INFLUENCE OF DROUGHT AND FOLIAR APPLICATION OF SALICYLIC ACID ON GROWTH AND DEVELOPMENT OF GLADIOLUS

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Abstract

Salicylic acid increase resistance in plants to overcome both biotic and abiotic stresses. Therefore a study was conducted to investigate the effect of drought and foliar application of salicylic acid on growth and development of Gladiolus grandiflorus L at University of Swabi, Khyber Pakhtunkhwa, Pakistan during spring 2019. Two factorial Completely Randomized Design (CRD) was used having three replications. Salicylic acid with levels (0, 40, 80 and 120 ppm) and drought with intensities (no stress, mild stress and severe stress of field capacity water volume) were tried on gladiolus crop. Drought was induced to main plots whereas; salicylic acid was applied to plants in subplots. Bulbs were sown in pots having dimensions 230 × 240 × 240 mm in a polytunnel and then normal practices were carried out for 45 days from plantation date. After that, control pots were irrigated with 3 days, mild stress with 6 days and severe stress with 9 days interval. Salicylic acid was prayed on 30th, 45th and 60th day after planting. Results disclosed that salicylic and droughts have significantly affect gladiolus growing attributes while their interaction was significant for plant height, leaf length and spike length. Maximum plant height, rachis length, number of leaves plant^{-1}, leaf length, leaf area, spike length, number of florets plant^{-1}, flower diameter and spike diameter were recorded in control plants as compared to mild and severe stressed plants. All the selected parameters recorded maximum results when plants were treated with 120 ppm of salicylic acid. It can be concluded that foliar application of salicylic acid at 120 ppm concentration should be sprayed during dry spell of gladiolus growth period.

Keywords: *Gladiolus, salicylic acid, drought, growth, flower attributes*

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INTRODUCTION

Gladiolus (*Gladiolus grandiflorus* L.) is a perennial herbaceous flowering bulbous plant, primarily used as a cut flower throughout the globe. There are more than 260 species, in which some 250 species are native to Africa (Goldblatt and Manning, 1998; Goldblatt and Manning, 2008). It is a member of the family Irridaceae, most species are diploids and are indigenous to South Africa. However, polypoid species belong to central Africa and Euro-Asiatic region [Tamberg, 1967]. Its leaves are sword like that ranges from 1 to 10 in numbers depending upon the species. Florets of gladiolus plant are present on a spike which varies in quantity with the type of cultivar. Gladiolus is cultivated and propagated asexually through corms on commercial scale. However, it is also propagated through seed for breeding purpose. A corm which is actually an underground stem provide nutrient during the whole life cycle (Ghamsari *et al*. 2007).

Gladiolus has a vital role in the industry of cut flower throughout the world. Floriculture sector of Pakistan has a good potential to uplift country's economy. Farmers are changing their approach from agronomic cropping system to floriculture in Pakistan due to its high profitability. During 2004-05, about 37% of farmers moved from ordinary cropping to floriculture (Riaz *et al.* 2007). Following roses, gladiolus is Pakistan's 2nd most popular cut flower. The production of cut flower in Pakistan ranges from 10 to 12 thousand tons annually and its market value is boosting day by day (Rehman, 2004). Gladiolus is more popular in terms of cultivation and utilization in the local markets. The suitable agro ecological conditions of Pakistan highly promote the cultivation of gladiolus. However lack of farm mechanization, farmers in Pakistan faces various problems regarding gladiolus cultivation. Corms of gladiolus experience dormancy for some period of time therefore the corms can be stored for next season at low temperature. Most of the farmers are unaware of corms storage as proper temperature and humidity is very crucial to prevent corms from deterioration (Ahmad, 2008).

Optimal water availability is the important and main factor promote plant growth and performance. In harsh conditions, plant changes itself morphologically, physiologically and biochemically to escape, avoid or tolerate water shortage (Basu *et al*. 2016). Severe moisture stress affect the chlorophyll content and hence vegetative growth and development is restricted (Lin *et al.* 2015). Leaf chemical composition undergoes changes due to moisture stress. Water stress also affect the production of specific phenolic acids compounds in order to save the photosynthetic apparatus (Hura *et al*. 2009). Moisture stress slow down photosynthetic activity initially due to the decrease in leaf area and rate of photosynthesis (Basu *et al*. 2016). The major factor that limit the growth in arid zones is the reduction in water resources. During water scarce conditions, plant growth may be maintained by adopting such practices that can improve drought resistance. Drought is an important factor responsible to limit photosynthesis and plant growth that can ultimately affect crop production (Flexas *et al*. 2004).

