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FOLIAR APPLICATION OF PLANT GROWTH REGULATORS AFFECTS GROWTH, FLOWERING, VASE LIFE AND CORM PRODUCTION OF *GLADIOLUS GRANDIFLORUS* L. UNDER CALCAREOUS SOIL

M. SAJID, M. A. ANJUM and S. HUSSAIN*
Department of Horticulture, Bahauddin Zakariya University, Multan 60800, Pakistan

Abstract

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The present work was conducted to investigate the effect of foliar application of gibberellic acid and 6-benzyl aminopurine on growth, flowering, post-harvest life and corm production of gladiolus cv. Traderhorn. First spray of BAP or GA_3 was applied 30 days and the second 60 days after planting at 0, 25, 50 or 100 mg L^{-1}. Results revealed that both the plant growth regulators increased plant height, stalk length, number of florets per spike, fresh weight of florets, vase life of spikes and diameter and weight of corms as compared to the control. However, GA_3 significantly increased chlorophyll content and spike length followed by BAP, while BAP significantly improved fresh weight of stalk followed by GA_3. Regarding concentrations, 100 mg L^{-1} performed the best for plant height, leaf chlorophyll content, stalk length, fresh weight of stalk, spike length, number of florets per spike, fresh weight of florets, vase life of spikes and diameter and weight of corms, followed by 50 mg L^{-1} as compared to 25 mg L^{-1} and control treatment. Days to spike emergence, diameter of florets and number of corm produced per plant were not affected by the PGRs, their concentrations and combined effect of these two factors.

Key words: BAP, GA_3, leaf chlorophyll content, number of florets per spike, vase life

Introduction

Gladiolus (*Gladiolus grandiflorus* L.), commonly known as queen of bulbous flowers, belongs to the family Iradiaceae and subfamily Ixidaceae. The genus *Gladiolus* is native to South Africa and includes 180 species with more than 10 000 cultivars (Sinha and Roy, 2002). The gladiolus gained popularity in different parts of the world due to its unsurpassed beauty and economic value. The flower is in high demand due to attractive spikes, big florets, dazzling colors and long vase life (Farid-Uddin et al., 2002).With the progress in development of floriculture industry in Pakistan, the farmers are diverting to high values floral crops due to increase in utilization of flowers in various social events. The most important floral crops in Pakistan used as cut flowers include rose, tuberose, gladiolus, marigold and jasmine (Saquib, 2010). However, local fresh flower market is flooded with mostly rose and tuberose. The gladiolus has the potential not only to fulfill the local requirements but also to earn foreign exchange as the crop is of short duration (110-120 days); wide varietal wealth, better economic returns than conventional crops and wide range of available climatic conditions in the country have contributed to its growth potentials. The commercial growers are planting gladiolus in different zones of the country to fulfill the local consumption demand; however the production and flower quality are still low to meet international standards. Therefore, research is required to increase the yield and quality of the flower to strengthen our local market and also to meet the export standards.

Gladiolus is a perennial bulbous plant but it is grown as annual for flower production. Flowering season of gladiolus in the country is months of February to April, which is very special time in southern Punjab as many wedding ceremonies take place during this period. Therefore, the flower has a very high consumption during these ceremonies and is mostly brought from far off places particularly central and

*Corresponding author: sajjad_h@yahoo.com

northern regions of the Punjab province. The huge cost of transportation from far off places increases its price and also spike quality gets deteriorated during transportation. Furthermore, Southern Punjab with sub-tropical to tropical climate have short winter season and temperature rises quickly in the spring. This abrupt increase in temperature affects stalk length and quality of the spikes. Locally produced (in Multan) gladiolus has short spikes, which are not of desirable quality and its yield is very low in the area; hence, it is not an attractive crop for growers.

