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GLADIOLUS GROWTH AND FLOWERING: IMPACT OF CHEMICALS AND PLANT GROWTH REGULATORS

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Abstract

To study the growth and flowering of gladiolus by using different chemicals and PGR, an experiment was conducted at the research field of the Department of Horticulture, Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur from September 2019 to May 2020. Medium sized (3.5-4.5 cm) corms of the variety BARI gladiolus-3 were planted at about 6-9 cm depth in a unit plot of 1.8 m X 1.2 m maintaining a spacing of 30 cm X 20 cm following Randomized Complete Block Design (RCBD) with 3 replications. Foliar spray with 3 levels of GA_3 (150, 200 and 250 ppm), 2 levels of KNO_3 (1 and 2%) and 2 levels of $Ca(NO_3)_2$ (1 and 2%) along with control (only tap water) was done at 30, 45 and 60 days after planting (DAP). Results revealed that although, the tallest plant (62.9 cm) was observed in T_3; where, GA_3 was applied at the highest concentration (250 ppm) but it was statistically at par with the height recorded in T_2 (60.7 cm) and T_4 (59.4 cm); where, GA_3 was applied @ 200 ppm and KNO_3 was applied @ 1%, respectively. Although, Spike length in T_3 (85.7 cm) varied statistically with T_2 (75.9 cm) but rachis length in T_3 (57.4 cm) was statistically similar with T_2 (56.8 cm). Floret length and breadth in T_2 (11.3 cm and 11.3 cm, respectively) were higher than T_3 (10.7 cm and 10.8 cm, respectively). Number of floret per spike was statistically similar in all treatments except T_4 (12.7) and T_7 (12.4). The highest leaf area was recorded in T_5 (189.5 cm^2); where, KNO_3 was applied @ 2% and this was statistically similar to all other treatments except T_6 (148.9 cm^2); where $Ca(NO_3)_2$ was applied @ 1%. On overall consideration, gibberellic acid (GA_3) @ 250 ppm may be used for better growth and flowering of gladiolus.

Keywords: Growth, flowering, gladiolus, chemicals, growth regulators.

Introduction

In Bangladesh, floriculture has emerged as a lucrative profession for higher income than most other fields and horticultural crops (Sultana, 2003). About 10,000 hectares of land is now devoted to flower cultivation in the country (Anon., 2016). Now-a-days, demand for flower is increasing very rapidly. Even the low to mid income groups love to present flowers on beautiful moments. Bangladesh is well suited for cut flower and ornamental production due to the favorable climatic and other conditions like cheap land, low labour cost, relatively low capital investment and

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high value addition (Dadlani, 2004) with good potentialities to become an important supplier of flower and ornamental plants for Asia, the Middle East and Europe (Momin, 2006).

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). Many studies have indicated that the application of different chemicals and growth regulators such as KNO_3, gibberellins (GA_3), 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, GA_3 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).

Increase in flower production and improvement of quality of spike can be achieved by following advanced techniques like use of plant growth regulators (Kumar *et al*., 2008). An increase in flower production and improvement of spikes quality like longer spikes and rachis in this crop can be achieved by application of plant growth regulators and chemicals. Although, we are producing gladiolus in Bangladesh but due to lack of these qualities we cannot enter in the world market. Hence, it is very much necessary to produce quality cut flowers of gladiolus. Research on gladiolus is scarce in Bangladesh and along with BARI other research based organization should come up immediately in the improvement and development of this crop. Realizing gladiolus as potential cut flower in the economy of Bangladesh, the present experiment was therefore, conducted to study the growth and flowering of gladiolus with different chemicals and plant growth regulators (PGRs).

