Research Article

Influence of Plant Growth Regulators by Foliar Application on Vegetative and Floral physiognomies of Gladiolus

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Abstract | Gladiolus grasps an exceptional position among ornamental plants due to its captivating spikes, with plane ruffle and deeply crinkled sepals, and it mainly used as cut flower and greatly demanded in floral markets. In order to achieve the maximum outcomes for the purchaser or community, a comprehensive study was conducted on gladiolus to enhance its vegetative and floral characteristics with the foliar application of growth hormones i.e. gibberellic acid (GA_3) and salicylic acid (SA). The results revealed that the application of GA_3 and SA had significant influence on vegetative as well as floral traits of gladiolus. The maximum numbers of days (7.90) for the sprouting of gladiolus corms were counted with 1mM of SA similarly maximum plant height (93.60cm) and maximum numbers of leaves (9.86) were observed by 1.75mM SA. The relationship between plant's vegetative phase and growth regulators stood noteworthy resulted in maximum leaf length (71.14cm), rachis length (57.33cm) and spike length (77.67cm) at 1.75mM concentration of GA_3. The Effect of SA found worthy as it enhanced the floral growth and decrease the number of days towards blooming. Moreover, the days to spike emergence, days to bud color and days to floret open were decreased (96.47, 101.20 and 105.77 respectively) with 1.75mM salicylic acid. However, the results showed the positive impact of GA_3 and SA on vegetative as well as floral physiognomies of gladiolus plants.

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Introduction

Gladiolus is a perennial flower belongs to family Iridaceae and commonly known as queen of bulbous flowers. Mushtaq *et al.* (2018) labelled that the cultivation of gladiolus were found in the gardens at the termination of 16th century. Furthermore, its farming attained admiration because of its extravagance exclusive variegated flowering spikes with longer shelf life of abridged floras (Ali *et al.*, 2016). In Pakistan, gladiolus is demanded commercially for cut-flower but the production and quality class is still low which was analyzed by Hussain and Ahmad (2018) as compared to worldwide ethics. However, on the ground to fulfil the demand of gladiolus, the growers have to adopt the new growing techniques at vendible level in accumulation of ideal amount of nutrients or growth regulators to improve the qualitative as well as quantitative characteristics (Rani and Singh, 2013) that is surely exceedingly valuable not alone for the growers and suppliers but also for the customers. A study by Iqbal *et al.* (2011) demonstrated that the foliar spray of gibberellic acid can be used to enhance the biological responses in floras and also modify the source-sink absorption over their results on photosynthesis and sink establishment. Research have also shown that GA_3 signing intricate in sustaining several plants-soil correlation, stacking and transportation of sucrose in Phloem through plant's vascular system (Emami *et al*., 2011) and also unpacking the relevant amount of sucrose from phloem to sink structures or materials effecting general presentation of plant's growth. Sure *et al.* (2012) proved that the applications of gibberellic acid have a significant part in sponsoring miscellaneous procedures in the progress of plant health. Salicylic acid is an unassuming phenolic complex that allows plant to survive in several soil and ecological states and can be pragmatic on various behaviors. In case of salicylic acid (SA), it is an endogenous plant growth regulator which takes part to produce a wide series of metabolic and physiological responses in plants thus distressing their growth and development (Hayat *et al*., 2010). The previous exploration of Rivas-San-Vicente and Plasencia (2011) highlighted that SA contributed in abiotic pressures like drought, chilling etc. Gladiolus hold higher spike fresh weight, antioxidant enzyme, constancy of sheath and important to postponement in petal senescence by the application of salicylic acid 150mg/L. Therefore, this experimental investigation was conducted to explore the effect of gibberellic acid and salicylic acid on vegetative and reproductive growth of gladiolus plants. Keeping in view the importance of gladiolus plant nationally and internationally, the present study was planned to evaluate the effect of two plant growth regulators on vegetative and floral physiognomies of gladiolus.