The use of plant growth regulators has brought a sort of revolution in the floriculture industry. Many beneficial effects of different plant growth regulators have been reported on different horticultural crops (Sridhar, 2006) including control of growth and flowering in many floral crops to produce high quality produce. Use of growth regulators in gladiolus has received due attention only in the recent past and still information available is very meager. Gibberellic acid is known to be involved in increasing stem height, number of leaves per plant, leaf area, shoot dry weight and flower diameter (Siraj and Al-Safar, 2006). GA_3 delays senescence of flowers by reducing the senescence-promoting effect of ethylene (Faraji et al., 2011). However, the role of GA_3in plants is complicated (Arora et al., 1992). Attempts have been made to explore the role of GA_3 in growth and flowering of gladiolus by various workers and the application of GA_3 was found to shorten number of days to flowering, increase spike length, number of flowers per spike, floret diameter, shoot elongation and vegetative growth significantly (Roychowdhury, 1989; Chopde et al., 2012a).

Cytokininsregulate processes associated with plant growth and development, including cell division and leaf senescence (Asil et al., 2011).Cytokinins including BAP (6-Benzylaminopurine) promote leaf expansion and thus size of flower in some plants (Nishijima et al., 2006). It has been observed that endogenous cytokinin levels fluctuate at floral induction (Bernier et al., 1993). BAP delays senescence by protecting cells and proteins (Faraji et al., 2011) and increase the postharvest life of different cut flowers by delaying breakdown and degradation of proteins and chlorophyll (Emami et al., 2011; Faraji et al., 2011).

The present investigation was therefore carried out to elucidate the low yield and quality in southern Punjab and investigate the effect of plant growth regulators (GA_3 and BAP) on growth, flowering, vase life and corm production of *Gladiolus grandiflorus* L.

Materials and Methods

Present work was conducted at the Experimental Area, Department of Horticulture, Bahauddin Zakariya University, Multan (Pakistan), during 2010-12. Multan is located in Southern Punjab (Pakistan) at the latitude of 30° 12` 54`` N and longitude of 71° 35` 27`` E. The area is a flat, alluvial plain with fertile land and is ideal for agriculture. The climate is arid with very hot summers and mild winters. The highest recorded temperature during summer is approximately 54°C, and the lowest during winter is −1°C. The average rainfall is around 127 mm per annum.

The soil for planting corms was thoroughly prepared and plots were laid out according to randomized complete block design (RCBD) with factorial arrangement. There were two plant growth regulators (BAP and GA_3) with one control, four concentrations (0, 25, 50 and 100 mg L^{-1}) and three replications. The Different treatment combinations are presented in Table 1.

The corms of gladiolus cv. Traderhorn were obtained from More Green Flowers and Vegetables Seeds, Lahore, an importer of Flora Biz International, Netherlands and kept cold stored. These were placed at room temperature on 1st November and planted on ridges, spaced 60 cm apart with 20 cm plant to plant distance on 15th November during both the years i.e. 2010 and 2011. Twenty corms were planted in each treatment, which was replicated thrice. First spray of BAP or GA_3 was applied 30 days and the second 60 days after planting. All other cultural practices like irrigation, fertilizer application, earthing up, weeding, plant protection measures, etc. were same for all the plots during entire period of study. During the course of time, data on different parameters of growth, flowering and post-harvest life were collected using standard procedures. Plant height was recorded 60 days after planting (DAP) the corms. Leaf chlorophyll contents (spot values) were measured with the help of a chlorophyll meter (SPAD, Minolta, Japan). For estimation of vase life, the spikes were harvested when lower most floret started showing color, immediately placed in buckets containing distilled water and shifted to the laboratory. The leaves from the stems

Table 1
Different treatment combinations of plant growth regulators used during the experiment

Treatment combinations	PGR × concentration
T0C0	Control (No PGR, water spray)
T1C1	BAP @ 25 mg L-1
T1C2	BAP @ 50 mg L-1
T1C3	BAP @ 100 mg L-1
T2C1	GA3 @ 25 mg L-1
T2C2	GA3 @ 50 mg L-1
T2C3	GA3 @ 100 mg L-1

were removed and these were placed individually in glass vases containing 200 mL of distilled water. After every two days, vase water was replaced with fresh distilled water and lower 2.5 cm of stem was also cut with the help of sharp secateurs. Spikes were considered dead when more than 50% florets were wilted, dried or faded.

