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Exogenous Application of Gibberellic Acid and Malic Acid to Check the Growth, Development and Longevity of *Gladiolus grandiflorus* Cv. White Prosperity

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ABSTRACT

Background and Objective: The Gladiolus (Sword Lily) is a bulbous plant that is grown throughout the world due to its allure, beauty and the long vase life. Its production demand is increasing on national and international level. Gladiolus belongs to Iridaceae family. Due to its economic value and peerless beauty, it gained popularity in the world. This field trial was conducted to evaluate the effect of Gibberellic acid (GA3) and Malic acid (MA) by foliar application on the morpho-physiological, yield and quality characteristics of Gladiolus cultivars.

Materials and Methods: Present study was conducted at Floriculture Research area, Institute of Horticultural Sciences, University of Agriculture, Faisalabad. Gladiolus cultivar, White Prosperity was selected for this research. Two plant growth regulators [Gibberellic acid (0, 100, 200, 300, 400 mg L^{-1}) and Malic acid (0, 100, 200, 300, 400 mg L^{-1})] were studied in this research. These regulators were applied as the foliar spray and then included in vase solution along with 3% sucrose. The collected data was analyzed statistically using the ANOVA with a Randomized Complete Block Design (RCBD). Treatment means were compared by using the Least Significant Difference test at 5 percent probability level.

Results: The data showed significant result in terms of plant height. The result indicated that maximum plant height was obtained from T_1 (GA_3 100 ppm) (97.163 cm) and Malic acid (96.650 cm), maximum plant weight (49.833 g) was obtained from T_1 (GA_3 100 ppm) maximum chlorophyll content (69.417) was obtained from T_7 (MA 300 ppm). Whereas the maximum diameter of corms (12.900 mm) was obtained from T_7 (MA 300 ppm), maximum vase life (14.550 days) was obtained from T_1 (GA_3 100 ppm), maximum solution uptake (54.427 mL), maximum number of florets (10.667) and maximum corms per clump (19.000) was obtained from T_1 (GA_3 100 ppm) as compare to control treatment.

Conclusion: Plant Growth Regulators (PGRs) can be used in an appropriate amount to increase the growth and development of floral crops and they can also be used to lengthen the vase life of various cut flowers.

INTRODUCTION

Gladiolus is well known as cut flower around the globe due to its elegance look and tremendous vase life. Globally, the demand for cut flowers and plants is increasing at a rate of 10 to 15% per year in all importing countries. It is grown for its fascinating spike as a cut flower and also in flower beds in gardens during winter season. Cut flowers are a valuable product of horticulture[1]. Production of cut flowers has increased due to the growing demand for bouquets, garlands, wreaths and decorations for public occasions, celebrations and decor[2]. Gladiolus (Sword Lily) is bulbus crop which is cultivated around the world due to its allure beauty color and marvelous vase life. It is an excellent corms producer which belongs to

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late maturity group[3]. Its demand is increasing on national and international level. Gladiolus belongs to Iridaceae family and considered as the queen of bulbous flowers. Due to its economic value and peerless beauty, it gained popularity in the world. Gladiolus spikes are mainly used for interior decoration and bouquet manufacturing. While, rose and tuberose are easily available in local markets. As well as fulfilling local requirements, Gladiolus can earn foreign exchange. Farmers are now rerouting towards the floral crops. Gladiolus is short duration (110-120 days) crop, a wide range of varieties, better economic return as compared to other crops that make it a popular crop. Climatic conditions are also suitable for this crop. Gladiolus corms are divided into many parts during propagation in order to increase plant material. One of the most cost-effective ways to boost the yield of corms and corms is to divide the corms[4]. Due to its increasing demand in local market, commercial growers are also planning to grow gladiolus in different areas of Pakistan. However, its production and quality do not meet international standards. A great revolution has occurred in floriculture industry due to the use of plant growth regulators. Several studies have shown that plant growth regulators stimulate bud growth and development[5,6]. Plant growth regulators will be more widely used to produce higher quality products, benefiting consumers as well as producers and marketers[7]. These growth regulators are used in many floral crops to control growth and flowering to produce high quality plants. Many growth regulators such as Gibberellic acid, humic acid and felvic acid etc are used. These growth regulators increase growth, stem length, number of leaves per plant, area of leaves, dry weight and diameter of flower[8]. In the current state of agriculture, intensive agricultural practices have created disadvantages and adversely affected the climate and natural ecosystems of the area. To overcome the disadvantages associated with intensive agricultural practices, new protocols should be developed. Due to the limited use of plant growth regulators, its recommendations are being used by hit-and-trial methods for applying fertilizer to gladiolus, which are unable to fulfill nutritional requirement of the crop. Keeping in view the role of different plant growth regulators in plant metabolism and to improve production, the present field trial was conduct to evaluate the effects of Gibberellic Acid (GA_3) and Malic Acid (MA) by foliar application on morpho-physiological, yield and quality attributes of Gladiolus. The objective of this study was to find the best combination of these plant growth regulators for better growth of quality cut flower with hypothesis that providing optimal doses of Gibberellic acid and Malic acid improved growth, yield and quality of cut flowers of gladiolus cultivar White Prosperity.