Materials and Methods

Experiment was conducted at research field area of Floriculture Program, Horticulture Research Institute, National Agriculture Research Centre, Islamabad in October 2018-2019. The corms of gladiolus cv. Rose-Supreme (size 8-10cm) imported from Netherlands, were stored at 10°C temperature before being planted. The corms were planted in open field condition at row to row 75cm and plant to plant 30cm distance. The experiment was laid out according to randomized complete block design (RCBD) consisted of 8 treatments including one control with 3 replications and each replication consisted of 10 plants. The freshly prepared solutions of gibberellic acid (1mM, 1.25mM, 1.75mM), salicylic acid (1mM, 1.25mM, 1.75mM) and a combination of GA_3+SA (1mM) were applied as a foliar application on gladiolus at different stages such as two leaves stage, 4-6 leaves stage and slipping stage. The measurement of growth parameters like Plant height, Spike length, Rachis length, Leaf length were assessed by measuring tape while other data were recorded by visual observations. The calculated characters used for analysis of variance and the mean assessments were compared at 5% level of significant using least significant difference (LSD method) according to Steel *et al.* (1997).

Results and Discussion

The plant morphological characteristics like plant height, No. of leaves, leaf length, days to spike emergence, spike length, rachis length, days to floret color, number of days to floret open and number of florets per spike were recorded. All parts of the plants expressively performed well by the foliar spray of GA_3 and SA as well as their combination. The data in Table 1 showed that the number of days to plant emergence increased by the foliar application of GA_3 and SA with relatively no significant difference. The minimum numbers of days (7.03±0.15^a) were recorded in controlled plants while the application of GA_3 with concentration 1.25mM took 7.16±0.75^a number of days to emergence. The other two foliar applications 1mM of GA_3, 1.75mM of SA acquired 7.40±0.95^a and 7.60±0.40^a days respectively. Similarly, Sajid *et al.* (2009) studied the effect of foliar application of gibberellic acid on flowers growth and characteristics of lily plants. The nourishment of plants with salicylic acid 1.25mM and with the combined solution GA_{3+}SA at concentration 1mM is imperative for an understanding because they attained equal number of days 7.73±0.42^a and 7.73±0.32^a with low difference significantly. The concentration of GA_3 (1.75mM) took 7.83±0.75^a days although the maximum numbers of days (7.90±0.52^a) were recorded with the foliar spray of 1mM SA. Rashid (2018) elevated numerous concerns about growth regulators. He claimed that the application of GA_3 with 125ppm increase the number of days by 50% for corms sprouting. Similar results were discovered with the foliar spray of SA when a comprehensive study was conducted on the vegetative growth of gladiolus by Pawar *et al.* (2018). The maximum plant height (93.60cm) was noted for SA at 1.75mM, tracked by the application of GA_3 at 1.25mM induced 89.40cm height of plant. It was found that the plants nourished with 1.75mM GA_3 alone or combined with SA 1mM exposed same height (81.7cm). The association among 1mM of SA, 1.25mM of SA and 1mM of GA_3 has been interesting due to lower difference in plant's height (68.4cm, 68.4cm and 68.6cm respectively). The minimum height of plant (61.10cm) was observed in controlled plants. Bhalla and Kumar (2007) stated that the foliar spray of gibberellic acid at concentration 300ppm induced extreme height (105.60cm) in gladiolus plants while SA improved plant height by amplified the Rubisco movement and photosynthetic proportion (Nagasubramaniam *et al*., 2007). The outcomes of the current trial exposed that the growth hormones presented substantial consequence on the plant height at all phases of growth presented in Table 1.

The results of present study indicated that the maximum numbers of leaves (9.86±0.38a) were counted for SA 1.75mM while application of 1.25mM of GA_3 produced 9.83±0.06^a number of leaves. The experiment proved that the combination of SA and GA_3 at 1mM concentration formed a relatively large number of leaves (9.60±0.87^a) as compared to 1.25mM of SA (9.53±1.81^a). The results also expressed that 1.75mM of GA_3 created 9.40^a±0.36^a, 1mM of SA induced 9.36±0.21^a and 1mM of GA_3 formed 9.06^a±0.57 number of leaves. In 2011, Kumari and colleagues demonstrated that the maximum number of leaves per plant was noted at per GA_3 100ppm (5.29) statistically. Pal *et al*. (2015) indicated the noteworthy information about plant nourished with 50ppm of salicylic acid represent the maximum plant height (104.83cm).