Materials and Methods

The experiment was conducted at the research field of the Department of Horticulture, Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur from September 2019 to May 2020. Corms of the variety BARI gladiolus-3 was planted on November 03, 2019. The unit plot size was 1.8 m X 1.2 m. Medium sized (3.5-4.5 cm) corms were planted at about 6-9 cm depth in the plots maintaining a spacing of 30 cm X 20 cm. The experiment was set up following Randomized Complete Block Design (RCBD) with 3 replications. Manures and fertilizers were applied at the rate of cowdung- 10 t/ha, Urea- 300 kg/ha, TSP- 375 kg/ha, MoP- 300 kg/ha, boric acid- 12.0 kg/ha and zinc sulphate- 8.0 kg/ha (Azad *et al.,* 2017). Entire quantity of manures and fertilizers except urea were applied during final land preparation and mixed with soil. Half of urea was top dressed after 25 days of planting and rest half was applied during spike initiation stage. Different intercultural operations like irrigation, weeding, earthing up, stacking, pesticide and fungicide application were performed as and when needed. Foliar spray with GA_3 @ 150 (T_1), 200 (T_2) & 250 ppm (T_3); KNO_3 @ 1% (T_4) & 2% (T_5) and $Ca(NO_3)_2$ @ 1% (T_6) & 2% (T_7) was done at 30, 45 and 60 DAP to observe growth and flowering of gladiolus. In control (T_8) plots, only water was used. Procedures of preparation of different concentration of plant growth regulators (PGRs) and chemicals solutions were as follows:

Gibberellic acid solution (150, 200, 250 ppm)

One hundred fifty milligrams of gibberellic acid were dissolved in 10 ml of acetone and the volume was made upto 1 litre by adding distilled water to prepare 150 ppm solution of GA_3. Similarly, 200 mg and 250 mg of gibberellic acid was dissolved in acetone and volume made upto 1 litre by adding distilled water to prepare 200 ppm and 250 ppm solution, respectively.

Potassium nitrate solution (1 and 2%)

Ten grams of potassium nitrate were dissolved in 1 litre of distilled water to prepare 1% solution. Similarly, 20 g potassium nitrate was dissolved in 1 litre of distilled water to prepare 2% solution.

Calcium nitrate solution (1 and 2%)

Ten grams of calcium nitrate were dissolved in 1 litre of distilled water to prepare 1% solution. Similarly, 20 g calcium nitrate was dissolved in 1 litre of distilled water to prepare 2% solution.

The spikes were cut when lower one or two florets showed color but still in tight bud stage. The cut spikes were kept into water to study the vase life. Corms and cormels were harvested only when the leaves turned into brown colour. The collected data were statistically analyzed using computer MSTAT-C program. Mean separation was done by Duncan's Multiple Range Test (DMRT).

Results and Discussion

Results regarding performance of different chemicals and growth regulators on gladiolus are presented in Table 1-3.

Days to emergence, number of leaf, number of shoot, length and breadth of the longest leaf of gladiolus as influenced by different chemicals and plant growth regulators (PGRs) are presented in Table 1. Days to emergence in different treatments varied significantly. The lowest time was taken at the highest concentration of GA_3 @ 250 ppm (18.1 days) followed by KNO_3 @ 2% (18.2 days). The maximum days (21.6) for sprout emergence from soil was recorded when GA_3 was applied @ 150 ppm followed by GA_3 @ 200 ppm (20.1 days), KNO_3 @ 1% (20.2 days), $Ca(NO_3)_2$ @ 1% (20.3 days), $Ca(NO_3)_2$ @ 2% (19.9 days) and control (21.1 days). Variable effect of growth regulators on sprout emergence in gladiolus was reported by many authors. Patel *et al.* (2011) studied the effect of growth regulators on gladiolus and opined that GA_3 @ 50 mg/l took the minimum days for corm sprouting as compared to control (only tap water). Kalsi (2016) observed the effect of different growth regulators on gladiolus and reported that among the treatments, the minimum time to sprouting was observed with the application of gibberellic acid 200 ppm (11.8 days) followed by BA 100 ppm and 125 ppm (12.1 and 12.2 days, respectively) followed by gibberellic acid 100 ppm (12.6 days). Their results also indicated that the maximum time under control was 16.7 days, which was significantly higher than all treatments. The discrepancies between the result of present study and findings of Kalsi (2016) regarding time of emergence at GA_3