Salicylic acid (SA) regulates plant growth, accelerates germination of seed and improves fruit yield, flowering and physiological processes (Shafiee *et al*. 2010). It has gained interest from plant biologists over the last 20 years because of its tendency to induce systemically gained resistance in crops to various pathogens, which is reflected in the appearance of pathogenesis-related proteins, while SA is regarded as a signal molecule in the evolution of the expression of these genes (Shakirova *et al*. 2003). Salicylic acid plays a vital function in the promotion of growth and initiation of stress resistance in plants; affect numerous physiological developments like stomatal closure, somatic embryogenesis, flower initiation, root growth and thermogenesis, (Larque, 1978; Raskin *et al*. 1987; Gutiérrez-Coronado, 1998). Application of Salicylic acid is not just promoting the operation of induction in angiosperms (Raskin, 1992) but as well, they have positive influence on chlorophyll level, photosynthetic activity of plant and it boosts mineral absorption by plants growing under stress environments (Karlidag, 2009). According to [Ram *et al*. 2012) exogenous application of SA improved most of the parameters of gladiolus plants. (Kang *et al*. 2013) observed that SA @100 ppm improves growth parameters like leaf length, numbers of leaves, spike length etc. Growth parameters like fresh mass, dry mass and root length were improved significantly after the application of salicylic acid (Kang *et al*. 2013).

In tropical and subtropical regions, plant growth and production are severely limited by a lack of water. In recent past, scientists have started research to develop new techniques and crop management practices in order to minimize the adverse effect of stress by drought on plant growth and production. The current study has been designed to achieve the following objectives.

Objectives:

- To study the performance of gladiolus under various levels of drought.
- To check the performance of gladiolus under various levels of salicylic acid.
- To evaluate the interaction between salicylic acid and drought on growth and reproductive attributes of gladiolus.

MATERIALS AND METHODS

The experiment entitled "Influence of drought and foliar application of Salicylic acid on growth and development of Gladiolus *grandiflorus* L'' was conducted at the Horticulture Research Farm, University of Swabi during Spring, 2019. The experiment was design as two-factor factorial Complete Randomized Design (CRD) with three replications. Gladiolus corms were sown in pots having dimensions of 230 × 240 × 240 mm and total 288 pots were used in the experiment. Potting media was comprised of 20% compost, 30% silt, 30% sand and 20% clay. Corms were planted 5 cm deep in pots and then irrigated immediately. Four levels of salicylic acid (0, 40, 80 and 120 ppm) and three levels of water stress (control, mild stress and severe stress of field capacity water volume) were applied to gladiolus. Water stress were applied to main plots while salicylic acid was applied to plants in subplots. Routine irrigation was given to all potted plants up to 45 days from the date of sowing. However, after 45 days, water stress was given to main plots at the given intervals and concentrations. Control was irrigated with 3 days, mild stress with 6 days and severe stress with 9 days interval. Salicylic acid was also sprayed on 30^{th}, 45^{th} and 60^{th} day of planting. Polytunnel was oriented on 400 m^2 area from east to west with a ceiling height of 13.5 feet and was covered with thin transparent plastic sheet. A thermo-hygrometer was installed inside the tunnel to measure maximum and minimum humidity and air temperature. In order to evaluate the growth performance of gladiolus, data was recorded on plant height, number of leaves plant^{-1}, number of florets spike^{-1}, flower diameter, spike length, rachis length, spike diameter, leaf area (via ADC leaf area meter) and leaf length