Leaf length is an imperative influential trait to examine overall growth of plants. The results revealed that maximum leaf length (71.14cm) were achieved by the application of 1.75mM GA_3 and other two treatments of GA_3 such as at concentration 1mM GA_3 and 1.25mM GA_3 provided different leaf length (65.18cm and 62.23cm respectively). In divergence, the outcomes by calculation designated that untreated plants represented the definitive leaf length (61.56cm). The combination of GA_{3+}SA (1mM) gave 66.64cm leaf length. On the other hand, at concentration 1.75mM SA and 1mM SA provided the same leaf length (57.84cm and 57.36cm) with little difference. The shortest leaf length (48.75cm) was observed by the application of SA at concentration 1.25mM. The maximum length of the elongated leaf (68.83cm.) was documented by Pal *et al*. (2015) after 100 days of sowing when salicylic acid spray was applied at concentration 100ppm. Ramachandrudu and Thangam (2007) studied that GA_3 at concentration 150ppm enhanced the length of leaf. Moreover, Abduo *et al*., 2014 also suggested the progress in the leaf length by the use of salicylic acid at concentration 100 or 200ppm.

Among all the parameters which were recorded during the research, rachis length expressively performed well by application of growth regulators. GA_3 solution at concentration 1.75mM increased the length of rachis with peak worth of 57.33cm whereas 1.75mM SA caused increment of 48.66cm in length of rachis. The nourishment of plants with 1.25mM GA_3 add 42.53cm rachis length, treatment concentration 1.25mM SA and 1.00mM GA_3 provided 38.63cm and 38.60cm respectively. The combined application of GA_{3+}SA (1mM) showed 39.16 cm lengths, 1mM SA gave 34.46cm rachis length while the lowest rachis length (33.50cm) was recorded in controlled plants. In 2013, Rani and Singh reported that the length of rachis (36.23cm) was evidently affected with the maximum dose of 150ppm GA_3.

The duration of spike emergence was noted from the sowing time of corms to appear first floral bud on the plants. It was found that plants-treated at concentration 1.75mM SA were emerged in significantly less number of days (96.47±1.17^f) followed by 1.25mM GA_3 (101.17±0.75^e) and 1mM SA (101.63±0.91^{de}) with abstemiously low significant level as shown in Table 2. Besides of these recordings, the combined application of GA_3 and SA at concentration 1mM had also imperative influence because of acquired (102.23±0.95^{cde}) days for spike emergence. Although, plants nourished at concentration 1.25mM SA and 1.75mM GA_3 had interesting relation by having the equal number of days (103.20±1.11^{bcd} and 103.57±1.05^{bc}). The maximum number of days (108.17±0.64^a) for spike emergence was calculated by the application of 1mM GA_3. A serious discussion of growth hormones on plants emerged during the 2011 by Kumari *et al*., 2011 highlighted the early spike emergence under GA_3 at concentration 100ppm corm treatment (74.61 days). Similar findings were noted during the rise in floral characteristics of gladiolus plant enlightened the minimum days for prominence of 1st spike (90.77 days) emergence Pal *et al*. (2015).

