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Effect of corm size and growth regulators on growth, flowering and quality of gladiolus (*Gladiolus grandiflorus* L.)

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ABSTRACT

Gladiolus is the 8th most important in the world cut flower trade grown for its elegant attractive spikes and good keeping quality. However, the farmers in Bangladesh have limited access to the scientific cultivation of this crop, and yield and quality production of flower is low compared to other gladiolus growing countries in the world. Growth regulating chemicals have been reported to be very effective in manipulating growth and flowering of gladiolus. Therefore, an experiment was conducted at the Landscaping section of the Department of Horticulture, Bangladesh Agricultural University, Mymensingh during the period from October 2017 to April 2018 to study the effect of corm size and plant growth regulators (PGRs) on growth, flowering and quality of gladiolus. The experiment consisted of two corm sizes *viz.*, 3.0∼4.0 and 4.1∼5.0 cm, and two PGRs *viz.* GA3 @ 250, 500 and 750 ppm; and NAA @ 100, 200 and 300 ppm along with tap water as control. The two-factor experiment was laid out in a randomised complete block design with three replications. The results revealed that the corm size and PGRs significantly affected growth, floral and quality traits of gladiolus. The highest plant height, maximum number of leaves per plant, longest leaf length, maximum number of florets per spike, longest spike and rachis length were observed in 4.1∼5.0 cm sized corms and GA3 @ 750 ppm, compared to rest of the treatments. Earliness in flower initiation and maximum duration of flower was observed in 4.1∼5.0 cm sized corms and GA3 @ 500 ppm. Significant variations among the treatment combinations were observed for all the parameters studied. The treatment combination of 4.1∼5.0 cm sized corms and GA3 @ 750 ppm was found to be best in respect of growth, floral and quality characters of gladiolus.

Keywords: Gladiolus, corm size, GA3, NAA, growth, flower quality

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1 Introduction

Gladiolus (*Gladiolus grandiflorus* L.) belongs to the family Iridaceae, commonly called sword Lilly or corn flag is one of the most important monocotyledonous bulbous ornamental plants grown in many parts of the world either as cut flower or for garden display (Baskaran et al., 2014). Gladiolus is a flower of glamour and perfection which is known as the queen of bulbous flowers due to its long spikes with florets of massive form, rich variations of colours, attractive shades, varying sizes of flowers and long vase life (Roy et al., 2017). Gladiolus is grown as flowerbed in gardens and the magnificent inflorescence is used in floral arrangements for interior decoration as well as making high quality bouquets (Lepcha et al., 2007). This crop possesses a great export potential to European countries especially during winter.

Gladiolus is a native of South Africa. Floriculture has become very lucrative and money-spinner industry globally and gladiolus has a great share of this flower industry which fetches good premium for the money invested (Verma et al., 2015). Bangladesh has a long tradition of cultivating flowers throughout the country on smallholdings. Recently, gladiolus is cultivated all over the country due to ever increasing demand of this elegant cut flower. However, in Bangladesh the area under gladiolus cultivation is only few hundred hectares and it occupied only about <1% per cent of the total cut flowers produced which is much less. In addition, quality production of flower is low compared to other gladiolus growing countries in the world. Hence, the latest technology of quality flower production required to be adopted. The technologies are selection and treatment to corms, judicious use of fertilizers and growth regulators, disease and pest control and post-harvest management, etc. (Sable et al., 2015).

Size of corm affects the growth, floral and corm yield attributes in Gladiolus. Smaller sizes of the corms are poor yielder and larger sized corms add in cost of cultivation (Singh, 1992). Therefore, it is essential to find out optimum size of corms for obtaining the best results. Many studies have indicated that the application of growth regulators such as gibberellins (GA3), Naphthalene acetic acid (NAA), etc. can affect the growth and development of gladiolus flowers (Chopde et al., 2012; Vijai et al., 2007; Kumar et al., 2008; Rana et al., 2005). In case of bulbous ornamental plants, GA3 stimulate the height of the plant, length of flower stalk, flower size, duration of flowering, early flowering, lengthening the life of the spike to a significant extent (Roy et al., 2017). However, for quality flower production concentrations of growth regulating chemicals are outmost importance. Otherwise, it will lead to an undesirable effect. Therefore, the present study was undertaken to find out the effect of corm size and plant growth regulators on growth, flowering and quality of gladiolus.