200 ppm might be due to the differences of soil, environment and genotypes. Number of leaves varied significantly due to different treatments. Although, the highest number of leaves were counted in the control (7.1) but it was statistically similar to all other treatments except KNO_3 @ 1% with an average of 6.8. Generally within GA_3 treatments, increased number of leaves per plant were recorded with increasing GA_3 concentration. Kumar and Singh (2005) as well as Padmalatha *et al.* (2013) also reported to have the highest number of leaves per plant by applying GA_3 @ 150ppm. Number of shoot among the treatments were found to be non-significant. However, the number of shoot per hill was the maximum (1.7) when KNO_3 was used @ 2% and all the shoots in this treatment were effective *i.e,* produced flower spike. The average number of shoot per hill was recorded as 1.5. Number of shoot per hill in GA_3 treatments were equal or less than number produced in control treatments, which meant the less or no response of the character to GA_3. Jinesh *et al.* (2010) and Prodhan (2014) also signposted less response of GA_3 to number of shoot per hill in their reports, which was in close conformity with the present findings. Significant difference was observed in length of the longest leaf. The highest leaf length was measured when KNO_3 was used @ 1% (51.1 cm) and it differed with all other treatments. Similarly, the breadth of the leaf was found to be varied significantly among the treatments. The largest leaf breadth (4.1 cm) was recorded in the treatment where $Ca(NO_3)_2$ was used @ 2% and it was statistically similar all other treatments except GA_3 @ 250 ppm (3.3) and KNO_3 @ 1% (3.3 cm). The average length and breadth were recorded as 45.4 cm and 3.8 cm, respectively (Table 1). Significantly the maximum plant height, leaf length and number of leaves per plant were registered with the same treatment (GA_3 50 mg/l) compared to control as reported by Patel *et al*. (2011). Whereas, Sharma *et al.* (2006)

Table 1. Days to emergence, number of leaf, length and breadth of the longest leaf of gladiolus as influenced by chemicals and PGRs

Treatment	Days to emergence	Number of leaves/plant	No. of shoot/ hill	Leaf	
				Length (cm)	Breadth (cm)
T_1= GA_3- 150 ppm	21.6 a	6.8 ab	1.5	45.4 d	3.9 a
T_2= GA_3- 200 ppm	20.1 ab	7.0 a	1.5	44.9 d	4.0 a
T_3= GA_3- 250 ppm	18.1 b	7.0 a	1.3	41.3 e	3.3 b
T_4= KNO_3- 1%	20.2 ab	6.2 b	1.1	51.1 a	3.3 b
T_5= KNO_3- 2%	18.2 b	6.9 ab	1.7	47.4 c	4.0 a
T_6= $Ca(NO_3)_2$- 1%	20.3 a	6.9 ab	1.2	39.2 f	3.7 ab
T_7= $Ca(NO_3)_2$- 2%	19.9 ab	6.7 ab	1.8	48.3 b	4.1 a
T_8= Control	21.1 a	7.1 a	1.5	45.4 d	3.9 a
Mean	19.9	6.8	1.5	45.4	3.8
CV (%)	5.4	5.4	10.6	9.6	11.5

Means followed by same letter in a column do not differ significantly at 5% level by DMRT.

reported to have the maximum plant height, number of leaves per plant, leaf length and width with GA_3 at 200 ppm in Red Beauty cultivar. Manasa *et al*. (2017) reported to have the maximum plant height, leaf length and leaf width with GA_3 at 150 ppm. Tawar *et al.* (2002) reported to have increased plant height, number of leaves per plant, leaf length and other characters with increasing doses of IAA, BA and GA_3 up to 250 ppm.

Plant height in gladiolus is important as it determines lodging of the crop. Longer plant tends to be lodged and needs to be staked essentially. Although, plant height was found to be varied significantly among the treatments but medium sized plants were observed in all treatments. The tallest plant (62.9 cm) was observed in T_3 (GA_3 @ 250 ppm). Plant height at this concentration was statistically at par to the heights recorded in T_2 (60.7 cm) and T_4 (59.4 cm); where, GA_3 @ 200 ppm and KNO_3 was applied @ 1%, respectively. In GA_3 treatments, plant height was found to be increased with the increase of dose. Reasons behind the enhanced plant height with increased level of GA_3 might be because of increase in the endogenous level of gibberellin in different phases of growth and development of plants which promotes vegetative growth by inducing active cell division and cell elongation in the apical meristem (Sharma *et al.,* 2004). Another probable reason of significant increase in plant height might be due to the effect of gibberellins on photosynthetic activity resulted in efficiently utilizing photosynthetic products by the plants. These findings are in consonance with the reports of Umrao *et al*. (2007), Kumar *et al.* (2008) and Chopde *et al*. (2012) in gladiolus. However, the lowest plant height (55.4 cm) was recorded in the treatment T_6; where $Ca(NO_3)_2$ was applied @1%. Plant height in most of the treatments was ranged from 55-60 cm, implied the medium sized plants (Fig. 1).