Data collected on different parameters for both the years were pooled and analyzed statistically by using Fisher's Analysis of Variance (ANOVA) technique. The treatment means were compared by employing Duncan's Multiple Range (DMR) test at $p = 0.05$. Co-stat statistical package software was used for the purpose.

Results and Discussion

Plant height

Statistical analysis of the data for plant height, recorded 60 DAP, revealed significant differences among PGR treatments, their concentrations and the interaction between these two factors. Both GA_3 and BAP significantly increased the plant height as compared to the control and behaved statistically alike. Among the concentrations used, 100 mg L^{-1} was most effective treatment in increasing plant height, followed by 50 mg L^{-1}. Both the concentrations were statistically similar. The control treatment registered the lowest plant height but stood statistically at par with concentration of 25 mg L^{-1}. Among the interaction means, four treatment combinations GA_3 at 100 mg L^{-1}, BAP at 100 mg L^{-1}, GA_3 at 50 mg L^{-1} and BAP at 50 mg L^{-1} performed the best and all these four treatment combinations were statistically at par with each other. The control resulted in the minimum plant height but was statistically similar with GA_3 at 25 mg L^{-1} and BAP at 25 mg L^{-1} (Table 2).

Cytokinins including BAP are involved in many physiological processes associated with plant growth and development, while GA_3 is known for stem elongation. Therefore, both the PGRs resulted in increased plant height as compared to the control plants. Further as the PGR concentration was increased, the plant height was also increased but up to certain level i.e. 50 mg L^{-1}, beyond which the increase was insignificant. Increase in plant height has already been reported in gladiolus when corms were treated with BAP before planting (Khan et al., 2011), possibly due to its role in increasing cell division and favor shoot formation. Application of GA_3 has increased plant height in gladiolus (Rana et al., 2005; Naveen et al., 2008; Chopde et al., 2012a), tulip (Saniewski et al., 1999), iris (Al-Khassawneh et al., 2006) and tuberose (Asil et al., 2011), possibly due to its growth promoting effect in stimulating and accelerating cell division and/or cell enlarge-

Table 2
Effect of foliar application of plant growth regulators and their concentrations on growth of gladiolus

PGR/ Concentration	Plant height 60 DAP, cm	Number of leaves plant^{-1}	Leaf chlorophyll content	Days to spike emergence
PGRs				
Control (No PGR)	48.00 b*	6.00 a	69.73 c	107.53 a
BAP	54.89 a	6.12 a	74.40 b	108.45 a
GA_3	55.04 a	6.12 a	77.05 a	107.74 a
Concentrations				
Control (0 mg L-1)	48.00 b	6.00 a	69.73 c	107.53 a
25 mg L-1	50.95 b	6.00 a	73.50 b	108.90 a
50 mg L-1	56.02 a	6.00 a	74.10 b	107.40 a
100 mg L-1	57.93 a	6.34 a	79.57 a	107.97 a
Interaction (PGR × Concentration)				
PGR 0 × 0 mg L^{-1}	48.00 b	6.00 a	69.73 d	107.53 a
BAP × 25 mg L^{-1}	51.56 b	6.00 a	72.73 c	109.33 a
BAP × 50 mg L^{-1}	56.06 a	6.00 a	72.86 c	107.73 a
BAP × 100 mg L^{-1}	57.03 a	6.33 a	77.60 b	108.27 a
GA_3× 25 mg L^{-1}	50.33 b	6.00 a	74.26 c	108.46 a
GA_3× 50 mg L^{-1}	55.96 a	6.00 a	75.33 bc	107.06 a
GA_3× 100 mg L^{-1}	58.83 a	6.33 a	81.53 a	107.66 a

* Means sharing similar letters in each group for each parameter, separately are statistically non-significant at $p = 0.05$ (DMR test).

ment or both. Therefore, the results of the present study are in conformity with the findings of previous workers.

Number of leaves plant^{-1}

Analysis of variance of the data for the parameter depicted non-significant differences among PGRs, their concentrations and interaction between these two factors. The results revealed that leaf number was not affected by the BAP and GA_3 application at any concentration applied, in the present study (Table 2). GA_3 causes stem elongation through increased internodal length; therefore, leaf number was not affected. Similar results have already been reported by Chopde et al. (2012a,b). Similarly, BAP was also ineffective in increasing leaf number in gladiolus.