MATERIALS AND METHODS

This study was conducted at Floriculture Research Area, Institute of Horticultural Sciences, University of Agriculture, Faisalabad, during the year 2021-2022. Gladiolus cultivar, "White Prosperity" was selected for this experiment. Corms of gladiolus cultivar "White Prosperity" was acquired from a recognized company viz, Greenworks, Lahore and acclimatize for a week at ambient temperature before sowing. Before planting, corms were treated with Topsin M 2% for 5 min followed by drying under shade. Soil was rigorously prepared and experiment was laid out. The corms were uniformly sized and ranged in diameter from 8 to 10 cm. Corms were sown on 13th of November 2021 after making ridges with dimension of 60 cm (2 feet) R×R and 7.5 cm P×P distance. This experiment was laid out using a Randomized Complete Block Design (RCBD) with nine treatments and three replications, one treatment served as a control. Eighteen corms were sown in each experimental unit at a depth of 4-7 cm. Gibberellic acid and Malic acid was used in different combinations as foliar application in the form of aqueous solution. Gibberellic acid and Malic acid was applied at three leaf stage and spray was repeated after 15 days of interval till the floret formation started. During the experiment all the cultural practices were kept same for all treatments viz., weeding, irrigation etc. The post- harvest experiment was conducted by cutting the spikes of Gladiolus when first florets from the base started showing color. After harvesting, gladiolus spikes were rehydrated for two hours at room temperature. The lower leaves of the spikes were removed and then kept in jars containing 300 mL Gibberellic acid and Malic acid solutions. Each treatment was replicated once, having twelve spikes of Gladiolus. Afterwards, they were transferred to Jars containing 300 mL distilled water, in a vase life evaluation room at 19±2°C and 60±10% relative humidity.

Detail of treatments:

- T_0 = Control (Distilled Water)
- T_1 = 100 mg L^{-1} Gibberellic acid
- T_2 = 200 mg L^{-1} Gibberellic acid
- T_3 = 300 mg L^{-1} Gibberellic acid
- T_4 = 400 mg L^{-1} Gibberellic acid
- T_5 = 100 mg L^{-1} Malic acid
- T_6 = 200mg L^{-1} Malic acid
- T_7 = 300 mg L^{-1} Malic acid
- T_8 = 400 mg L^{-1} Malic acid

In the postharvest experiment, the following treatments were applied to the crop via foliar spray along with 3% sucrose as a base solution.

T_0 : Control
T_1 : Gibberellic acid 100 mg L^{-1} + sucrose 3%
T_2 : Gibberellic acid 200 mg L^{-1} + sucrose 3%
T_3 : Gibberellic acid 300 mg L^{-1} + sucrose 3%
T_4 : Gibberellic acid 400 mg L^{-1} + sucrose 3%
T_5 : Malic acid 100 mg L^{-1} + sucrose 3%
T_6 : Malic acid 200 mg L^{-1} + sucrose 3%
T_7 : Malic acid 300 mg L^{-1} + sucrose 3%
T_8 : Malic acid 400 mg L^{-1} + sucrose 3%

Statistical analysis: All data generated were subjected to a One-way Analysis of Variance (ANOVA) with a Randomized Complete Block Design (RCBD). Individual treatment means were compared by using the Least Significant Difference test at 5 percent level of significance.

RESULTS AND DISCUSSION

Plant height: Gibberellic acid and Malic acid spray has significant effects on the plant height when compared to other treatments (Fig. 1). Results showed that Gibberellic acid (T_1 = GA_3 100 ppm) produced the maximum plant height (97.163 cm) and another treatment of Malic acid showed comparatively good result (96.650 cm) as compare to other treatment of Malic acid. Minimum plant height (80.66 cm) was obtained from Control.

Fresh weight of plant (g): The spray of Gibberellic acid and Malic acid has significant effect on the fresh weight of plant as compare to other treatments (Fig. 2). Results showed that Gibberellic acid (T_1 = GA_3 100 ppm) produced maximum fresh weight of plant (49.833 g) and another treatment of Malic acid showed comparatively good result (47.807 g) as compare to other treatment of Malic acid and minimum fresh weight of plant (40.440 g) was obtained from the treatment of Control. The results showed that foliar application of Gibberellic acid and Malic acid with different combinations gave the better results among all other treatments. Obviously it increased the fresh weight of Gladiolus plant. So, it is suggested that combination of T_1 (100 ppm Gibberellic acid) and T_7 (300 ppm Malic acid) is the best as compared to control.

So, Kumar et al.[9] conducted an experiment to study the Impact of plant growth regulators on growth and flowering of gladiolus cv. Candyman. Three growth regulators with three concentrations were NAA, GA_3 and CCC each at three concentrations. The results revealed that T_4 (GA_3 200 ppm) showed superior results in terms of the plant height, number of leaves, length of leaves, length of spike, length of rachis, number of floret per spike, diameter of florets and vase life compare to all other treatments. Plant growth regulators are important for vegetative propagation, abscission suppression, bud dormancy prevention, growth control, flowering stimulation, floral vase life extension and senescence retardation. GA3 are natural plant growth regulators that contain tetracyclic, diterpenoid chemicals that are commercially used to increase yield and morpho-physiological features in a variety of ornamental and vegetable crops[10]. The GA_3 improved the quality of vase solution and the antioxidants capacity of the flower. The longest vase life, floret opening and fresh weight was caused by gibberellic acid application. Zhang et al.[11] discovered that GA3 and auxin have a relationship in inter biosynthesis, enhancing their concentration and, as a result, assisting in growth improvement via enzyme activation.