2 Materials and Methods

2.1 Experimental site, climate and soil

The experiment was carried out at the Landscaping section of the Department of Horticulture, Bangladesh Agricultural University, Mymensingh (24°42′56.7″N, 90°25′50.5″E) during the period from October 2017 to April 2018 to investigate the effect of corm size and plant growth regulators on growth, flowering and quality of gladiolus (*Gladiolus grandiflorus* L.). The experimental area is situated in the sub-tropical climate zone and characterized by three different seasons, the monsoon or rainy seasons (May to October), the winter or dry season (November to February) and pre-monsoon or hot season (March to April). The experimental site was medium high land belonging to the Old Brahmaputra Floodplain under the Agro-Ecological Zone 9 having non-calcareous dark gray floodplain soil (UNDP/FAO, 1988). The soil of the experimental plot was silty loam in texture and neutral (pH 7.0) in reaction, which is suitable for gladiolus production.

2.2 Treatments

The experiment consisted of two factors *viz.* corm size (3.0∼4.0 and 4.1∼5.0 cm) and plant growth regulators (PGRs) (GA3 @ 250, 500 and 750 ppm, and NAA @ 100, 200, 300 ppm and tap water as control). Here 'C' indicates corm size and 'T' indicates plant growth regulators.

2.3 Planting materials

The healthy corms of gladiolus of 3.0∼4.0 and 4.1∼5.0 cm diameter were purchased from a private nursery in Jessore. The corms were then stored for 6 months keeping on the sand in a cool and dry place of the storeroom to get better quality flower and corm production.

2.4 Experimental design and layout

The two-factor experiment was laid out in a randomised complete block design (RCBD) with three replications. The treatments were applied randomly in the experimental plots. Thus, there were 42 unit plots (2 × 7 × 3) in total. The size of the plot was 1 m × 1 m, where the spacing was 30 cm × 30 cm. The spacing between unit plots was 0.50 m to facilitate different intercultural operations.

2.5 Land preparation and planting of corms

The experimental area was cleaned first and tilled three to four times thoroughly followed by clod breaking, levelling, and layout was prepared manually. The rested corms were placed at room temperature for 15 days before plantation. Corms were dipped at different doses of growth regulator solutions and tap water as control for 12 hours and shade dried. The shade-dried treated corms were planted at a depth of 5∼6 cm in raised beds in the month of October. Gladiolus was grown with all recommended cultivation practices throughout the experiment.

2.6 Preparation and application of PGRs

Desired quantities of GA3 were first dissolved in few drops of alcohol (C_2H_5OH) and made the volume up to 1 L of distilled water to prepare the proper concentrations of GA3. Then desired quantities of NAA were first dissolved in few drops of ammonium hydroxide and made the volume up to 1 L of distilled water to make the proper concentrations of NAA. Corms were then dipped in solution of plant growth regulators overnight as per the treatment concentration and shade dried before planting.

2.7 Data collection

The observations were recorded from nine plants under each plot on growth parameters *viz.* plant height (cm), number of leaves per plant, leaf length (cm), floral characters *viz.* days to first flowering, duration of flower (days), and quality traits *viz.* number of florets per spike, spike length (cm) and rachis length (cm).

2.8 Statistical analysis

The collected data on various parameters were analysed statistically using MSTAT computer programme. The means for all the treatments were calculated and analysis of variance was performed by F-test. The mean difference between a pair of treatments was evaluated by LSD at 5% level of significance.

3 Results and Discussion

3.1 Effect of corm size

The corm size had significant effects on plant height, number of leaves per plant, leaf length, days to first flowering, duration of flower, number of florets per spike, and spike and rachis length of gladiolus (Table 1). The higher plant height (76.76 cm) and greater number of leaves per plant (7.27) were found when 4.1∼5.0 cm sized corms were planted, whereas, the lower plant height (74.69 cm) and smaller number of leaves per plant (6.28) were found in 3.0∼4.0 cm sized corms. These might be due to more stored food materials in larger sized corms, which helped in early and rapid growth of the plant. The corm size 3.0∼4.0 cm gave the higher leaf length (46.67 cm), while the corm size 3.0∼4.0 cm gave the lower leaf length (44.77 cm).