Table 1: *Influence of gibberellic acid and salicylic acid on vegetative growth of gladiolus.*

Treatments	Days to plant emergence	Plant height (cm)	No of leaves	Leaf length (cm)	Rachis length (cm)
T_0 (control)	7.03±0.15^{a}	61.1±0.56^{e}	7.60±0.61^{b}	61.56±0.84^{c}	33.50±0.60^{e}
T_1 (1mM GA_3)	7.40±0.95^{a}	68.6±0.95^{d}	9.06±0.57^{a}	65.18±0.68^{b}	38.60±0.61^{d}
T_2 (1.25mM GA_3)	7.16±0.75^{a}	89.4±1.21^{b}	9.83±0.06^{a}	62.23±0.81^{c}	42.53±1.03^{c}
T_3 (1.75mM GA_3)	7.83±0.75^{a}	81.7±1.01^{c}	9.40±0.36^{a}	71.14±1.3^{4}a	57.33±1.9^{7}a
T_4 (1mM SA)	7.90±0.5^{2}a	68.4±1.91^{d}	9.36±0.21^{a}	57.36±0.69^{d}	34.46±1.37^{e}
T_5 (1.25mM SA)	7.73±0.42^{a}	68.4±1.41^{d}	9.53±1.81^{a}	48.75±1.30^{e}	38.63±0.35^{d}
T_6 (1.75mM SA)	7.60±0.40^{a}	93.6±1.0^{8}a	9.86±0.3^{8}a	57.84±0.70^{d}	48.66±1.10^{b}
T7(1mM GA_3+SA)	7.73±0.32^{a}	81.7±1.70^{c}	9.60±0.87^{a}	66.64±0.91^{b}	39.16±1.57^{d}

Table 2: *Influence of gibberellic acid and salicylic acid on the floral growth of gladiolus.*

Treatments	Days to spike emergence	Spike length (cm)	Days to bud color	Days to floret open	No of floret/ spike
T_0 (control)	104.17 ± 0.7^{6}b	52.00 ± 0.44^{f}	107.30±0.8^{5}b	110.43±0.87^{b}	7.067±0.51^{bc}
T_1 (1mM GA_3)	108.17 ± 0.6^{4}a	57.06 ± 0.46^{e}	110.87±0.2^{9}a	112.80±0.3^{6}a	8.533±0.40^{ab}
T_2 (1.25mM GA_3)	101.17 ± 0.7^{5}e	66.26 ± 0.06^{c}	105.03±0.2^{9}d	109.27±0.4^{0}b	9.667±0.9^{8}a
T_3 (1.75mM GA_3)	103.57 ± 1.05^{bc}	77.66 ± 1.0^{5}a	107.20±1.2^{8b}c	111.40±1.5^{6a}b	7.600±1.9^{0b}c
T_4 (1mM SA)	101.63 ± 0.91^{de}	51.66 ± 1.65^{f}	105.17±1.6^{1c}d	110.87±1.2^{7a}b	7.267±1.2^{5b}c
T_5 (1.25mM SA)	103.20 ±1.1^{1bc}d	57.63 ± 1.17^{e}	106.43±1.3^{7bc}d	111.57±0.9^{5a}b	6.200±0.4^{0}c
T_6 (1.75mM SA)	96.47 ± 1.1^{7f}	69.93 ±0.4^{5}b	101.20±1.0^{4}e	105.77±1.0^{8}c	10.233±0.7^{8}a
T7(1mM GA_{3+}SA)	102.23 ±0.9^{5cd}e	61.51 ± 0.89^{d}	106.17±1.6^{9bc}d	110.40±2.64^{b}	7.167±0.70^{bc}

The consequences concerning spike length described substantial modifications between several treatments. Maximum spike length (77.66cm) was originated in the plants nourished with 1.75mM GA_3 tracked by1.75mM SA (69.93cm). The plants exposed to 1.25mM GA_3 and (1mM GA_{3+}SA) also attained good results (66.26cm and 61.51cm) equated with 1.25mM SA and 1mM GA_3 embodied spike length of 57.63cm and 57.06cm correspondingly. However, controlled plants induced 52.00cm and shortest length (51.67cm) was observed by 1mM SA. The conceivable cause for growing spike length and rachis length might be due to rise in the cell partition and cell elongation of intercalary meristem ensuing the fast internode elongation (Shanker *et al*., 2011).

