38[e]	0.43[bc]	0.45[c]	8.29[cd]	8.03[de]
T_{12} (Thiourea 1000 ppm+ $KNO_3$1.5%)	11.07[j]	10.88[i]	0.31[def]	0.31[ef]	2.73[e]	5.41[g]
T_{13} (Thiourea 1000 ppm+ KNO_3 2.5%)	14.66[hi]	13.82[g]	0.34[def]	0.34[def]	3.75[e]	5.89[fg]
T_{14} (Thiourea 1500 ppm+ KNO_3 1.5%)	11.46[j]	12.14[hi]	0.32[def]	0.34[de]	3.03[e]	4.95[g]
T_{15} (Thiourea 1500 ppm+ KNO_3 2.5%)	15.84[fgh]	15.82[f]	0.37[cd]	0.37[d]	4.58[e]	5.86[fg]
T_{16} (Control)	18.28[def]	17.61[e]	0.36[de]	0.34[def]	7.68[cd]	8.79[cd]
CD (p=0.05)	2.58	1.54	0.06	0.04	2.01	1.59

**Different lowercase letters represent significant differences among different growth substances*

Concomitant to the influence of different treatments on leaf length and width, significant enhancement in leaf area was recorded with different treatments (Table 2). In Punjab Glad-1, the maximum leaf area was recorded with GA_3 200 ppm (12.55 cm^2) followed by GA_3 150 ppm (10.78 cm^2) whereas least leaf area was recorded by TU 1000 ppm+ KNO_3 1.5% (2.73 cm^2). In Punjab Pink Elegance, the maximum leaf area was observed by GA_3 200 ppm (12.18 cm^2) followed by GA_3 150 ppm (10.92 cm^2) whereas minimum leaf area (3.06 cm^2) was recorded with BA 100 ppm followed by BA 125 ppm (4.79 cm). The priming of cormels with GA_3 resulted in enhancement of vegetative growth of plants, in terms of leaf length and width that ultimately increased the leaf area, which could be accounted for its physiological role in enhancing cell elongation in plants (Sharma and Tirkey, 2022; Tiwari *et al.,* 2022; Kumar *et al.,* 2021).

Size and weight of cormel

The priming of cormels with different plant growth substances significantly affected the size of cormels (Table 3). In Punjab Glad-1, the maximum size of the cormel was recorded with GA_3 200 ppm (2.10 cm) which was statistically at par with BA 125 ppm (2.02 cm) and GA_3 150 ppm (1.99 cm). The increase in size of cormel was 4.20 times with GA_3 200 ppm, 4.04 times with BA 125 ppm and 3.99 times with GA_3 150 ppm. However, least size was found with TU 1000 ppm+ KNO_3 1.5% (0.79 cm) which was statistically at par with KNO_3 1.5% (0.81). In Punjab Pink Elegance, the maximum size of cormel was recorded with GA_3 200 ppm (2.11 cm) followed by GA_3 150 ppm (2.04 cm) and BA 125 ppm (2.00 cm) which were found to be at par with each other. The minimum cormel size was recorded with TU 1000 ppm+ KNO_3 1.5% (0.85 cm) which was statistically at par with TU and KNO_3 1.5% (0.86 cm). The increase in size was 4.23 times with GA_3 200 ppm followed by 4.08 times with GA_3 150 ppm and the least increase in size was 1.71 times with TU 1000 ppm+ KNO_3 1.5% treatment.

Table 3: Effects of priming of cormels with different growth substances on cormel-associated traits in gladiolus (pooled data of 2 years)