The longer time for first flowering (67.19 d) was required for 3.0∼4.0 cm sized corms, while the corm size 4.0∼5.0 cm took the shorter time for first flowering (65.71 days). Time required for first flowering was found to be delayed gradually with the decrease in corm size (Uddin et al., 2002). The longer flower duration (11.81 d) was recorded with 4.1∼5.0 cm sized corms, while the shorter flower duration (11.19) was found with 3.0∼4.0 cm sized corms. Duration of flower was found to be increased with the increase in corm size.

The variation in number of florets per spike was statistically significant due to the corm size. The higher number of florets/spike (9.38) was obtained in the plants grown from 4.1∼5.0 cm sized corm and the lower number (8.49) from 3.0∼4.0 cm sized corm. This might be due to higher food reserve in the larger corm. The length of spike and rachis was increased significantly with the increase in corm size. The longer spike (62.04 cm) and rachis length (36.50 cm) were obtained when the 4.1∼5.0 cm sized corm was used. On the contrary, the shorter spike (60.96 cm) and rachis length (35.08 cm) were found in the 3.0∼4.0 cm sized corm. Previous findings also reported that large corms were superior in terms of number of shoots per corm, plant height, spike length, number of spikes, number of florets per spike and the diameter of corms produced (Singh, 1996; Syamal et al., 1987; Kalasareddi et al., 1998).

3.2 Effect of plant growth regulators

The data presented in Table 1, revealed that the growth and flowering parameters of gladiolus plants were significantly affected by pre corm soaking treatment of plant growth regulators (PGRs). The plant height, number of leaves per plant, leaf length, days to first flowering, duration of flower, number of florets per spike, spike length and rachis length were significantly increased due to GA3 and NAA application (Chopde et al., 2012; Awasthi et al., 2012). The tallest plant (86.87 cm) was recorded in GA3 @ 750 ppm, while the shortest plant (66.05 cm) was recorded under control. Taiz and Zeiger (1998) found that an application of GA3 increased cell division and cell elongation in plants resulting in more number of cells and increase in cell length which ultimately affected plant height in gladiolus. The treatment T3 (GA3 @ 750 ppm) produced maximum number of leaves per plant (8.05) followed by treatment T5 (NAA @ 200 ppm) and T2 (GA3 @ 500 ppm), respectively. The minimum numbers of leaves per plant (4.90) noticed with control. The increasing number of leaves per plant under the treatment of GA3 might be due to GA3 improves the physiological efficiency of the plant such as improvement of rate of photosynthesis, control of transpiration and photorespiration, efficient water and nutrient uptake, control of leaf senescence (Bhalla and Kumar, 2008). The longest leaf length (50.74 cm) was observed in GA3 @ 750 ppm, while the shortest leaf length (40.37 cm) was recorded under control. The GA3 increased the height of the plant and number of leaves per plant consequently. There was increase in the plant height with the increase in number of leaves.

Table 1. Individual effect of corm size and plant growth regulators on the growth, flowering and quality of gladiolus