Leaf chlorophyll content

Statistical analysis of the data for the parameter indicated significant differences among PGRs, their concentrations and also interaction between these two factors. The chlorophyll content was increased remarkably by both the PGRs applied and their concentrations used. GA_3 application resulted in maximum leaf chlorophyll content, followed by the BAP application. However, both the PGRs were statistically different. The control plants had the minimum chlorophyll contents in their leaves. The highest concentration of these PGRs (i.e. 100 mg L^{-1}) resulted in significantly higher chlorophyll content and differed from other concentrations. Among the interaction means, results reveled that GA_3 applied at 100 mg L^{-1} resulted in maximum chlorophyll contents, clearly indicating the dominating effect of GA_3 and the highest concentration (100 mg L^{-1}) (Table 2). GA_3 has already been reported to increase leaf chlorophyll content in gladiolus (El-Naggar, 1999). GA_3 treatment retards chlorophyll degradation and helps in retaining high leaf chlorophyll content in gladiolus (Faraji et al., 2011). Emongor and Tshwenyane (2004) observed that accel (mixture of 1.8% BAP and 0.18% $GA_{4,7}$) at 50 mg L^{-1} increased leaf chlorophyll content in Easter lily. BAP at 75 mg L^{-1}also had an effective role in preventing chloroplast and chlorophyll degradation which resulted into decrease in leaf senescence and increase in total chlorophyll content of lily leaves (Emami et al., 2011). Thus, the results of the present study are in accordance with the previous findings.

Days to spike emergence

Analysis of variance of the data for the parameter exhibited non-significant differences among PGRs, their concentrations and interaction means of these two factors (Table 2). The results indicated that the flowering in gladiolus was not affected by growth regulators used, as this is regulated by day length. Gilbertson-Ferriss and Wilkins (1981) also reported that BAP does not affect number of days to flower in *Freesia hybrida*.

Stalk length

Statistical analysis of the data for stalk length revealed significant differences among the PGRs, their concentrations and interaction between these two factors. Both the PGRs significantly increased that stalk length as compared to control and were statistically at par. Among the PGR concentration used, 100 mg L^{-1} resulted in the largest stalk and 0 mg L^{-1} (control) into the smallest stalk. Other two concentrations (25 and 50 mg L^{-1}) were in the middle and behaved statistically alike. Among the interaction means, GA_3 at 100 mg L^{-1} and BAP at 100 mg L^{-1} gave the maximum stalk length, clearly indicating the supremacy of PGRs and the highest concentration (100 mg L^{-1}) (Table 3). GA_3 increases stem length through cell division and cell enlargement, which might has elongated stalk length. Several workers have already reported increase in length of stalk/flowering stem in carnation (El-Naggar et al., 2009; Verma et al., 2000), anthurium (Chandrappa et al., 2006), iris (Al-Khassawneh et al., 2006) and in tuberose (Asil et al., 2011) due to GA_3 application. Among the cytokinins, kinetin has also been found to increase the length of flowering stalk in gladiolus (Roychoudhuri et al., 1985).

Fresh weight of flower stalk

Data on fresh weight of complete flower stalk were subjected to statistical analysis and the results revealed significant differences among PGRs, their concentrations and interaction between the two factors. The PGR treatments differed significantly from each other. BAP gave maximum fresh weight of flower stalk, followed by GA_3. However, both the growth regulators were statistically different in their effect on the parameter under study. Significantly minimum fresh weight of flower stalk was recorded in control. Regarding the effect of PGR concentrations, as the concentration was increased, the fresh weight of flower stalk also increased significantly. However, control (0 mg L^{-1}) and the lowest concentration (25 mg L^{-1}) were statistically similar. As for as interaction means are concerned, both the PGRs at the highest concentration (100 mg L^{-1}) resulted in maximum fresh weight of flower stalks due to the dominating effect of PGRs and the highest concentration individually (Table 3). This increase in fresh weight was possibly attributed to increased stalk length in these treatments/treatment combinations. Increase in fresh weight of flower stalk due to the application of GA_3 has already been reported in tuberose (Panwar et al., 2006), carnation (Verma et al., 2000) and iris (Al-Khassawneh et al., 2006). Similarly BAP also promotes stalk growth which ultimately results in increased fresh weight of flower stalk.