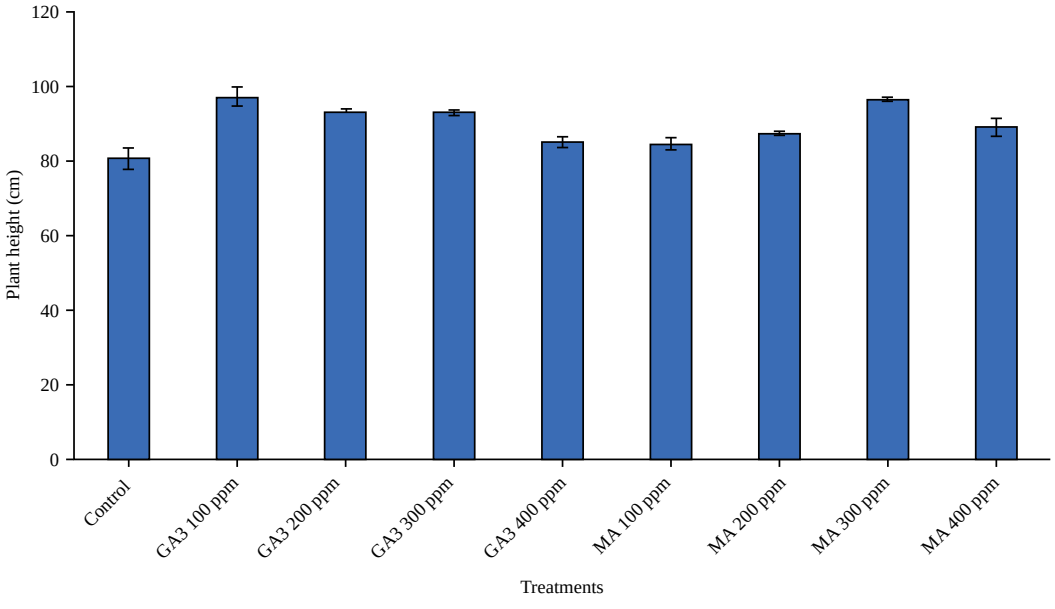

Fig. 1: Plant height of gladiolus as influenced by various concentration of gibberellic acid and malic acid

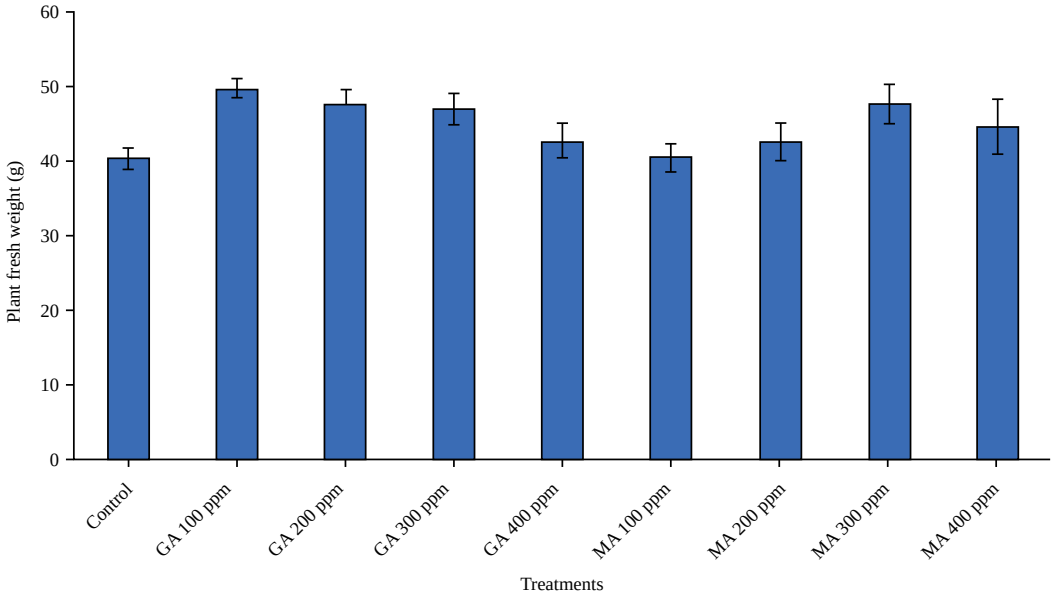

Fig. 2: Plant fresh weight of gladiolus as influenced by various concentration of gibberellic acid and malic acid

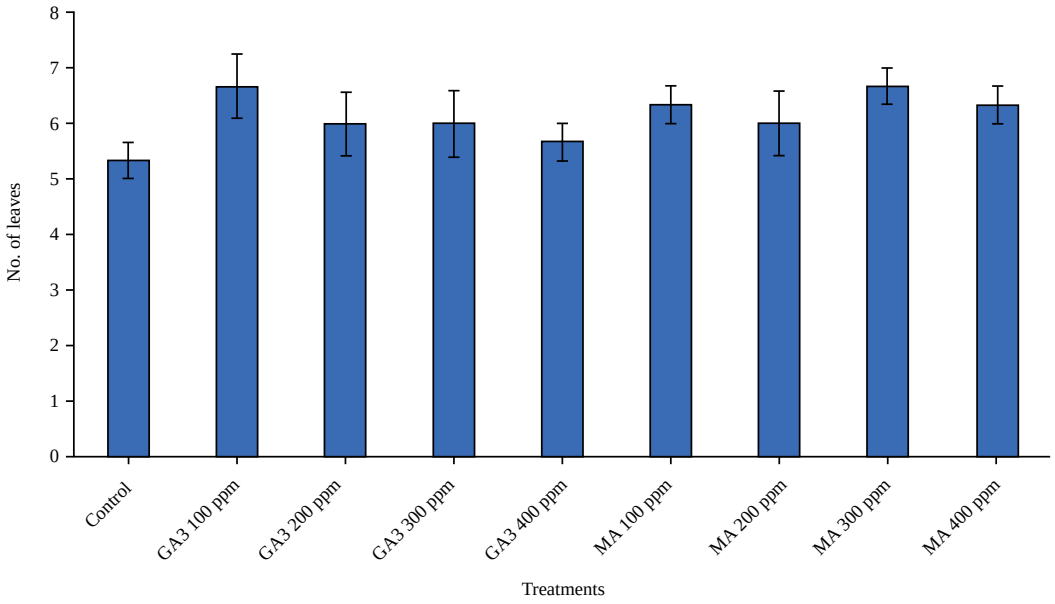

Fig. 3: Number of leaves on Gladiolus as influenced by various concentration of gibberellic acid and malic acid

Number of leaves: Analysis of variance showed that the spray of Gibberellic acid and Malic acid has significant effect on the number of leaves as compare to other treatments (Fig. 3). Results showed that Gibberellic acid (T_1= GA_3 100 ppm) produced the maximum number of leaves (6.6667) and another treatment of Malic acid showed comparatively good result (6.6667) as compare to other treatment of Malic acid while minimum number of leaves (5.3333) was obtained from the control treatment.