RESULTS

There was a significant variation in plant height of gladiolus plants in response to drought, salicylic acid levels, and their interaction Table 1. It is obvious from the mean table that plant height of gladiolus was significantly decreased with the increase in drought. The maximum plant height (71.02 cm) was observed in control plants, followed by plant height (70.75 cm) in plants that experienced mild stress. However, minimum plant height (68.87 cm) was recorded in plants under severe drought. The tallest plants (71.51 cm) were observed in the plot received 120 ppm of SA, followed by 70.93 and 69.94 cm in plants that received 80 ppm and 40 ppm of SA respectively. The shortest plant height (68.47 cm) was recorded in control plants. The interaction of water stress and exogenous application of SA had a significant effect on plant height of gladiolus plants as shown in Figure 1. Maximum plant height (73.4 cm) was observed in plants that received 120 ppm of SA under mild drought, however, the least plant height (67.33 cm) was observed in plants that were treated with severe drought in the control plot. Data pertaining to rachis length is given in Table 2, which reveals that rachis length of gladiolus was significantly affected by drought and salicylic acid, however, the interaction of drought and salicylic acid had a non-significant effect on rachis length of gladiolus plant. The maximum rachis length (21.04 cm) was exhibited by control plants, followed by plants grown at mild stress conditions (20.85 cm). However, minimum rachis length rachis (18.29 cm) was recorded in plants under severe drought. Statistical analysis regarding impact of exogenous application of SA on rachis length reveals that salicylic acid (SA) had significantly afftected the rachis length of gladiolus. The tallest plants (21.86 cm) were observed that received 120 ppm SA, followed by 20.58 and 19.44 cm taller plants that received 80ppm and 40 ppm of SA respecively however, the minimum rachis length (18.34 cm) was recorded in control plants.

The means data in Table 3 revealed that there was a significant effect of water stress and Salicylic Acid (SA) on the number of leaves, however, their interaction had a non-significant effect on number of leaves. It is clear from the mean data that number of leaves of gladiolus plant were significantly decreased with the increase in drought.The maximum number of leaves (5.93) was produced by control plants, followed by plants (5.79) under mild stress. However, the least number of leaves (4.71) were recorded in plants grown under severe drought condition. The maximum number of leaves (6.27) were observed in plot that received 120 ppm SA, followed by 6.13 and 5.21 in plants received 80 ppm and 40 ppm of SA respectively while the minimum number of leaves (4.29) was recorded in control plants. The mean data regarding leaf length as affected by water stress and salicylic acid are given in Table 4. The statistical analysis reveals that there was a significance variation found in leaf length of gladiolus plants in respect to drought, salicylic acid and their interaction. The maximum leaf length (41.00 cm) was observed in control plants, followed by mild stress (40.53 cm). However, minimum leaf length (36.51 cm) was recorded in plants under severe drought. Maximum leaf length (41.69 cm) was observed in plots, received 120 ppm SA, followed by 40.02 and 38.62 cm in plants, received 80 ppm and 40 ppm of SA respectively however, the minimum leaf length (37.05 cm) was recorded in control plants. The interaction of water stress and exogenous application of SA had a significant effect on leaf length of gladiolus plants as shown in Figure 2. The means table reveals that the maximum leaf length (23.56 cm) was observed in plants that received 120 ppm of SA under mild drought, however, the least leaf length (16.70 cm) was recorded in plants that were treaded with severe drought in control plot.

The means data in Table 5 revealed that there was a significant effect of drought and salicylic acid on the leaf area, however, their interaction had a non-significant effect on leaf area. Table 5 revealed that leaf area of gladiolus plants was significantly decreased with the increase in water stress. The maximum leaf area (77.58 cm^2) was exhibited by control, followed by mild stress (77.21 cm^2). However, the minimum leaf area (72.64 cm^2) was recorded in plants under severe drought. Maximum leaf area (80.08 cm^2) was observed in plot received 120 ppm SA, followed by 76.64 and 74.65 cm^2 in plants received 80 ppm and 40 ppm of SA respectively while minimum leaf area (71.67 cm^2) was recorded in control.

Table 1. Plant height (cm) of gladiolus plant as affected by water stress and salicylic acid

Water stress	**Salicylic acid (ppm)**				**Mean**
	0	**40**	**80**	**120**	
Control	70.00 def	70.567 cde	71.13 bcd	72.40 ab	71.02 a
Mild stress	68.10 gh	69.50 efg	72.00 abc	73.40 a	70.75 a
Severe stress	67.33 h	69.77 def	69.67 defg	68.73 fgh	68.87 b
Mean	68.48 c	69.94 b	70.93 a	71.51 a	

Table 2. Rachis length cm of gladiolus plant as affected by water stress and salicylic acid.