Table 3
Effect of foliar application of plant growth regulators and their concentrations on flower quality parameters and vase life of gladiolus

PGR/ Concentration	Stalk length, cm	Fresh weight of stalk, g	Length of spikes, cm	Number of florets spike-1	Fresh weight floret^{-1}g	Vase life of spikes, days
PGRs						
Control (No PGR)	65.33 b*	61.00 c	39.00 c	14.66 b	2.63 b	9.06 b
BAP	77.27 a	77.12 a	41.67 b	16.69 a	3.58 a	12.45 a
GA_3	77.56 a	74.38 b	43.18 a	16.00 a	3.65 a	12.40 a
Concentrations						
Control (0 mg L^{-1})	65.33 c	61.00 c	39.00 c	14.66 c	2.63 c	9.06 c
25 mg L^{-1}	72.50 b	64.64 c	40.74 bc	15.54 bc	3.20 b	9.87 c
50 mg L^{-1}	76.90 b	77.84 b	42.06 b	16.07 b	3.44 b	12.40 b
100 mg L^{-1}	82.84 a	84.77 a	44.47 a	17.44 a	4.20 a	15.00 a
Interaction (PGR × Concentration)						
PGR 0 × 0 mg L^{-1}	65.33 e	61.00 d	39.00 d	14.66 c	2.63 c	9.06 c
BAP × 25 mg L^{-1}	72.20 d	67.86 c	40.73 c	15.86 bc	3.00 b	9.80 c
BAP × 50 mg L^{-1}	78.26 b	78.66 b	41.26 bc	16.53 ab	3.60 b	12.26 b
BAP × 100 mg L^{-1}	81.33 a	84.80 a	43.00 b	17.66 a	4.13 a	15.26 a
GA_3 × 25 mg L^{-1}	72.80 cd	61.40 d	40.73 c	15.20 c	3.40 b	9.93 c
GA_3 × 50 mg L^{-1}	75.53 bc	77.00 b	42.86 b	15.60 b	3.26 b	12.53 b
GA_3 × 100 mg L^{-1}	84.33 a	84.73 a	45.93 a	17.20 a	4.26 a	14.73 a

* Means sharing similar letters in each group for each parameter, separately are statistically non-significant at $p = 0.05$ (DMR test).

Spike length

Analysis of variance of the data for the parameter depicted significant differences among PGRs, their concentrations and interaction between these two factors. Among the PGR treatments, application of GA_3 resulted in significant increase in spike length, followed by BAP. However, both the treatments were statistically different. The control treatment gave the lowest spike length, which significantly differed from other two treatments. Concerning the PGR concentrations, 100 mg L^{-1} performed the best, followed by 50 and 25 mg L^{-1}. However, later two concentrations behaved statistically alike but differed significantly from the former one. The control treatment resulted in minimum spike length and stood at par with 25 mg L^{-1}.Among the interaction means, GA_3 at 100 mg L^{-1} gave the maximum spike length clearly indicating the effect of GA_3 and the highest concentration. The control resulted in minimum spike length which was significantly different from all the treatment combinations (Table 3). GA_3 is known to cause stem elongation by increasing cell division and cell enlargement, which ultimately results in elongated spikes. In response of GA_3 application, increase in spike length has already been reported in many flowering plants i.e. tuberose (Panwar et al., 2006; Devedanam et al., 2007; Tyagi and Singh, 2008; Asil et al., 2011), narcissus (Roein et al., 2008) and also in gladiolus (Maurya and Nagada, 2002; Naveen et al., 2008; Siraj and Al-Safar, 2006; Devi et al., 2007; Chopde et al., 2012b). Therefore, the results of the present study are in agreement with the previous findings.