The outcomes about the number of days to bud color exhibited that the plants fed with 1mM GA_3 grabbed maximum numbers of days (110.87±0.29^{a}) for floret color appearance. Results from present study indicated that the foliar spray of 1.75mM GA_3 acquired the comparable numbers of days (107.20±1.28^{bc}) as in controlled plants (107.30±0.85^{b}) trailed by the application of 1.25mM SA (106.43±1.37^{bcd}) and 1mM GA_{3+}SA (106.17±1.69^{bcd}). The findings suggested that minimum number of days (101.20±1.04^{e}) for bud color obtained with 1.75mM SA while the application of 1.00mM SA and 1.25mM GA_3 took the average number of days (105.17±1.61^{cd} and 105.03±0.29^{d}).

Consequences showed that the least number of days to floret open (105.77±1.08^{c}) were noted by 1.75mM SA followed by 1.25mM GA_3 (109.27±0.40^{b}). The results of the present study also suggested that plants nourished with 1mM of GA_{3+}SA, 1mM of SA ,1.75mM of GA_3, 1.25mM of SA and 1.25mM of GA_3 attained number of days (110.40±2.64^{b},110.87±1.27^{ab}, 111.40±1.56^{ab}, 111.57±0.95^{ab} and 112.80±0.36^{a} respectively) with a little variance. It has been suggested that the use of gladiolus at 500ppm concentration (Baskaran and Misra, 2007) caused the earliness in flowering of gladiolus and Salicylic acid enthused instigation of flowers then tangled in the biological progressions (Hayat *et al*., 2010).

The numbers of florets per spike (10.23±0.78a) were obtained at 1.75mM concentration of SA and at 1.25mM concentration of GA_3 formed (9.667±0.98^{a}). These findings were also found similar with findings of past studies by Kumar *et al*. (2014), which clarified that the flower inaugural may also be linked to the levels of gibberellin and abscisic acid in gladiolus, and a higher ABA/GA_3 may lead to premature floret opening. Table 2 proved that squirting plants at 1mM concentration of GA_3 tempted (8.53±0.40[ab]) number of florets/spike. The most surprising results of the numerical simulation directed that the application of 1.75mM GA_3, 1mM SA and 1mM GA_{3+}SA precast the relatively equal number of florets per spike (7.600±1.90[bc], 7.267±1.25[bc] and 7.167±0.70[bc] respectively) with low difference. The current discoveries also suggested that foliar spray of 1.25mM SA contributed the lowest number of florets per spike (6.200±0.40[c]) in comparison with controlled plants (7.067±0.51[bc]). Singh *et al*. (2007) reviewed the available literature on number of florets per spike was improved knowingly with the increase in absorptions of GA_3 and analogous results alike number of florets per spike or floret diameter were found in different varieties of gladiolus with the treatment of GA_3 at 200ppm concentration (Singh *et al*., 2013). Almost similar results were reported by Sajjad *et al*. (2014) that GA3 is involved in enhancing number of florets per spike.

Conclusions and Recommendations

The outcome of this research highlighted the importance of growth regulators and their impact on vegetative as well as floral growth of gladiolus plants. Gibberellic acid improved the floral traits like rachis length and spike length which are economically important traits in gladiolus. On the other hand, salicylic acid also had a great influence on floral growth of gladiolus with maximizing the number of florets/spikes, shortened the number of days to spike emergence, bud color and floret open etc. Thus, the use of growth regulators on gladiolus plants helps to improve the vegetative and floral traits which would ultimately lead to fetch more prices in local and international markets.

Novelty Statement

Gibberellic acid improved the floral traits like rachis length and spike length which are economically important traits in gladiolus. On the other hand, salicylic acid also had a great influence on floral growth of gladiolus with maximizing the number of florets/spikes, shortened the number of days to spike emergence, bud color and floret open etc.

Author's Contribution

Shahid Nadeem: Conducted field experiment, collected data and written manuscript.
Taj Naseeb Khan: Proposed research methodology.
Mushtaq Ahmad: Supervised and collected data.
Adnan Younis: Literature review.
Iram Fatima: Data analysis.

Conflict of interest

The authors have declared no conflict of interest.

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