For spike initiation, the minimum days was recorded by T_1 (56.5 days) in GA_3 @ 150 ppm and was very close to T_5 (57.8 days); where, KNO_3 was applied @ 2%. Except these two treatments, more than 60 days were required for spike initiation. In GA_3 treatments, days taken to spike initiation was found to be increased with the increase of dose. Spike length was measured the highest (85.7 cm) in T_3 (GA_3 @ 250 ppm) and this was statistically similar to T_5 (79.8 cm), T_6 (78.2 cm) and T_7 (77.8 cm). Similar responses were recorded among the treatments for rachis length. The increased spike length in T_3 (GA_3 @ 250 ppm) treatment might be due to rapid internodal elongation, rapid cell division and cell elongation in the intercalary meristem. The increase in rachis length might be due to increased activity of growth promoting enzymes by synthesizing more nucleic acid and other compounds (Ashwini *et al*., 2019). In all treatments except KNO_3 @ 1% and $Ca(NO_3)_2$ @ 2%, more than 50.0 cm rachis length was recorded (Table 2). Length and breadth of floret in the treatments did not vary significantly. Sharma *et al.* (2006) reported significant effect of gibberellic acid on the spike length, number of florets per spike, rachis length, floret length and recorded the maximum values with GA_3 at 200 ppm in Red Beauty cultivar of gladiolus. Padmalatha *et al.* (2013) recorded the maximum spike length, number of florets per spike and spike field life in gladiolus with GA_3 @ 150 ppm. Tawar *et al.* (2002) reported the increased

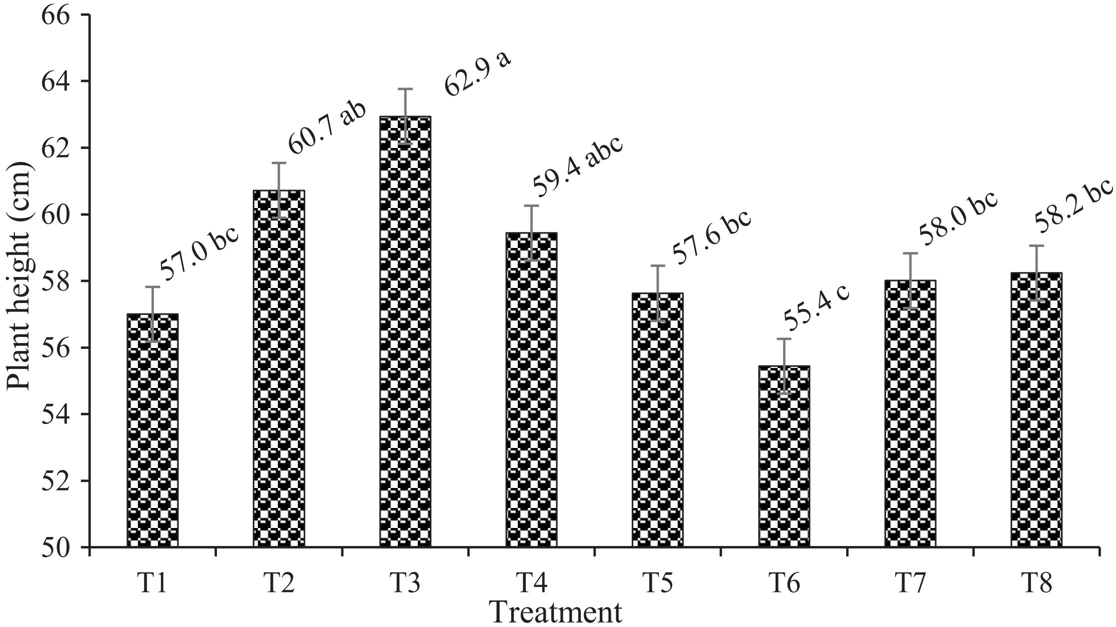

Fig. 1. Plant height of gladiolus at spike initiation stage with chemicals and PGRs. (T_1= GA_3- 150 ppm, T_2= GA_3- 200 ppm, T_3= GA_3- 250 ppm, T_4= KNO_3- 1%, T_5= KNO_3- 2%, T_6= $Ca(NO_3)_2$- 1%, T_7= $Ca(NO_3)_2$- 2% and T_8= Control.)