Number of florets per spike

Statistical analysis of the data for the parameter indicated significant differences for PGR treatments, their concentrations and interaction between these two factors. Both the PGRs significantly increased the number of florets as compared to control treatment and were statistically similar in their effect. Among the PGR concentrations, 100 mg L^{-1} performed the best, followed by 50 mg L^{-1} while the control treatment resulted in minimum florets per spike. As the PGR concentration increased, floret number per spike also increased. Regarding combined effect of PGRs and their concentrations (interaction), both the PGRs at the highest concentration excelled all other combinations, clearly demonstrating the dominant effect of PGRs and the highest concentration on the parameter under study (Table 3). Increase in number of florets

with the application of GA_3 has already been reported by several workers in tuberose (Panwar et al., 2006; Asil et al., 2011) and gladiolus (Naveen et al., 2008)**.** Among the cytokinins, application of kinetin and BAP has been reported to increase number of floret in gladiolus (Roychoudhuri et al., 1985) and in *Leucospermum* (Napier et al., 1986), respectively.

Fresh weight per floret^{-1}(g)

Data for fresh weight per floret were subjected to statistical analysis and the results indicated that both the PGRs significantly increased fresh weight per floret as compared to control. However, both the PGRs were statistically similar in their effect. Among the PGR concentrations used, 100 mg L^{-1} resulted in significantly greater fresh weight per floret as compared to other concentrations. As the PGR concentration was increased, fresh weight per floret also increased. Regarding the combined effect of PGRs and their concentrations (interaction), both the PGR at the highest concentration gave maximum fresh weight floret^{-1}. The minimum fresh weight was recorded in the case of control (Table 3). As plant height and leaf chlorophyll contents were significantly improved by PGRs and their concentration, therefore increased fresh weight per floret in the present study may be attributed to positive effect of PGRs and their concentrations on plant growth. Increase in cut flower fresh weight has already been reported in lily due to application of GA_3 (Emongor and Tshwenyane, 2004) and BAP (Emami et al., 2011).

Vase life of spikes

Statistical analysis of the data for vase life of the spikes revealed significant differences among the PGRs, their concentrations and interaction between these two factors. Both the PGRs significantly improved the vase life of spikes as compared to control and were similar in their effect. Among the PGR concentrations, the highest concentration (100 mg L^{-1}) resulted in maximum vase life of spikes. As PGR concentration was increased, vase life was also enhanced. The minimum vase life was recorded in the case of control (0 mg L^{-1}), followed by 25 mg L^{-1} and both the treatments were statistically at par. Concerning the combined effect of PGRs and their concentrations (interaction), both the PGRs at the highest concentration (100 mg L^{-1}) ousted the all other treatment combinations demonstrating the supremacy of PGRs and their highest concentration (Table 3).

PGRs especially cytokinins and gibberellins have positive effects on post-harvest life of cut flowers. Exogenously-applied cytokinins reduce rate of respiration (Franco and Han, 1997) hence delay flower senescence (Jaroenkit and Paull, 2003; Padhye et al., 2008; Faraji et al., 2011) and enhance the vase life of cut flowers. BAP improves cell membrane permanency, delays lipid peroxidation in cells and decrease ion leakage, hence increases vase life of cut flowers (Emami et al., 2011). Prolonged vase life has already been reported due to the application of BAP in lilies (Ranwala and Miller, 2000; Gulzar et al., 2005; Emami et al., 2011) and tuberose (Asil et al., 2011). GA_3 delays petal abscission and color fading (Emongor, 2004; Khan and Chaudhry, 2006) and may enhance post harvest life in cut flowers. Foliar application of GA_3has been reported to significantly extend the vase life of tuberose (Asil et al., 2011) and lily (Ranwala and Miller, 2000; Emami et al., 2011). Thus the findings of the present study for gladiolus are in accordance with the results already reported for other floral crops. Increased spike field life/longevity of flower on plant have also been reported in gladiolus due to foliar spray of GA_3 (Naveen et al., 2008; Chopde et al., 2012b). Further, treating gladiolus corm with GA3@100 ppm has also been reported to increased flower duration and vase life (Kumari et al., 2011).