Treatments	Plant height (cm)	No. of leaves plant^{-1}	Leaf length (cm)	Days to first flowering	Duration of flower (day)	No. of florets spike^{-1}	Spike length (cm)	Rachis length (cm)
Factor A: Corm size								
3.0∼4.0 cm	74.69	6.28	44.77	67.19	11.19	8.49	60.96	35.08
4.1∼5.0 cm	76.76	7.27	46.67	65.71	11.81	9.38	62.04	36.5
$LSD_{0.05}$	0.24	0.12	0.21	0.24	0.14	0.18	0.15	0.16
Level of significance	*	*	*	*	*	*	*	*
Factor B: Plant growth regulator								
Control	66.05	4.9	40.37	77.83	7.33	7.0	55.13	28.44
GA3 @ 250ppm	81.1	6.88	46.4	60.5	11.84	9.15	63.07	39.25
GA3 @ 500ppm	83.77	7.25	48.47	57.5	14.5	10.27	63.15	40.16
GA3 @ 750ppm	86.87	8.05	50.74	62.67	12.33	11.27	66.97	44.79
NAA @ 100ppm	68.97	6.3	43.07	77.5	10.67	7.64	58.87	32.47
NAA @ 200ppm	72.12	7.28	45.93	67.17	11.34	8.59	61.07	32.85
NAA @ 300ppm	71.18	6.75	45.05	62.0	12.5	8.67	62.23	32.6
$LSD_{0.05}$	0.46	0.22	0.39	0.46	0.26	0.34	0.29	0.29
Level of significance	*	*	*	*	*	*	*	*

Table 2. Combined effects of corm size and plant growth regulators on the growth, flowering and quality of gladiolus

Treatment combinations†	Plant height (cm)	No. of leaves plant^{-1}	Leaf length (cm)	Days to first flowering	Duration of flower (day)	No. of florets spike^{-1}	Spike length (cm)	Rachis length (cm)
C1T0	65.1	4.7	40.03	79.33	7.32	6.5	54.43	28.1
C1T1	80.17	6.47	45.11	61.0	11.0	8.47	62.17	38.43
C1T2	82.43	6.67	47.13	58.0	13.67	9.53	62.77	39.03
C1T3	83.9	7.4	49.85	63.33	12.33	10.53	65.67	44.3
C1T4	68.57	5.7	42.71	77.67	10.67	7.6	58.53	31.8
C1T5	71.9	6.77	44.8	68.0	11.0	8.5	60.93	32.23
C1T6	70.73	6.27	43.73	63.0	12.33	8.33	62.2	31.7
C2T0	67.0	5.1	40.7	76.33	7.33	7.5	55.83	28.77
C2T1	82.03	7.3	47.7	60.0	12.67	9.83	63.97	40.07
C2T2	85.1	7.83	49.8	57.0	15.33	11.0	63.53	41.3
C2T3	89.83	8.7	51.63	62.0	12.33	12.0	68.27	45.27
C2T4	69.37	6.9	43.43	77.33	10.67	7.67	59.2	33.13
C2T5	72.33	7.8	47.07	66.33	11.67	8.67	61.2	33.47
C2T6	71.63	7.23	46.37	61.0	12.67	9	62.27	33.5
$LSD_{0.05}$	0.65	0.3	0.55	0.64	0.37	0.48	0.4	0.41
Level of significance	*	*	*	*	*	*	*	*

† C1 = 3.0∼4.0 cm, C2 = 4.1∼5.0 cm, T0 = Control, T1 = GA3 @ 250 ppm, T2 = GA3 @ 500 ppm, T3 = GA3 @ 750 ppm, T4 = NAA @ 100 ppm, T5 = NAA @ 200 ppm, T6 = NAA @ 300 ppm

The results of the present findings are in conformity with the findings of Singh and Sharma (2004) in calendula. Early flowering was recorded in GA3 @ 500 ppm (57.50 d) which was found to be at par with GA3 @ 250 ppm (56.50 d), whereas, late flowering was recorded in control and NAA @ 100 ppm (77.83 and 77.50 d, respectively). GA3 application might be attributed to the enhanced growth early phase due to increased photosynthesis and CO_2 fixation. The late flowering by the application of NAA, which might have caused ethylene formation, is correlated with an inhibition of the growth instead of promoting the cell division (Baskaran and Misra, 2007).

GA3 @ 500 ppm was found the most effective in increasing the flowering duration (14.50 d) and it was minimum (7.33 d) in control. These results are in conformity with Sharma et al. (2004) and Baskaran and Misra (2007) in gladiolus. The highest number of florets/spike (11.27) was recorded in GA3 @ 750 ppm on par with GA3 @ 500 ppm, while the lowest number of florets/spike (7.0) was found in control. Gibberellic acid promotes the growth of auxiliary buds and their flowering. The longest spike (66.97 cm) and rachis (44.79 cm) were recorded in GA3 @ 750 ppm on par with GA3 @ 500 ppm (63.15 and 40.16 cm, respectively), while, the shortest spike (55.13 cm) and rachis length (28.44 cm) were found in control. This might be due to the enhanced growth rate of plant parts as influenced by GA3, which also increases the photosynthetic and metabolic activities causing more transportation and utilization of photosynthetic products (Chopde et al., 2012; Jinesh et al., 2010).