The results showed that foliar application of Gibberellic acid and Malic acid with different combinations gave the better results among other all treatment. Obviously it increased the number of leaves of Gladiolus. So, it is suggested that combination of T_1 (100 ppm Gibberellic acid) and T_7 (300 ppm Malic acid) is the best as compared to control. By applying GA3, Sable et al.[12] investigated the impact of plant regulators on gladiolus flower quality and growth and found that the number of leaves, range of florets, floret diameter and rachis length have definitely increased. These findings contradict the results of the present study.

Leaf total chlorophyll content (SPAD): Analysis of variance showed that the spray of Gibberellic acid and Malic acid has significant effect on total chlorophyll content as compare to other treatments (Fig. 4). Results showed that Malic acid (T_7 = MA 300 ppm) produced maximum

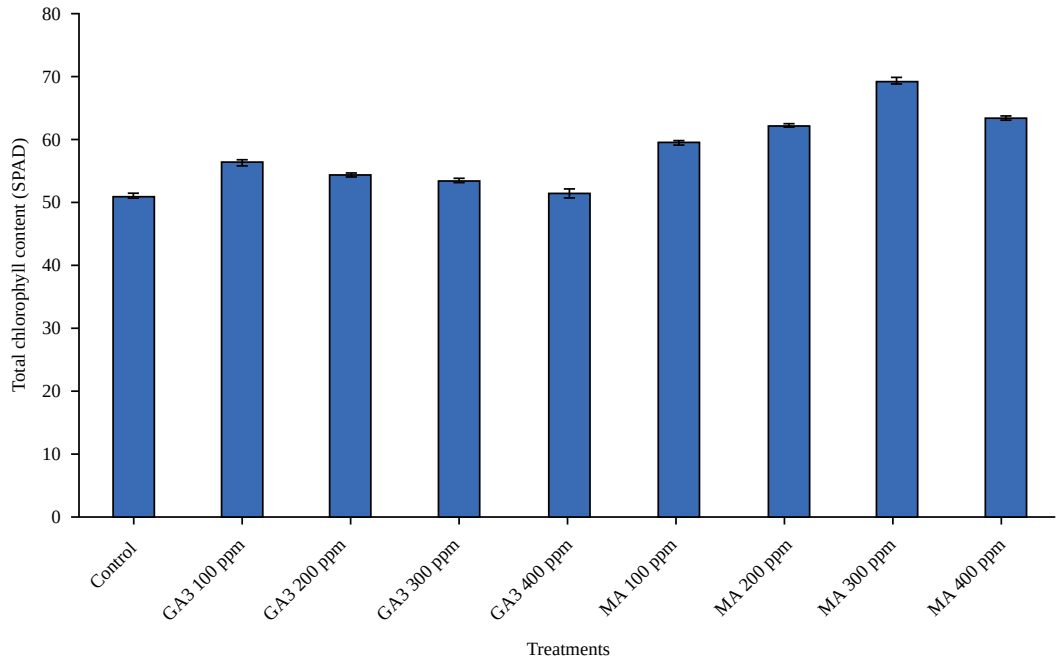

Fig. 4: Total chlorophyll content of Gladiolus as influenced by various concentration of gibberellic acid and malic acid

chlorophyll content (69.417) and another treatment of Malic acid showed comparatively good result (63.487) as compare to other treatment of Malic acid while minimum chlorophyll content (51.067) was obtained from the Control treatment. The results showed that foliar application of Malic acid with different combinations gave the better results among other all treatments. Obviously, it increased total chlorophyll content of Gladiolus. So, it is suggested that the combination of T_8 (400 ppm) and T_7 (300 ppm) of Malic acid is the best combination as compared to control.

In comparison with control and other plant growth regulators, GA3 at 100 ppm caused larger flowers, more leaves, rapid blooms and heavier flowers however GA_3 not only improve flower size but also higher chlorophyll content and senescence were reduced in GA_3[6]. Another study found that 50 mg L^{-1} malic acid had the highest total chlorophyll content. Results showed that malic acid extended the vase life of cut flowers[13]. These previous findings support the result of the present study.

Floret diameter (mm): Analysis of variance showed that the spray of Gibberellic acid and Malic acid has significant effect on the floret diameter as compare to other treatments (Fig. 5). Results showed that Gibberellic acid ($T_1 = GA_3$ 100 ppm) produced maximum floret diameter (101.11 mm) and another treatment of Malic acid showed comparatively good result (96.56 mm) as compare to other treatment of Malic acid while minimum floret diameter (91.47 mm) was obtained from the treatment of Control. The results showed that foliar application of Gibberellic acid and Malic acid with different combinations gave the better results among other all treatment. Obviously, it increased floret diameter of Gladiolus. So, it is suggested that T_1 (GA_3 100 ppm) and T_7 (MA 300 ppm) combination is the best as compared to control.

Snow Princess was observed which had the earliest flowering, largest floret diameter and maximum weight of corm. The effect of bioregulators on the growth and yield of tuberose cv. was studied by Padaganur et al.[14], who discovered that GA3 at 150 ppm had the highest plant height, the greatest number of leaves, the earliest spike emergence, the longest spike, the widest range of florets aligned with spikes and the largest floret diameter.

Number of florets: Analysis of variance showed that by the spray of Gibberellic acid and Malic acid has significant effect on the number of florets as compare to other treatments (Fig. 6). Results showed that Gibberellic acid (T_1 = GA_3 100 ppm) produced the maximum number of florets (10.667) and another treatment of Malic acid showed comparatively good result (10.000) as compare to other treatment of Malic acid while minimum number of florets (8.667) was obtained from the treatment of Gibberellic acid (T_4 = GA_3 400). The results showed that foliar application of Gibberellic acid and Malic acid with different combinations gave the better results among other all treatments. Obviously, it increased the number of florets of Gladiolus. So, it is suggested that T_1 (GA_3 100 ppm) and T_7 (MA 300 ppm) combination is the best as compared to control.