Number of corms per plant

Analysis of variance of the data for the parameter depicted non-significant differences among PGRs, their concentra-

Table 4
Effect of foliar application of plant growth regulators and their concentrations on corm production of gladiolus

PGR/ Concentration	No. of corms plant^{-1}	Diameter of corm, cm	Weight corm^{-1}, g
PGRs			
Control (No PGR)	1.0 a*	3.85 b	29.40 b
BAP	1.1 a	4.81 a	38.85 a
GA_3	1.1 a	4.94 a	39.07 a
Concentrations			
Control (0 mg L-1)	1.0 a	3.85 c	29.40 d
25 mg L-1	1.1 a	4.34 b	34.47 c
50 mg L-1	1.1 a	5.07 a	38.04 b
100 mg L-1	1.2 a	5.20 a	44.37 a
Interaction (PGR × Concentration)			
PGR 0 × 0 mg L^{-1}	1.0 a	3.85 c	29.40 c
BAP × 25 mg L^{-1}	1.1 a	4.30 b	34.20 b
BAP × 50 mg L^{-1}	1.0 a	5.04 a	38.06 b
BAP × 100 mg L^{-1}	1.1 a	5.06 a	44.26 a
GA_3× 25 mg L^{-1}	1.0 a	4.37 b	34.73 b
GA_3× 50 mg L^{-1}	1.2 a	5.08 a	38.00 b
GA_3× 100 mg L^{-1}	1.2 a	5.33 a	44.46 a

* Means sharing similar letters in each group for each parameter, separately are statistically non-significant at p = 0.05 (DMR test).

tions and interaction between these two factors. The results revealed that number of corms produced per plant was not affected by the PGRs at the concentrations applied (Table 4), indicating that BAP and GA_3 are ineffective in increasing number of corms per plant in gladiolus.

Diameter of corm

Data procured on the parameter were subjected to statistical analysis. The results showed significant differences for PGR treatments, their concentrations and interaction between these two factors. Both the PGRs significantly increased the corm diameter as compared to control. However, both the PGRs were statistically similar in their effect on the parameter. Among the PGR concentrations, higher concentrations (100 and 50 mg L^{-1}) significantly increased the corm diameter and these two concentrations were statistically alike. The minimum corm diameter was recorded in control. Concerning the interaction means, GA_3× 100mg L^{-1}, GA_3× 50 mg L^{-1}, BAP × 100 mg L^{-1} and BAP × 50 mg L^{-1} performed well and all these four treatment combinations stood statistically at par with each other. The minimum corm diameter was recorded in control, which significantly differed from all other treatments combinations (Table 4). Some research workers have already reported that GA_3 treatments increased diameter of corms in gladiolus (Arora et al., 1992; Siraj and Al-Safar, 2006; Khan et al., 2011). Similarly, BAP has also been reported to increase diameter of bulblets in lily (Simmonds and Cumming, 1976).

Weight of corm

Data for weight of corm were subjected to statistical analysis and the results revealed that the PGRs significantly increased the weight of corms as compared to the control and both the PGRs were statistically similar in their effect. As for as PGR concentrations are concerned, 100 mg L^{-1} resulted in maximum weight of corm, while the control gave the minimum weight. As the concentration of PGR increased, corm weight was significantly increased. Regarding the combined effect of PGRs and their concentrations (interaction), both BAP and GA_3 at the highest concentration (100 mg L^{-1}) gave maximum corm weight. These two treatment combinations were statistically similar but differed significantly from rest of the treatment combinations. The minimum weight of corm was recorded when no PGR was applied (control) (Table 4). Increase in corm weight has already been reported in gladiolus (Arora et al., 1992; Siraj and Al-Safar, 2006; Khan et al., 2011) with the application of GA_3. When gladiolus cormels treated with BAP were planted, these also resulted in increased corm size and weight (Ram et al., 2002). Therefore, these results are in line with previous findings.

Conclusion

The PGRs applied at the early stage of growth, not only influenced vegetative growth and flowering in gladiolus but also affected vase life of spikes. Although corm size and weight were significantly affected by the PGR treatments, number of corms produced per plant remained unaffected. From the results of the present study, it can be concluded that gladiolus can successfully be grown under the Multan conditions by foliar application of GA_3 and BAP but the corms for planting have to be either imported or brought from some other areas every year.

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