3.3 Combined effects of corm size and plant growth regulators

The combined effect of corm size and PGRs had significant influence on all the parameters under study *viz.* plant height, number of leaves per plant, leaf length, days to first flowering, duration of flower, number of florets per spike, spike length and rachis length (Table 2). The tallest plant (89.83 cm) was recorded with the combination of 4.1∼5.0 cm sized corm and GA3 @ 750 ppm followed by C2T2 (85.10 cm), while the shortest plant (65.10 cm) was found from the 3.0∼4.0 cm sized corm with control treatment (C1T0). Increase in plant height with 4.1∼5.0 cm sized corm and GA3 treatment might be due to the reservation of food materials and growth regulators effect on cell elongation. The maximum number of leaves per plant (8.70) was found when 4.1∼5.0 cm sized corms were pre soaked with GA3 @ 750 ppm, while, the minimum number of leaves per plant (4.70) was found in 3.0∼4.0 cm sized corm without any PGRs treatment (C1T0). The increase in number of leaves may be due to the increase in height and GA3 encourage the more growth in view of more number of leaves. Above findings are in close conformity with the findings of Dutta et al. (1998) in chrysanthemum. The highest leaf length (51.63 cm) was observed in the treatment combination of 4.1∼5.0 cm sized corm pre soaked with GA3 @ 750 ppm, followed by C1T3 (49.85 cm) and C2T2 (49.80 cm), respectively, while, the lowest length (40.03 cm) from 3.0∼4.0 cm sized corm with control treatment (C1T0). This might be due to the larger size corm and cell elongation effects of GA3 and NAA.

The longest time (73.33 d) was required by the treatment combination of 3.0∼4.0 cm sized corm with control and the shortest period (57.0 d) was found for the treatment combination of 4.1∼5.0 cm sized corm treated with GA3 @ 500 ppm. This might be due to the effects of GA3 on advanced bud formation and early flowering. The treatment combinations of 4.1∼5.0 cm corm size and GA3 @ 500 ppm were found to be most effective in increasing the flowering duration (15.33 d), while, it was minimum (7.32 d) in 3.0∼4.0 cm sized corm with control. The highest number of florets/spike (12.0 was obtained from the treatment combination of 4.1∼5.0 cm sized corms and pre soaking of GA3 @ 750 ppm, while the lowest number of florets/spike (6.50) was found in form 3.0∼4.0 cm sized corms with control. This might be due to the higher food reserve in the larger corm as well as influence of gibberellins on the development of the auxiliary buds and their flowering.

It was observed that the length of inflorescence stalk and rachis increased gradually with increasing corm size and GA3 concentrations. The longest spike (68.27 cm) and rachis (45.27 cm) were recorded in the treatment combination of 4.1∼5.0 cm sized corm pre soaked with GA3 @ 750 ppm, while, the shortest spike (54.43 cm) and rachis length (28.10 cm) were found in 3.0∼4.0 cm sized corm with control. This might be due to the large size of the corms and influence of higher concentration of GA3 which enhanced the growth rate of plant parts, which consequently increases the photosynthetic and metabolic activities causing more transportation and utilization of photosynthetic products (Chopde et al., 2012; Jinesh et al., 2010).

4 Conclusions

From the above results, it can be concluded that in respect of cultivation of gladiolus, pre soaking of 4.1∼5.0 cm sized corms with GA3 @ 750 ppm followed by 4.1∼5.0 cm sized corms with GA3 @ 500 ppm was most effective for enhancing growth, flowering and quality of gladiolus.

Conflict of Interest

The authors declare that there is no conflict of interests regarding the publication of this paper.

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