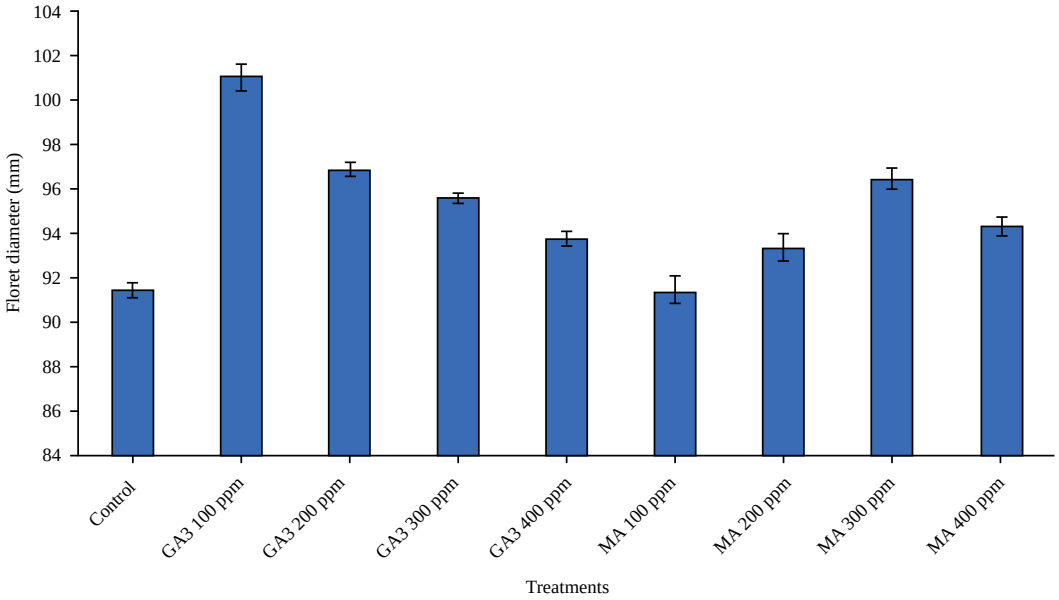

Fig. 5: Floret diameter of Gladiolus as influenced by various concentration of gibberellic acid and malic acid

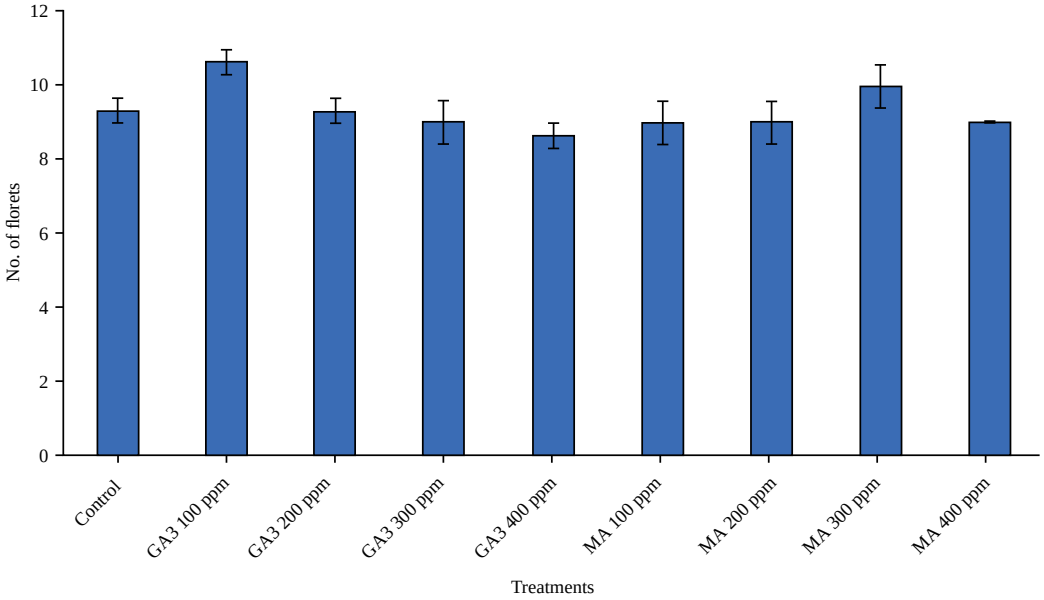

Fig. 6: Number of floret on Gladiolus as influenced by various concentration of gibberellic acid and malic acid

As a result of using plant growth regulators in this study, the growth rate has been enhanced and significant number of florets have been produced, which will lead to higher yields and lower production costs. El-Shanhorey et al.[15] found that foliar application of MA at 300 ppm considerably increased numbers of flowers, fresh weight of flowers and Rachis length. At the same quantity, Malic Acid (MA) showed maximum chlorophyll content in the tuberose. Malic acid (MA) also extended the shelf life of cut flowers. These findings support the results of the current study where it is observed that the application of Gibberellic acid and Malic acid increased number of florets.