Water stress	**Salicylic acid (ppm)**				**Mean**
	0	**40**	**80**	**120**	
Control	19.63	20.50	21.30	22.73	21.04 a
Mild stress	18.70	19.60	21.53	23.56	20.85 a
Severe stress	16.70	18.23	18.93	19.30	18.29 b
Mean	18.34 c	19.44 bc	20.58 ab	21.867 a	

Table.3 Number of Leaves of gladiolus plant as affected by water stress and salicylic acid.

Water stress	**Salicylic acid (ppm)**				**Mean**
	0	**40**	**80**	**120**	
Control	4.88	5.56	6.49	6.77	5.93 a
Mild stress	4.10	5.20	6.63	7.23	5.79 a
Severe stress	3.90	4.88	5.26	4.80	4.71 b
Mean	4.29 c	5.21 b	6.13 a	6.27 a	

Table.4 Leaf length cm of gladiolus plant as affected by water stress and salicylic acid.

Water stress	**Salicylic acid(ppm)**				Mean
	0	**40**	**80**	**120**	
Control	38.70 cd	39.77 bc	41.57 b	43.96 a	41.00 a
Mild stress	36.79 de	39.90 bc	41.33 b	44.10a	40.53 a
Severe stress	35.68 e	36.20 e	37.16 de	37.00 de	36.51 b
Mean	37.05 d	38.62 c	40.02 b	41.69 a	

Table.5 Leaf area cm^2 of gladiolus plant as affected by water stress and salicylic acid

Water stress	**Salicylic acid(ppm)**				**Mean**
	0	**40**	**80**	**120**	
Control	74.63	76.06	77.50	82.13	77.58 a

Mild stress	71.00	76.13	78.39	83.33	77.21 a
Severe stress	69.40	72.26	74.03	74.79	72.64 b
Mean	71.67 c	74.85 b	76.64 b	80.08 a	

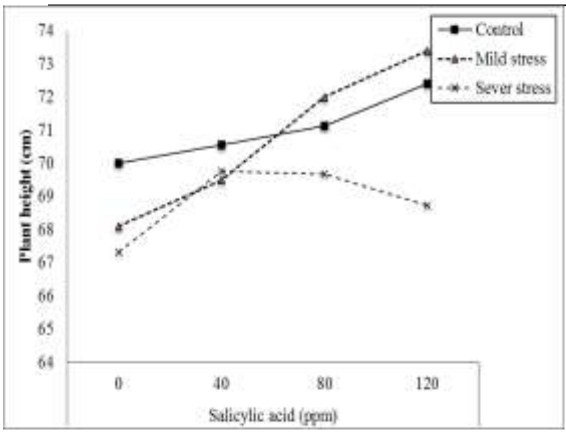

Fig.1 Interactive effect of drought and salicylic acid on plant height of gladiolus

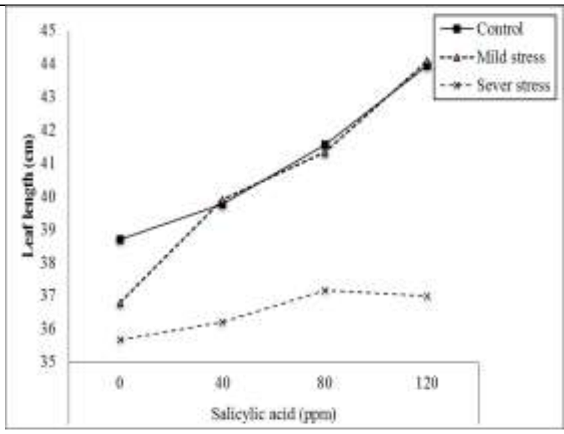

Fig.2 Interactive effect of water stress and salicylic acid on leaf length of gladiolus

