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Plant Growth Regulators Impact on Vegetative and Reproductive Characteristics of Gladiolus Cut Flowers (*Gladiolus hybridus* Hort.)

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Abstract

Gladiolus is an important marketable cut flower, especially valued for use in floral arrangements. We assessed the effects of two different methods of application (foliar spray and drench) and various concentrations of gibberellic acid (GA_3), salicylic acid (SA), mival (MI) and krizatcin (KR) on vegetative and reproductive features of *Gladiolus hybridus*. The experiment was planned in a factorial experiment based on a completely randomized design with four replicaties. The results showed that plant growth regulators (PGRs) had significant effect on florets number, leaf area and corm weight and volume. The best treatment to increase the floral stalk length was 50 mg L^{-1} GA_3 spray. Our results indicated that higher GA_3 doses significantly increased leaf area more than lower doses. Furthermore, maximum floret diameter was achieved at 100 mg L^{-1} MI applied as foliar spray. The maximum number of florets (15.87) was obtained in the plants treated with intermediate concentrations of MI in both application methods. Corms drenched with 25 mg L^{-1} MI effectively increased their corm weight and volume. Generally, MI was found to be more effective than other PGRs. Therefore, due to greater efficacy of mival, it is suggested to use this PGR in order to increase the growth of vegetative organs as well as reproductive attributes.

Keywords: Application method, Gibberellin, Krizatcin, Mival, Salicylic acid.

Abbreviations: GA: Gibberellic acid, KR: Krizatcin, MI: Mival, PGRs: Plant growth regulators, SA: Salicylic acid.

INTRODUCTION

Gladiolus (*Gladiolus hybridus* Hort.) is one of the four famous cut flowers in the world, which is extensively cultivated in many countries (Ji-gang *et al*., 2009; Singh, 1997). Due to its attractive shapes and colors, it is an ideal ornamental plant for gardens as well as cut flower (Barzegar *et al*., 2004). It has been known that growth regulators among the agriculture practices are the most favorable for promoting and improving plant growth (Eid and Abou-Leila, 2006). At present, due to their key role in the growth and developmental processes of plants, PGRs are used widely. Foliar sprays and drenches are the most common methods of application of growth regulators (Al-khassawneh *et al*., 2006). Although drench method allows more uniform control of plant height and uses less active material and lower concentrations of the growth regulator, it has higher labor costs than foliar sprays (Al-khassawneh *et al.*, 2006).

Gibberellins (GAs) are a family of plant hormones controlling many aspects of plant growth and development, including stem elongation, germination, and the transition from vegetative growth to flowering (Thomas *et al*., 2005; Gul *et al*., 2006). Pre-sowing treatment of corms with GA_3 proved effective in increasing the flower number, plant height and corm yield of gladiolus (Bhattacharjee, 1984; Roychowdhury, 1989). It was reported that GA_3 significantly increased the length of flower stalk of *Rosa hybrid* cv. Poison (Hashemabadi and Zarchini, 2010). Gul *et al.* (2006) reported that GA_3 accelerated flowering and enhanced plant height of *Araucaria heterophylla*. Salicylic acid is considered as a potent plant hormone because of its diverse regulatory roles in plant metabolism (Popova *et al*., 1997; Hayat and Ahmad, 2007). Exogenous application of SA may influence a range of diverse processes in plants, including seed germination, stomatal closure, ion uptake and transport, membrane permeability, photosynthetic and growth rate (El-Tayeb, 2005). Krizatsin (2-metyl phenoxy acetic acid) and mival (chlormethyl silatrane) are extensively used in Russia (Kazimirovskaya *et al*., 2001). These compounds have hormone-like activity and their impact on the growth of cells, formation of embryonic organs and improvement of embryo growth has been demonstrated (Voronkov *et al*., 2005; Voronkov *et al.*, 1978). It was found that soaking barley seeds in mival solution increased seed germination (Voronkov et al., 2005). Furthermore, mival treatment significantly improves the yield of tomatoes (by 8–24%) and sugar beets (by 10%) (Voronkov and Baryshok, 2010). Krizatcin is the homolog of the herbicide 2, 4-D, but it has no toxicity effect on the plants. It is one of the main secondary metabolites such as vitamins A and E, and therefore, enhances the strength and stability of the cell membrane and also stimulates sexual activities in both plants and animals.