Table 2. Days to spike initiation, spike length, rachis length, floret length and breadth of gladiolus as influenced by chemicals and PGRs

Treatment	Days to spike initiation	Spike length (cm)	Rachis length (cm)	Floret	
				Length (cm)	Breadth (cm)
T_1= GA_3- 150 ppm	56.5 c	73.5 b	53.7 abc	11.8	11.5
T_2= GA_3- 200 ppm	61.8 abc	75.9 b	56.8 a	11.3	11.3
T_3= GA_3- 250 ppm	62.0 abc	85.7 a	57.4 a	10.7	10.8
T_4= KNO_3- 1%	64.7 ab	75.2 b	48.7 cd	11.2	11.1
T_5= KNO_3- 2%	57.8 bc	79.8 ab	55.4 ab	11.2	11.3
T_6= $Ca(NO_3)_2$- 1%	66.9 a	78.2 ab	53.9 abc	10.9	11.0
T_7= $Ca(NO_3)_2$- 2%	61.4 abc	77.8 ab	46.1 d	11.1	11.3
T_8= Control	61.1 bc	75.1 b	50.4 bcd	10.8	11.1
Mean	61.5	77.6	52.8	11.1	11.2
CV (%)	9.5	16.4	8.7	8.8	5.6

Means followed by same letter in a column do not differ significantly at 5% level by DMRT.

spike length, rachis length, number of florets per spike, spike weight and other characters with increasing dose of IAA, BA and gibberellic acid up to 250 ppm. From another study, Kumar and Singh (2005) reported that GA_3 (50, 100 and 150 ppm) and ethrel (250, 500 and 750 ppm) at higher doses enhanced number of leaves per plant, plant height, days to spike emergence, flowering duration, number of flowers per spike, spike length, number of corms per plant, corm diameter and corm. Padmalatha (2011) reported the effect of foliar sprays of other chemicals and growth regulators like SA @ 150 ppm, BA @ 100 ppm and $Ca(NO_3)_2$ on different characters of gladiolus.

Number of floret per spike of gladiolus after applying different chemicals and growth regulators was found to be varied statistically (Fig. 2). The highest number of floret per spike was recorded in T_5 (14.7) and T_6 (14.7). These values of number of florets per spike were statistically similar to all other treatments except T_4 (12.7) and T_7 (12.4). Number of floret per spike among the treatments ranged from 12.4- 14.7. In GA_3 treatments, number of floret was found to be increased with the increase of dose. Sable *et al.* (2015) recorded the maximum floret per spike (13.4) in GA_3 at 200 ppm. Sharma *et al.* (2006) also reported that gibberellic acid significantly affected number of florets per spike in gladiolus and they counted the maximum number of floret with GA_3 at 200 ppm in Red Beauty cultivar of gladiolus. Gupta *et al.* (2006) reported to have the maximum number of florets per spike (18.0) with GA_3 @ 200 ppm. Application of