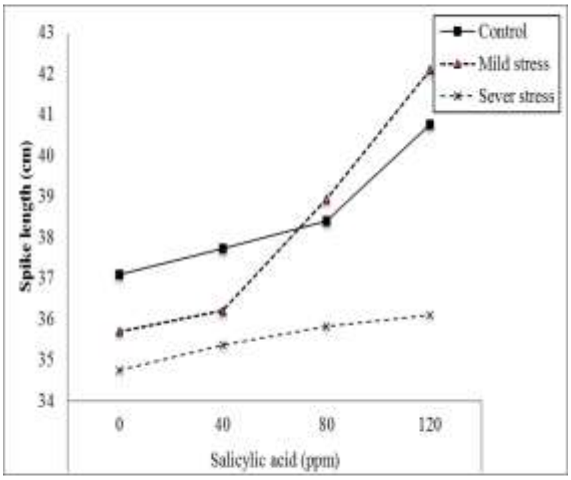

Fig.3 Interactive effect of drought and salicylic acid on spike length of gladiolus

The mean values in Table 6 pertaining to spike length shows that a significant variation in spike length of gladiolus in relation to drought, salicylic acid and their interaction. The spike length of gladiolus plant was significantly decreased with the increase in drought. The maximum spike length (38.50 cm) was observed in control plants, followed by mild stress (38.23 cm). However, the minimum spike length (35.51 cm) was recorded in plants grown under severe drought. The tallest spike length of plants (39.65 cm) were observed in plot received 120 ppm of SA, followed by 37.72 and 36.43 cm in plants received 80 ppm and 40 ppm of SA respectively. The shortest spike length (35.85 cm) was recorded in control plants. The interaction of water stress and exogenous application of SA signifcantly affected the spike length of gladiolus plants as shown Figure 3. The means table reveals that the maximum spike length (42.10 cm) was observed in plants that received 120 ppm of SA under mild drought, however, the least spike length (34.76 cm) was observed in plants that were grown without SA application under severe drought condition. Mean data collected for number of florets plant^{-1} of gladiolus at different water stresses and foliar application of salicylic acid are presented in Table 7. The means table revealed a significance variation in number of florets in gladiolus plants in relation to Salicylic Acid (SA) and drought levels, however, there was a non-significant effect of salicylic acid × drought on number of florets of gladiolus. It is obvious from the means Table 7 that plant number of florets of gladiolus plant was significantly decreased with the increase in drought.The maximum number of florets (5.42) was exhibited by control, followed by mild stress (5.30). However, Minimum number of florets (4.44) was recorded in plants under severe drought. Maximum number of florets (5.97) was observed in plot received 120 ppm SA, followed by 5.30 and 4.73 in plants received 80 ppm and 40

ppm of SA respectively while, the minimum number of florets (4.22) was recorded in control.
Data regarding flower diameter is given in Table 8. The data revealed that there was a significant effect regarding flower diameter of gladiolus due to drought and salicylic acid. However the interaction of drought with salicylic acid had a non-significant effect on flower diameter of gladiolus plant. It is obvious from the means table that flower diameter of gladiolus plant was significantly decreased with the increase in drought. The maximum floret diameter (46.05 mm) was observed in control plants, followed by mild stress (45.88 mm). However, Minimum floret diameter (43.33 mm) was recorded in plants grown in severe drought. The maximum flower diameter (47.05 mm) was observed in plot received 120 ppm of SA, followed by 45.77 and 44.78mm in plants received 80 ppm and 40 ppm of SA respectively. The minimum (42.74 mm) florest diameter was recorded in untreated plants.
Means data regarding spike diameter as affected by water stress and foliar application of salicylic acid are presented in Table 9. The means table reveals a significance variation in spike diameter of gladiolus plants in relation to salicylic acid and drought levels, however, there interaction had a non-significant effect regarding spike diameter. It is clear from the recorded data that spike diameter of gladiolus plant had significantly decreased with the increase in drought. The maximum spike diameter (5.44 mm) was observed in control plants, followed by mild stress (5.03 mm). However, Minimum spike diameter (3.3 mm) was recorded in plants under severe drought. The maximum spike diameter (5.26 mm) was observed in plot received 120 ppm of SA, followed by 4.85 and 4.35 mm in plants received 80 ppm and 40 ppm of SA respectively. The minimum spike length (3.93 mm) was recorded in control plants.