Diameter of corms (mm): Analysis of variance showed that the spray of Gibberellic acid and Malic acid has significant effect on the diameter of corms as compare to other treatments (Fig. 7). Results showed that Malic acid (T_7 = MA 300 ppm) produced the maximum diameter of

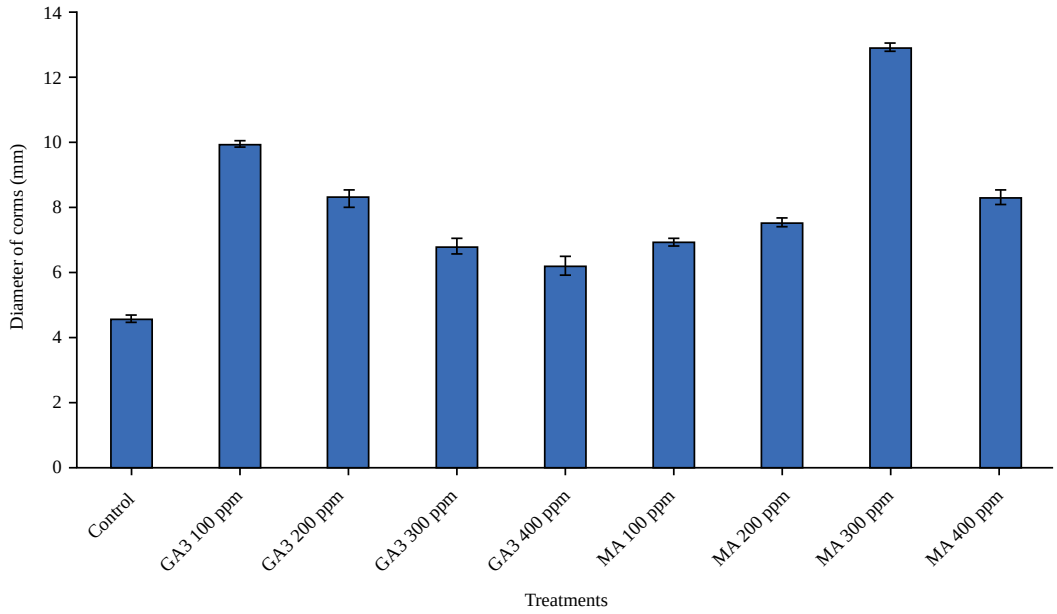

Fig. 7: Diameter of corms on Gladiolus as influenced by various concentration of gibberellic acid and malic acid

corms (12.900 mm) and another treatment of Gibberellic acid showed comparatively good result (9.933 mm) as compare to other treatment of Gibberellic acid while minimum diameter of corms (4.533 mm) was obtained from control treatment. The results showed that foliar application of Gibberellic acid and Malic acid with different combinations gave the better results among other all treatment. It obviously increased diameter of corms of Gladiolus. So, it is suggested that combination of T_7 (MA 300 ppm) and T_1 (GA_3 100 ppm) is the best as compared to control. These finding are consistent with the results of the present study which showed an increase in the diameter of corms. The effects of plant regulators on the flowering of Hippeastrum were studied and GA3 at 500 ppm was found to be the most effective in producing flowers per plant, best period of flower, the maximum flowers diameter, the maximum quantity of bulblets in each plot and best bulb diameter[16]. These results agree with the findings of the present study.

Number of corms per clump: Analysis of variance showed that the spray of Gibberellic acid and Malic acid has significant effect on the total number of corms per clump as compare to other treatments (Fig. 8). Results showed that Gibberellic acid (T_1 = GA_3 100 ppm) produced maximum corms per clump (19.000) and another treatment of Malic acid showed comparatively good result (16.667) as compare to other treatment of Malic acid while minimum corms per clump (9.333) was obtained from control treatment. The results showed that foliar application of Gibberellic acid and Malic acid with different combinations gave the better result.

Sajjad et al.[17] observed that the foliar application of 1mM gibberellic acid maximize the height of plant, length of spike, florets per spike, diameter of corms, weight of corms and total caramel weight as compare to benzyl amino purine and salicylic acid. These findings are consistent with the results of the present study, which showed an increase in cormel diameter.

Weight of corms (g): Analysis of variance showed that the spray of Gibberellic acid and Malic acid has significant effect on the weight of corms as compare to other treatments (Fig. 9). Results showed that Gibberellic acid (T_1 = GA_3 100 ppm) produced maximum weight of corms (25.167 g) and another treatment of Malic acid showed comparatively good result (20.520 g) as compare to other treatment of Malic acid while minimum weight of corms (16.687 g) was obtained from control treatment. The results showed that foliar application of Gibberellic acid and Malic acid with different combinations gave the better results among other all treatment. It obviously increased weight of corms of Gladiolus. So, it is suggested that T_1 (Gibberellic acid 100 ppm) and T_7 (Malic acid 300 ppm) is the best combination as compared to control.

Sajjad et al.[17] observed that foliar application of 1 mM gibberellic acid maximize the height of plant, length of spike, florets per spike, diameter of corms, weight of corms and total caramel weight as compare to control treatment.

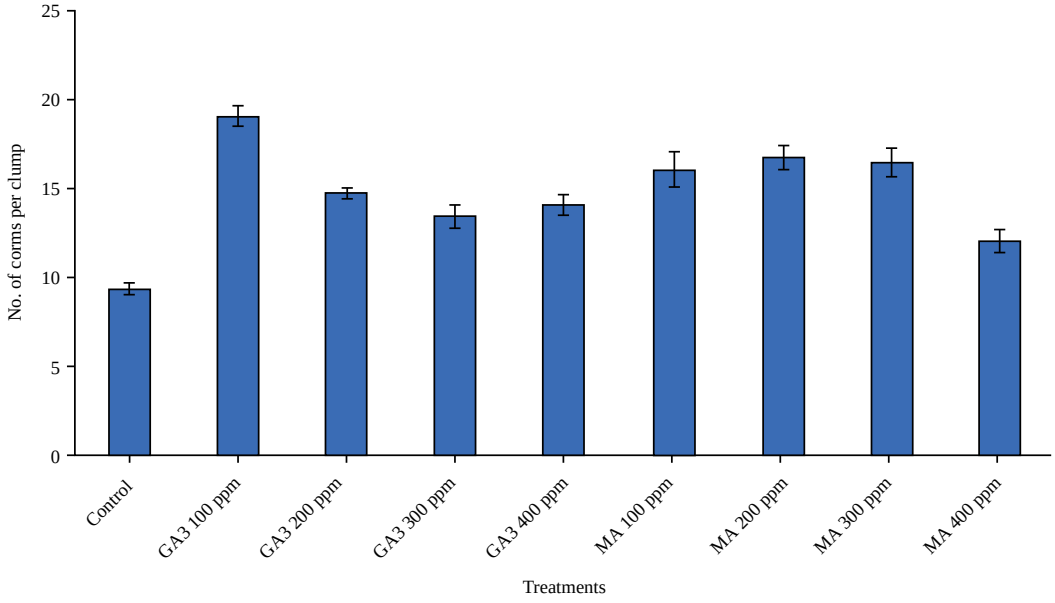

Fig. 8: Number of corms per clump of Gladiolus as influenced by various concentration of gibberellic acid and malic acid