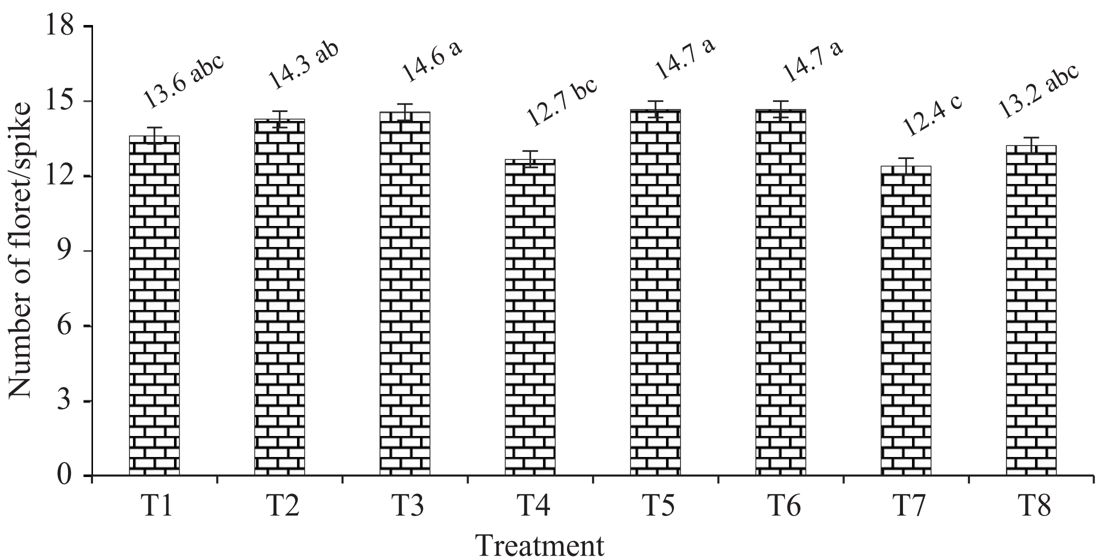

Fig. 2. Number of floret per spike in gladiolus with chemicals and PGRs. (T_1= GA_3- 150 ppm, T_2= GA_3- 200 ppm, T_3= GA_3- 250 ppm, T_4= KNO_3- 1%, T_5= KNO_3- 2%, T_6= $Ca(NO_3)_2$- 1%, T_7= $Ca(NO_3)_2$- 2% and T_8= Control.)

GA_3 at 200 ppm resulted in maximum number of florets/spike in cv. Snow Princess followed by GA_3 at 100 ppm in cv. Snow Princess observed by Neetu *et al*. (2013). Umrao *et al.* (2007) reported that the number of florets per spike was maximum (14.20) with 400 mg/l of GA_3.

The duration of flowering in the field was found to be varied in the treatments. Flowers in plants treated with GA3 at 250 ppm lasts for the maximum (15.2 days) period and it was statistically different from the flowers in other treatments. The minimum flowering duration (11.4 days) was observed in control (Fig. 3). GA3 increases the photosynthetic and metabolic activities causing more transportation and utilization of photosynthetic products, which might have helped the spikes to last longer on plant in the field. These results are in conformity with Baskaran and Misra (2007), Aier *et al.,* (2015) and Chopde *et al.,* (2015) in gladiolus.

The Soil Plant Analysis Development (SPAD) chlorophyll meter is one of the most commonly used optical methods for measuring leaf chlorophyll content to specify the relative leaf chlorophyll content, but not absolute chlorophyll content or concentration (Richardson *et al*., 2002). This numerical SPAD value is linearly and positively correlated to actual leaf chlorophyll content within the sample leaf. The SPAD values in different dates did not differ significantly among the treatments. However, in GA_3 treatments, SPAD values were found to be decreased with increase of concentration. The mean SPAD value at 90 days measured the highest (72.1) than at 60 days (64.1) or