Table 6. Spike length (cm) of gladiolus plant as affected by water stress and salicylic acid

Water stress	Salicylic acid(ppm)				Mean
	0	**40**	**80**	**120**	
Control	37.10 cdf	37.73 cd	38.40 c	40.76 ab	38.50 a
Mild stress	35.70 def	36.20 def	38.93 bc	42.10 a	38.23 a
Severe stress	34.76 f	35.36 ef	35.83 def	36.10 def	35.51 b
Mean	35.85 c	36.43 c	37.72 b	39.65 a	

Table 7. Number of florets of gladiolus plant as affected by water stress and salicylic acid.

Water stress	Salicylic acid(ppm)				Mean
	0	**40**	**80**	**120**	
Control	5.03	5.13	5.53	6.00	5.42 a
Mild stress	3.93	5.16	5.76	6.36	5.30 a
Severe stress	3.70	3.90	4.60	5.56	4.44 b
Mean	4.22 d	4.73 c	5.30 b	5.97 a	

Table 8. Flower diameter (mm) of gladiolus plant as affected by water stress and salicylic acid.

Water stress	Salicylic acid(ppm)				Mean
	0	**40**	**80**	**120**	
Control	45.10	45.46	46.36	47.30	46.05 a
Mild stress	42.50	45.96	46.93	48.13	45.88 a
Severe stress	40.63	42.93	44.03	45.73	43.33 b
Mean	42.74 c	44.78 b	45.77 ab	47.05 a	

Table 9. Spike diameter (mm) of gladiolus plant as affected by drought and salicylic acid.

Water stress	Salicylic acid(ppm)				Mean
	0	**40**	**80**	**120**	
Control	5.06	5.20	5.53	5.96	5.44 a
Mild stress	3.80	4.60	5.60	6.13	5.03 b
Severe stress	2.93	3.26	3.43	3.70	3.33 c
Mean	3.93 b	4.35 b	4.85 a	5.26 a	

DISCUSSION

According to our results, salicylic acid increased the plant height of gladiolus plants under drought. (Kang et al. 2012) also reported an increase in plant height and dry mass, and less wilting of leaves were found in drought-exposed and SA (0.5

mM)-supplemented wheat. This might be due to the fact that salicylic acid improves dry weight and leaf area of plants grown under stress (Bayat *et al*. 2012). SA also increases turgor pressure in the cells due to the soluble sugars and other osmotic active substances, including proline and soluble proteins (Khan *et al*. 2012). An increase in turgor pressure leads to increased cell expansion (Morgan, 1984). Healthy growth leads to higher biological yield with bold grains, their length and diameter increases, their number and weight per plant rises (Farouk and Usamn, 2011). The increase in plant height might be due to a reduction in transpiration rates (Azizi, 2010), Stomatal regulation, and photosynthesis (Arfan *et al*. 2007). Plant growth and development is regulated by various internal and external stimuli. Salicylic acid has been at the center of intensive research in recent years because of its crucial role in regulating physiological and biochemical processes throughout plant life and plays a central role in regulating its growth and productivity (Alberg, 1981) Our results are in line with [Pirlak and Eşitken, 2004; Saied *et al*. 2005; Sajjad *et al*. 2014). Our findings also revealed that drought reduces the rachis length while salicylic acid improves the rachis length of gladiolus. Moisture is the most essential demand of a plant for its proper growth and development. Water stress is responsible for reduction in root length, shoot lenght, leaf growth, transpiration and turgor pressure (Javed et al. 2016), all these factors are responsible for the reduction in rachis length. Maximum rachis length was resulted at 120 ppm SA, as plant hormone has synergistic effect on auxin due to which cell division and enlargement takes place. The plant height, number of leaves and tuberose shelf life was also positively affected by SA (Anwar *et al*. 2014). Our results are also supported by the findings of Pervez *et al*. 2009.

Drought had a negative affect on number of leaves while SA have a positive impact. Anwar *et al*. 2014 observed an increase in plant height, number of leaves and length of floral stalk of tuberose when sprayed with adequate concentration of SA. Our results are also in conformity with Ali Rezaei *et al*. 2012, who reported that number of leaves, leaf area and total leaves fresh weight decreased with increase in drought. The drought induces decline in leaf size (Kahlaoui *et al*. 2011). SA encouraged deposition of sucrose which facilitated in loading of phloem via sucrose transporters, this keeps leaf turgor, osmotic potential, and delay senescence under water stress environments. In wheat, application of SA enhanced antioxidant system and utilization of nitrogen under drought (Sharma *et al*. 2017). Similar results were also reported by (Lee and Park, 2010).