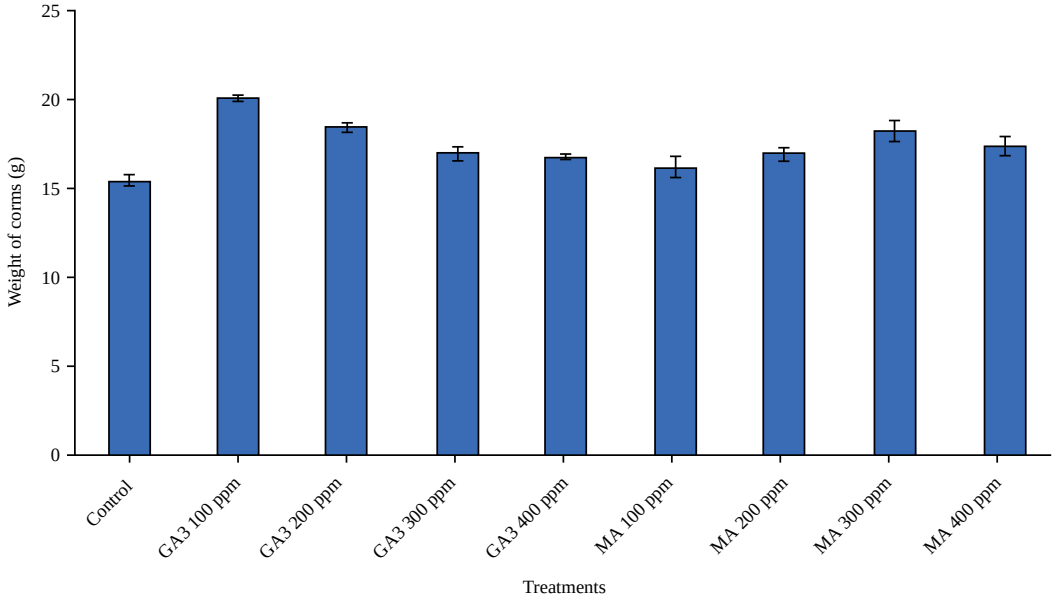

Fig. 9: Weight of corms on Gladiolus as influenced by various concentration of gibberellic acid and malic acid

The use of plant growth regulators in this study may have enhanced the growth rate, resulting in significant plant height, which is helpful not only to produce crops on a large scale but also to lower production costs. According to Kumar et al.[18], bioregulators (GA3 and BAP) have been found to influence gladiolus cv. Candyman blooming, flowering and corm production. At GA3 two hundred ppm, early first florets that showed colour, an absolutely open first floret and the beginning of closing florets were observed, whereas BAP increased the corms weight in accordance with the plant and BA augmented the number of sprouts, these results support my research authenticity.

Solution uptake (mL): Analysis of variance showed that the spray of Gibberellic acid and Malic acid has significant effect on the solution uptake as compare to other treatments (Fig. 10). Results showed that Gibberellic acid (T_1 = GA_3 100 ppm) produced maximum solution uptake (54.427 m L) and another treatment of Malic acid showed comparatively good result (42.460 mL) as compare to other treatment of

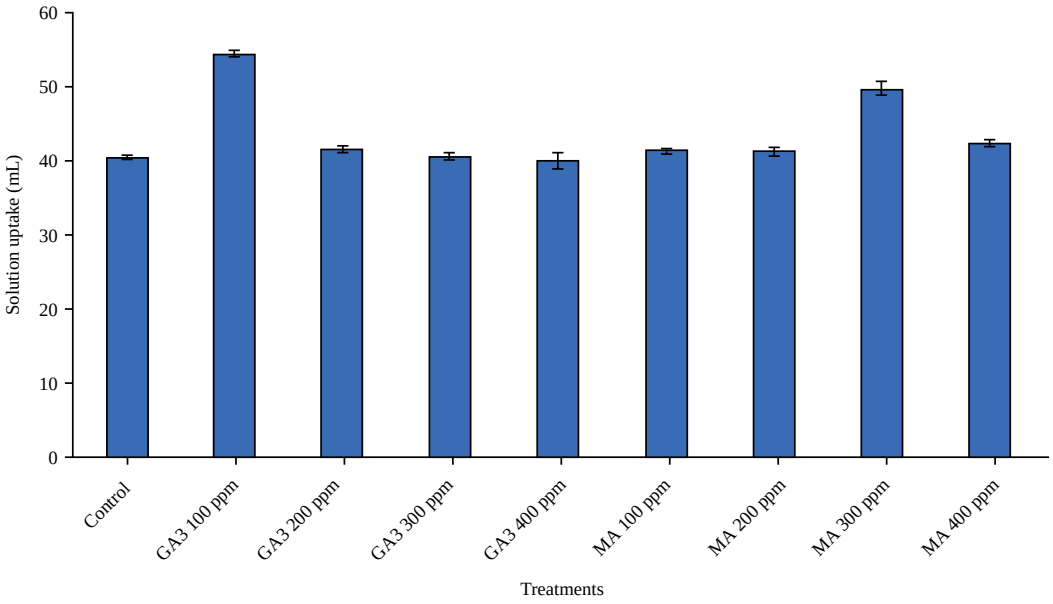

Fig. 10: Solution uptake of Gladiolus as influenced by various concentration of gibberellic acid and malic acid