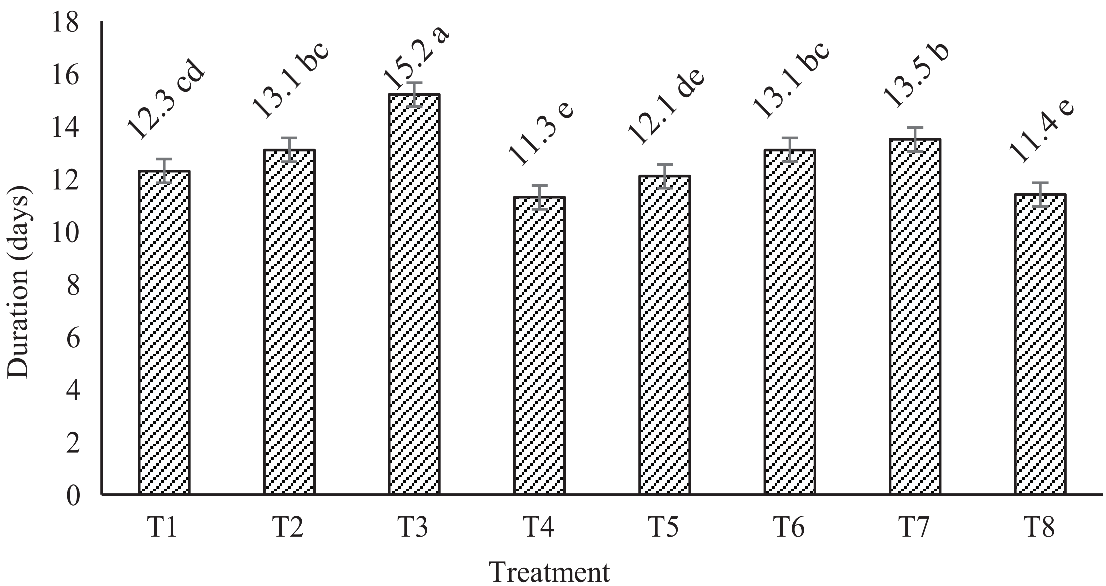

Fig. 3. Duration of gladiolus flowering in field with chemicals and PGRs. (T_1= GA_3- 150 ppm, T_2= GA_3- 200 ppm, T_3= GA_3- 250 ppm, T_4= KNO_3- 1%, T_5= KNO_3- 2%, T_6= $Ca(NO_3)_2$- 1%, T_7= $Ca(NO_3)_2$- 2% and T_8= Control.)

Table 3. SPAD value and leaf area of gladiolus as influenced by chemicals and PGRs

Treatment	SPAD value at			Leaf area (cm^2)
	60 days	90 days	120 days	
T_1= GA_3- 150 ppm	66.1	72.4	76.4	164.4 ab
T_2= GA_3- 200 ppm	63.8	66.4	69.3	175.4 a
T_3= GA_3- 250 ppm	61.6	68.4	66.0	164.6 ab
T_4= KNO_3- 1%	59.7	75.7	69.0	174.6 a
T_5= KNO_3- 2%	63.8	75.6	68.7	189.5 a
T_6= $Ca(NO_3)_2$- 1%	66.8	71.2	67.5	148.9 b
T_7= $Ca(NO_3)_2$- 2%	65.6	72.1	66.9	177.4 a
T_8= Control	70.4	75.2	72.5	170.1 ab
Mean	64.1	72.1	68.7	170.6
CV (%)	7.8	13.7	9.9	11.1

Means followed by same letter in a column do not differ significantly at 5% level by DMRT.

120 days (68.7). Different authors reported to have significant effect of different chemicals and growth regulators on chlorophyll content of gladiolus (El-Naggar, 1999; Sajid *et al*., 2015). Faraji *et al*. (2011) opined that GA_3 treatment retards chlorophyll degradation and helps in retaining high leaf chlorophyll content in gladiolus. Statistically significant differences regarding leaf area among the treatments was observed. The highest leaf area was recorded in T_5 (189.5 cm^2); where, KNO_3 was applied @ 2% and this was statistically similar to all other treatments except T_6 (148.9 cm^2); where $Ca(NO_3)_2$ was applied @ 1% (Table 3). Variation in leaf area with different PGR and chemicals was reported by Kumar *et al*. (2002). Among the GA_3 treatments, the maximum leaf area was observed when GA_3 was applied @ 200 ppm (175.4 cm^2). Kalsi (2016) recorded the maximum leaf area of 57.3 cm^2 when GA_3 was applied @ 200 ppm. Gupta *et al.* (2006) also recorded the maximum leaf area of 159.22 cm^2 from GA_3 @ 200 ppm. Sharma *et al.* (2006) also recorded the maximum leaf area in Red Beauty cultivar of gladiolus with the same level of GA_3. Sable *et al.* (2015) also recorded the maximum leaf area (86.05 cm^2) in their experiment; while, foliar application of GA_3 was done @ 200 ppm. Results of these reports confirmed the integrity of the present findings. But Padmalatha *et al.* (2013) and Manasa *et al.* (2017) recorded the maximum leaf area with GA_3 at 150 ppm. These discrepancies might be attributed due to soil, climatic as well as cultivar variations. Kumar *et al.* (2002) applied GA_3 on gladiolus by dipping corms in it and spraying at 40, 65, 90 days after planting. They also indicated the effects of GA_3 on leaf area and other characters in their report.

Conclusion

Foliar spray of gibberellic acid (GA_3) @ 250 ppm was found to be effective in increasing spike length, rachis length and duration of flowering in field. Therefore, GA_3 @ 250 ppm may be used for better growth and flowering of gladiolus. But before recommendation, economic analysis should be done as GA_3 is an expensive PGR.

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