Yao *et al*. 2015 reported an increase in leaf area with the application of SA in calendula, marigold and gladiolus. Our results are in lined with the findings of Zanghami *et al*. 2014, who recorded maximum leaf area with foliar application of SA (2 mM) in petunia hybrida. Our results are also supported by Kahlaoui *et al*. 2011. Water stress reduces spike length while SA improves spike length in gladiolus when subjected to different water stresses. Salicylic Acid (SA) improved plant environmental stress tolerance by increasing the activities of antioxidant enzymes such as CAT under drought (Ghadar *et al*. 2015). SA had a positive role in enhancing the photosynthate assimilation and chlorophyll content as well as improved mineral uptake by plants (Karlidag *et al*. 2009). An increase in spike length with the application of SA was also evaluated by Anwar *et al*. 2014 and Yao *et al*. 2015 in tuberose, rose cv. Angelina and gladiolus respectively. Similarly, Hussain *et al*. 2008 observed increase in plant growth and biomass under drought condition when SA was applied. Jakab *et al*. 2007 also reported that Salicylic Acid (SA) improved the availability of nutrients by enhancing turgor of the plants under stress.

Maximum number of florets at 120 ppm SA application might be due to the fact that Salicylic Acid (SA) increased the leaf area, chlorophyll contents hence enhanced photosynthetic activity resulted in long healthy spikes with greater number of florets. SA helps in accumulation of carbohydrates and increases mineral uptake that positively affect number of flowers. Our results are in lined with Khurana and Cleland, 1992; Fariduddin *et al*. 2003, who concluded that SA application significantly improved number of florets in gladiolus plant. Khan *et al*. 2015 observed the least number florets under severe drought. The drought induces reduction in the chlorophyll content could be attributed to inducing the chloroplast destruction and the instability of chlorophyll protein complex. resulting in minimum number of florets. These findings are in line who also noted that severe drought conditions reduced growth characteristics of plants. Reduction in flower diameter under severe drought may be due to decrease in physiochemical processes within the plant body that led to stunted growth resulting in minimum flower diameter. These findings are in line with Souri and Dehnavand, 2017, who also observed that severe stress condition reduced growth characteristics of plants. This can partly be due to reduced leaf area and smaller cells induced by salinity that may result in concentrated chlorophyll content, quite similar to ammonium toxicity effects on tomato plants. Highest flower diameter as a result of 120 ppm the beneficial effect of SA on crop growth might be due to its involvement in severeal physiological processes in plants such as stomatal opening and closing, nutrients uptake and inhibition of biosynthesis and transpiration. which ultimately results in enhanced flower diameter process. Our results are in line with Khan *et al*. 2003; Shakirova *et al*. 2003) who concluded that Salicylic Acid (SA) application significantly improved flower diameter in gladiolus plant.

Drought reduces the biomass production in tomato plant by decreasing the leaf number, leaf width and size (Pervez *et al*. 2009). Ali Rezaei *et al*. 2012 reported that leaf numbers and leaf width decreased with increase in drought. Highest spike diameter was a result of 120 ppm SA, as plant hormone has a synergistic effect on auxin due to which cell division and enlargement takes place (Karlidag *et al*. 2009). SA had a positive role in enhancing photosynthate assimilation and chlorophyll content as well as improved mineral uptake by plants.

CONCLUSIONS

Based on the results of current experiment, it can be concluded that;

- All growth parameters (vegetative and reproductive) of gladiolus decreased under severe drought as compared to mild stress and no stress (control).
- High dose of Salicylic acid had positive impact on growth parameters of Gladiolus plant.

RECOMMENDATIONS

- It is recommended that foliar application of salicylic acid @ 120 ppm should be applied to gladiolus crop under drought condition in order to produce quality flowers.

Declaration

Data availability

All data and materials are available from the corresponding author. Therefore, at a reasonable request, the corresponding author shared it via email.

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COMPETING INTERESTS

Authors have declared that no competing interests exists

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