The main aim of the present study was to determine the effectiveness of GA_3, SA, KR and MI on vegetative and reproductive parameters of *Gladiolus hybridus*.

MATERIALS AND METHODS

The experiment was carried out in a greenhouse at the Faculty of Agriculture and Natural Resources, Persian Gulf University (PGU), Bushehr, Iran (29° 169' N, 51° 129' E, elevation, 65 m). The corms were disinfected with a benomyl fungicide (0.2%) for 10 minutes just before planting and then corms were divided into two groups. Half of corms were applied as a pre-plant drench for 8 h at 0, 25, 50 mg L^{-1} for all chemical PGRs. The other half was used for spray treatments with SA, MI and KR at 0, 50, 100 mg L^{-1} and GA_3 at 0, 25, 50 mg L^{-1} (Nov. 15, 2008). The corms were planted on ridges (20 cm) at 8-10 cm depth. After harvesting flowering shoots in order to complete the growth of the corms, watering continued until leaves were yellow. Drip irrigation system was used for the experiment. After the appearance of floral stalk, traits including length of floral stalk, florets number, floret diameter, leaf area, leaf chlorophyll index and corm weight and volume were measured. Leaf area and leaf chlorophyll index were measured by portable leaf area meter (Model Cl-202) and chlorophyll meter (SPAD), respectively. The experiment was planned as factorial design in a completely randomized design with four replicates. Treatments included PGRs solutions (GA_3, SA, MI and KR) at various concentrations with two methods of application (drenched and foliar sprayed). All studied traits were subjected to analysis of variance. Statistical analysis of data was carried out by SAS and mean comparison was done by Duncan's multiple range test ($P<0.05$).

RESULTS

Length of floral stalk

Data presented in Table 1 showed that the application methods and PGRs had no significant effect on the length of floral stalk. However, the interaction of application methods × PGRs type × concentration was significant ($P<0.01$). The application of 50 mg L^{-1} of GA_3 and SA as spray significantly increased the length of floral stalk of gladiolus by 105.37 and 105.25 cm as compared to control (94.75 cm), respectively (Fig. 1).

Floret diameter

The floret diameter was significantly ($P<0.05$) affected by the interaction of application methods × PGRs type × concentration (Table 1). The highest floret diameter (14.25 mm) was obtained when the plants were sprayed with MI at 100 mg L^{-1} (Fig. 2).

Florets number

The number of florets was significantly affected by the interaction of PGRs type × application methods (Table 1). The maximum number of florets (16.25) was observed in the plants treated with MI at intermediate concentrations in both application methods (Fig. 3).

Table1. Analysis of variance for *Gladiolus hybridus* to evaluate the effects of GA_3, SA, MI and KR treatments on studied traits.

		MS						
S. O. V.	df	Length of floral stalk	Floret diameter	Floret number	Leaf area	Corm weight	Corm volume	Leaf chlorophyll index
Application methods (A)	1	47.91 ^{ns}	0.041 ^{ns}	2.04 ^{ns}	311.3 ^{ns}	153.41**	38.64**	52.06*
PGRs (B)	3	21.58 ^{ns}	1.52 ^{ns}	7.52**	435*	1202.2**	807.55**	21.12 ^{ns}
Concentration (C)	2	199**	0.322 ^{ns}	6.50**	171.03 ^{ns}	1640.1**	2614.87**	36.81 ^{ns}
A ×B	3	42.70 ^{ns}	2.06 ^{ns}	1.40 ^{ns}	304.4 ^{ns}	285.6**	526.09**	45.70*
A×C	2	14.99 ^{ns}	0.01 ^{ns}	0.54 ^{ns}	82.55 ^{ns}	742.60**	512.46**	15.23 ^{ns}
B×C	6	65.75**	1.05 ^{ns}	4.73**	826.2**	680.42**	509.34**	31.07*
A×B×C	6	117.74**	1.91*	1.52 ^{ns}	223.8 ^{ns}	119.97**	149.07**	24.94 ^{ns}
Error	72	17.85	0.784	1.27	136.07	2.72	2.56	11.95

*: Significant at P< 0.05; **: Significant at P< 0.01; ns: not significant.