Treatments	Size of cormel (cm)		Increase in size of cormel (No. of times)		Cormel weight (g)/ plant	
	Punjab Glad-1	Punjab Pink Elegance	Punjab Glad-1	Punjab Pink Elegance	Punjab Glad-1	Punjab Pink Elegance
T_1 (GA_3 150 ppm)	1.99^{a}	2.04^{a}	3.99^{a}	4.08^{a}	8.11^{b}	8.88^{a}
T_2 (GA_3 200 ppm)	2.10^{a}	2.11^{a}	4.20^{a}	4.23^{a}	9.37^{a}	9.37^{a}
T_3 (BA 100 ppm)	1.83^{b}	1.72^{b}	3.67^{b}	3.27^{b}	4.76^{cd}	4.41^{cd}
T_4 (BA 125 ppm)	2.02^{a}	2.00^{a}	4.04^{a}	4.00^{a}	5.07^{cd}	5.48^{b}
T_5 (SA 100 ppm)	0.99^{ef}	1.01^{cde}	1.99^{ef}	2.02^{cde}	4.43^{de}	4.40^{cd}
T_6 (SA 150 ppm)	1.25^{c}	1.09^{cde}	2.50^{c}	2.18^{cde}	4.85^{cd}	4.91^{bc}
T_7 (Thiourea 1000 ppm)	0.97^{efg}	0.90^{de}	1.94^{efg}	1.80^{e}	3.99^{ef}	3.85^{def}
T_8 (Thiourea 1500 ppm)	1.17^{cd}	1.08^{cde}	2.34^{cd}	2.17^{cde}	4.86^{cd}	4.29^{cd}
T_9 (KNO_3 1.5%)	0.81^{h}	0.86^{e}	1.63^{hg}	1.73^{e}	3.63^{fg}	3.54^{f}
T_{10} (KNO_3 2.5%)	0.92^{efgh}	1.15^{cd}	1.84^{efgh}	2.30^{cd}	3.69^{f}	3.84^{def}
T_{11} (Ethrel 250 ppm)	1.19^{c}	1.20^{c}	2.39^{c}	2.41^{c}	5.31^{c}	5.12^{b}
T_{12} (Thiourea 1000 ppm+ $KNO_3$1.5%)	0.79^{h}	0.85^{e}	1.58^{h}	1.71^{e}	3.73^{f}	3.61^{ef}
T_{13} (Thiourea 1000 ppm+ KNO_3 2.5%)	0.83^{gh}	0.92^{de}	1.64^{gh}	1.85^{de}	3.95^{ef}	4.22^{de}
T_{14} (Thiourea 1500 ppm+ KNO_3 1.5%)	0.85^{fgh}	0.91^{de}	1.71^{fgh}	1.82^{e}	3.93^{ef}	3.87^{def}
T_{15} (Thiourea 1500 ppm+ KNO_3 2.5%)	1.02^{de}	1.07^{cde}	2.04^{de}	2.14^{cde}	3.97^{ef}	4.01^{def}
T_{16} (Control)	0.93^{efgh}	0.86^{e}	1.87^{efgh}	1.72^{e}	2.99^{g}	3.52^{f}
CD (p=0.05)	0.15	0.25	0.31	0.50	0.64	0.67

** Different lowercase letters represent significant differences among different growth substances*

The weight of cormels was significantly augmented in the cormels treated with various growth substances as compared to the control (Table 3). Punjab Glad-1 recorded the maximum weight of cormels (9.37 g) with GA_3 200 ppm, followed by $GA_3$150 ppm (8.11 g). However, non-primed cormels weighed the least (2.99 g). Likewise, priming with GA_3 200 ppm (9.37 g) and GA_3 150 ppm (8.88 g) were found to be the most effective at achieving the maximum weight of cormels in Punjab Pink Elegance.

The priming with GA_3 was found highly effective in increasing the size and weight of cormels which could be attributed to an increase in the number of leaves per plant that increased the photosynthetic assimilation. These assimilates resulted in daughter cormels with higher size and weight as compared to their respective parent cormel (Singh, 2021; Kumar *et al.,* 2021; Tiwari *et al.,* 2022). Priming of cormels with different growth substances influenced vegetative growth and cormel-related traits. The treatment of cormels with GA_3 200 ppm was found to be the most effective among all the treatments in enhancing the vegetative growth, size and weight of cormels in both varieties. Thus, the priming of cormels with GA_3 200 ppm could shorten the production cycle of cormels to flowering grade corm by enhancing the cormel size and weight.

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