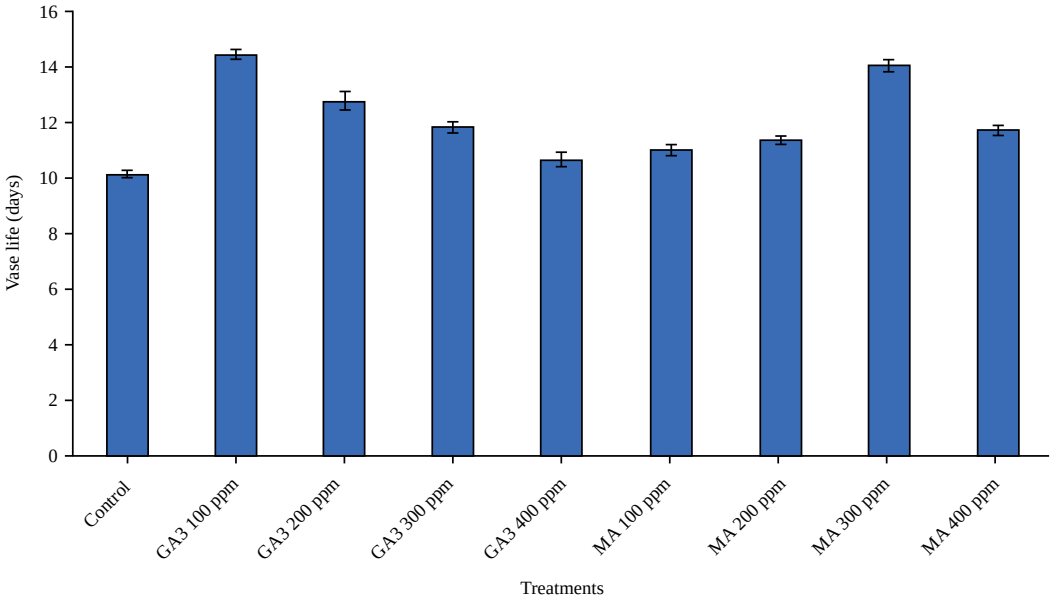

Fig. 11: Vase life of Gladiolus as influenced by various concentration of gibberellic acid and malic acid

Malic acid while minimum solution uptake (39.967 mL) was obtained from the treatment of T_4 = 400 mL. It is observed that foliar application of Gibberellic acid and Malic acid with different combinations gave the better results among other all treatments. It obviously maximized the solution uptake of Gladiolus. So, it is suggested that combination of T_1 (GA_3 100 ppm) and T_7 (MA 300 ppm) is the best as compared to control. By applying plant growth regulators to crops, Soumya et al.[19] observes that crop yield increases, crop tolerance for abiotic stress is enhanced and physiological traits of crops are improved.

In an experiment, Singh et al.[13] observed that Gibberellic acid and Benzyl Adenine (BA) with sucrose gave good membrane stability and vase life, while water uptake (solution uptake), fresh weight and dry weight of cut spikes showed significant differences. Malic acid was applied to lisianthus cut flowers in an experiment performed by Singh et al.[13]. Significant results showed maximum water

uptake (solution uptake), maximum dry mass, maximum chlorophyll content and maximum vase life. An experiment was conducted to study the effect of 5-sulfosalicylic acid (5-SSA) on the vase life of cut flowers of *Gladiolus grandiflorus* variety Green Willow. The vase solution containing 5-SSA significantly increased vase life, cumulative uptake of vase solution, number of open florets and decreased the number of unopen florets compared to the controls[20]. These previous finding also indicated that application of the plant growth regulators maximized the solution uptake which favors my results.

Vase life (days): Analysis of variance showed that the spray of Gibberellic acid and Malic acid has significant effect on the vase life as compare to other treatments (Fig. 11). Results showed that maximum vase life (14.550) was obtained from T_1 (GA_3 100 ppm) and another treatment of Malic acid showed comparatively good result (14.167) as compare to other treatment of Malic acid while minimum vase life (10.207) was obtained from control treatment. The results showed that foliar application of Gibberellic acid and Malic acid with different combinations gave the better results among other all treatment. It obviously increased vase life of Gladiolus. So, it is suggested that the combination of T_1 (GA_3 100 ppm) and T_2 (GA_3 200 ppm) is the best as compared to control.

El-shanhorey et al.[17] found that foliar application of Malic Aicd (MA) at 300 ppm considerably increased numbers of flowers, fresh weight of flowers and Rachis length. At the same quantity, Malic Acid (MA) showed maximum chlorophyll content in the tuberose. Malic acid (MA) can also extend the shelf life of cut flowers. These finding are consistent with the results of the present study which showed that application of Gibberellic acid and Malic acid increased vase life of cut flowers. Plant growth regulators are important for vegetative propagation, abscission suppression, bud dormancy prevention, growth control, flowering stimulation, floral vase life extension and senescence retardation. GA3 are natural plant growth regulators which contain tetracyclic, diterpenoid chemicals that are commercially employed to increase yield and morpho-physiological features in a variety of ornamental and vegetable crops[11].

CONCLUSION

Results revealed that Plant Growth Regulators (PGRs) can be used in an appropriate amount to increase the vase life of different cut flowers, the overall growth and development of the floral crops. Due to intensive agricultural practices, agriculture is currently at a level that creates disadvantages and it also negatively affects the climate as well as the natural ecosystems in the area. New protocols should be provided to overcome the disadvantages of the intense agricultural activities. Due to less use of plant growth regulators its recommendations are being used by hit and trial methods for applying fertilizer to gladiolus, which are unable to fulfill nutritional requirement of the crop. Foliar application of Gibberellic Acid (GA_3) 100 ppm and Malic Acid (MA) 300 ppm improved the vase life (14.55 days), physiological traits i.e. chlorophyll content (69.42 SPAD) of crops, increased the yield and improved the quality attributes i.e. plant height (97.16 cm), cormel diameter (12.90 mm) of Gladiolus.

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