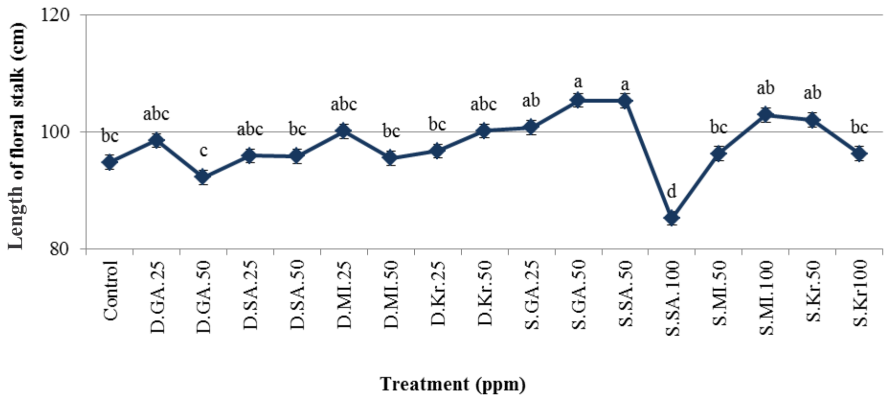

Fig.1. Interaction of application method × PGRs type × concentration for the length of floral stalk(D: drenched plant, S: sprayed plant).

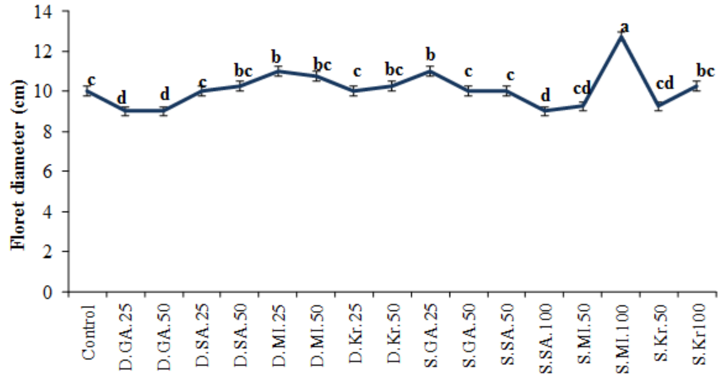

Fig. 2. Interaction of PGRs × application methods × concentration for floret diameter.

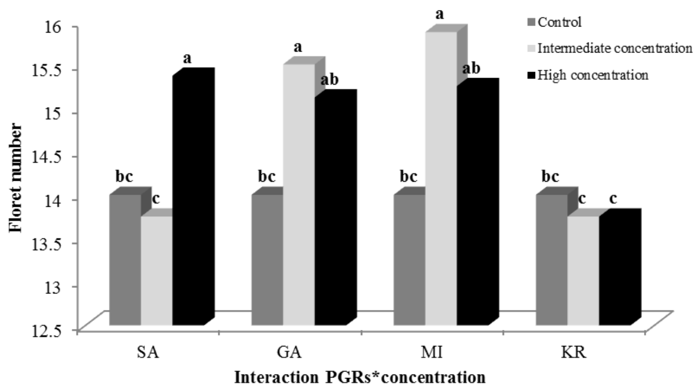

Fig.3. Interaction of hormone × concentrations for floret number.

Leaf area

Leaf area of gladiolus cut flowers was significantly ($P< 0.05$) affected by PGRs (Table 1). In addition, leaf area was significantly ($P<0.01$) affected by the interaction of PGRs type × concentration. The highest and the lowest leaf areas were related to the high concentrations of GA_3 and SA, respectively (Fig. 4).

Corm weight and volume

It was also revealed that application methods and different concentrations of PGRs had significant impact on the weight and volume of corm (Table 1). Moreover, these traits were significantly ($P<0.01$) affected by the interaction of application methods × PGRs type × concentration. Plants treated with MI at 25 mg L^{-1} had significantly higher weight and volume of corm.

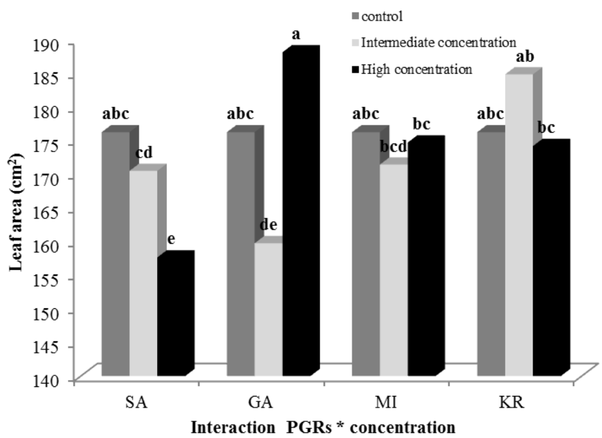

Fig.4. Interaction of PGRs type × concentrations for leaf area.

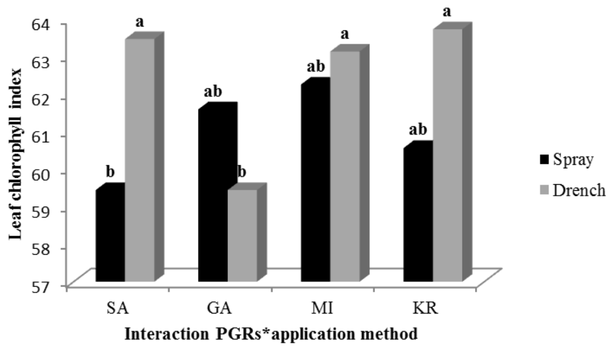

Fig.5. Interaction of PGRs × application method for leaf chlorophyll index.

Leaf chlorophyll index

There was no significant difference among PGRs types in terms of leaf chlorophyll index (Table 1). However, leaf chlorophyll index was significantly ($P<0.05$) affected by the interaction of PGRs type × concentration and also application methods × PGRs type (Table 1). The highest leaf chlorophyll index was observed in KR, SA and MI as drench application (Fig. 5).

DISCUSSION

In this study, it was found that PGRs treatments significantly improved some traits of gladiolus cut flowers as compared to control. Plants sprayed with GA_3 and SA at 50 mgL^{-1} exhibited significantly longer floral stalk. Our findings are in agreement with Hassanpour Asil *et al*. (2011) on *Polianthes tuberosa* and Al-Khassawneh *et al.* (2006) on *Iris nigricans* who indicated drenching with GA_3 increased the floral stalk height as compared to the control. It may be attributed to the effect of GA3 in stimulating and accelerating cell division, increasing cell elongation and enlargement, or both (Hartmann *et al*., 1990). In contrast to our results, Hashemabadi and Zarchini (2010) on cut rose (*Rosa hybrida* cv. Poison) reported that SA did not show any significant effect on flower stem height as compared to the control. In this study, the highest and lowest leaf areas were achieved in plants treated with high GA_3 and SA doses, respectively. Our findings are in agreement with Emongor (2004) who reported that GA_3 application increased petiole length and leaf area. Also, consistent with our results, Hassanpour Asil *et al*. (2011) indicated that the application of 50 and 100 mg L^{-1} of GA_3 significantly increased leaf length of *P. tuberosa* by 21.94 and 21.13 cm, respectively. Our results showed that plants sprayed with 100 mg L^{-1} MI exhibited significantly higher floret diameter. It seems that MI (chloromethyl silatrane) increases floret diameter through stimulating the growth of cells (Voronkov *et al.,* 2005).

The maximum number of florets was obtained in the plants treated with intermediate concentrations of MI and GA_3 and high concentration of SA. Our findings agree with Muchopadhyay and Banker (1983) who mentioned that the GA3 spray increased spike length and florets number per spike of *Polianthes*. In contrast to our results, Hassanpour Asil *et al.* (2011) reported that GA_3 reduced the number of florets.

In this research, the highest corm weight and volume was obtained when 25 mg L^{-1} MI was applied as drench to cut flowers, whereas the application of GA_3 reduced these traits in both application methods. In contrast to our results, Ram *et al*., (2002) reported that GA_3 increased corm weight of *Gladiolus*. This effectiveness of MI may be due to an increase in assimilate mobilization, as the water potential of the corm (the competitive sink) remained high aiding its growth and assimilate attraction.

CONCLUSION

Based on these results, it is concluded that the use of MI had major positive effects on florets number, floret diameter and corm weight and volume. Additionally, the application method showed no significant effect on the majority of traits in this experiment. SA showed the least effect among plant growth regulators applied to gladiolus cut flowers.

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