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Influence of arbuscular mycorrhiza, gibberellic acid and kinetin on growth, quality parameters and petal senescence in gladiolus cv. Jessica

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ABSTRACT

An experiment was conducted to study the influence of arbuscular mycorrhiza (AM) and plant growth regulators on growth, quality parameters, petal senescence and post harvest life of gladiolus cv. Jessica. The field experiment was laid out in randomized block design, replicated thrice, with two levels of gibberellic acid, *i.e.* 100, 200 and kinetin, *i.e.*, 50 and 100 ppm by dipping the corms overnight and foliar spray during growth period. The laboratory experiment was laid out in completely randomized design, replicated thrice, with sucrose 4 per cent and 8-HQC at 200 ppm as vase solution to increase the post-harvest life of flower. Pre-soaking and foliar spray of kinetin 50 ppm + AM was found to be the best for plant height, early emergence of spike, number of florets per spike and vase-life followed by pre-soaking and foliar spray of gibberellic acid 100 ppm + AM and pre-soaking with kinetin 50 ppm + AM. Reduced level of total protein, reducing sugar, starch, total anthocyanins, and total carotenoids content; and increased level of non-reducing sugar, and phenol content were noticed during petal senescence as compared to fresh, fully grown petals. However, higher concentration of kinetin and gibberellic acid reduced growth and post-harvest life of florets relative to lower concentration.

Key words: Arbuscular mycorrhizal gibberellic acid, gladiolus kinetin, 8-HQC, vase-life.

INTRODUCTION

Gladiolus is an important bulbous ornamental crop, valued for its wide range of flower colours, attractive shapes, varying sizes, large number of florets per spike, excellent keeping quality and popular as cut flower in the domestic and international market. Arbuscular Mycorrhiza (AM) plays an important role in increasing plant growth and health by improving availability of soil phosphorous and trace elements such as zinc, copper etc., improves root proliferation and reduces the disease symptoms. Kinetin and gibberellic acid helps in breaking dormancy, stimulates the synthesis of specific RNA for protein metabolism. Use of floral preservatives at all stages of flower handling and marketing known to improve the flower quality, longevity and better consumer acceptability. Prolonging the vase-life depends on water balance and retardation of petal senescence which can be achieved by the use of sucrose and certain chemicals (Beura and Singh, 3). Since, ethylene plays critical roles in flower senescence; it is desirable to inhibit the ethylene action. Although, the involvement of plant growth hormones in senescence process of flowers has been thoroughly investigated, however, the actual mechanism of action is still not clear (Bhattacharjee, 5). Therefore, the present investigation was undertaken with the objective to investigate the effect of AM with plant growth regulators on growth, quality parameters and cause of petal senescence in gladiolus cv. Jessica.

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MATERIALS AND METHODS

The field experiment was laid out in randomized block design, replicated thrice, with two levels of gibberellic acid, *i.e.* 100 and 200 ppm and kinetin, *i.e.* 50 and 100 ppm by dipping the corms overnight and foliar spray during growth period at Horticulture Farm, CCS Haryana Agricultural University, Hisar. Gladiolus corms were planted at spacing of 30 cm x 30 cm using arbuscular mycorrhiza (AM) inoculants a 20 g per plant. Foliar spray in the respective treatment combinations was applied at 45 days after planting of the corms. The treatment combinations used was T_1 (control), T_2 (pre-soaking with GA_3 100 ppm + AM), T_3 (pre-soaking with GA_3 100 ppm + AM), T_4 (pre-soaking with kinetin 50 ppm + AM), T_5 (pre-soaking with kinetin 100 ppm + AM), T_6 (foliar spray of GA_3 100 ppm + AM), T_7(foliar spray of GA_3 200 ppm + AM), T_8(foliar spray of kinetin 50 ppm + AM), T_9 (foliar spray of kinetin 100 ppm + AM), T_{10} (pre-soaking and foliar spray of GA_3 100 ppm + AM), T_{11} (pre-soaking and foliar spray of GA_3 200 ppm + AM), T_{12} (pre-soaking and foliar spray of kinetin 50 ppm + AM), T_{13} (pre-soaking and foliar spray of kinetin 100 ppm + AM).

The laboratory experiment was laid out in completely randomized design, replicated thrice, with 4 percent sucrose and 8-HQC at 200 ppm as vase

solution to increase the post-harvest life of cut flower. The flowers were harvested in the afternoon using sharp secateurs. Gladiolus were cut when basal floret just showed colour and immediately put in the bucket containing cold water. The basal portion of the stem was re-cut at 2 cm from the point of previous cut. Selected five cut flowers of all treatment combinations were kept in each graduated conical flask having 4 percent sucrose and 8-HQC at 200 ppm. The pH 3.5 of the standard solution was maintained by adding citric acid.

The observations were recorded on various parameters, *viz.*, days taken for sprouting of corms, plant height, number of days required for spike initiation, total number of florets per spike, fresh weight of cut spike, daily elongation of spike, days to elongation of spike, length of floret, floret diameter, water uptake, water loss, time required for opening of basal floret, number of days to senescence of basal floret, number of florets per spike open at the time of senescence of basal floret, number of florets per spike open before stem collapse, longevity, total proteins, reducing sugar, non-reducing sugar, total carbohydrates, starch, phenol, total anthocyanins, total carotenoids and pH. The data were recorded on five plants and the mean values of the data were statistically analyzed as per Panse and Sukhatme (13).

RESULTS AND DISCUSSION

The data presented in Table 1 showed that the minimum number of days required for sprouting of corms was in pre-soaking of kinetin 50 ppm + AM. Significant increase in plant height was noticed under pre-soaking and foliar spray of kinetin 50 ppm + AM which was at par with pre-soaking of kinetin 100 ppm + AM and differed significantly with pre-soaking and foliar spray of gibberellic acid 100 ppm + AM. Increased plant height might be due to higher level of mycorrhizal colonization due to symbiotic relationship with the plants and growth regulators (Baylis, 2). However, earliness in spike emergence and maximum florets per spike was recorded in pre-soaking and foliar spray of kinetin 50 ppm + AM followed by pre-soaking and foliar spray of kinetin 100 ppm + AM and pre-soaking and foliar spray of gibberellic acid 100 ppm + AM. The similar findings were noted by Baskaran and Misra (1), and Patel *et al.* (14).

Significant fresh weight of spike under all treatments was noticed except foliar spray of kinetin 100 ppm + AM. Maximum fresh weight of spike was recorded under pre-soaking and foliar spray of kinetin 50 ppm + AM. Earliness in spike emergence, maximum florets per spike and fresh weight of spike at the time of harvesting might be due to increased phosphorous uptake, better nutrient absorption during reproductive phase, increased rate of photosynthesis as a result of symbiotic relationship of AM (Meyer, 12; Singh *et al.*, 16).

Elongation of the cut-flower spike and period was significantly increased by all the treatment combinations over the control (3.42 mm and 5.02 days) except foliar spray of kinetin 100 ppm + AM (3.89 mm and 5.11 days). Maximum diameter of basal floret (10.65 cm) was observed in pre-soaking and foliar spray of kinetin 50 ppm + AM and the minimum diameter was recorded in control (7.98 cm). The increased rate of elongation of spike and diameter of basal floret was also observed by Sharma and Singh (15). Length and diameter of flower might have enhanced due to increase in the length of petals and pedicel (Carpenter and Carlson, 6; Gabryszewska, 9).

The data presented in Table 2, show significant increase in water uptake and water loss except foliar spray of kinetin 100 ppm + AM. Pre-soaking and foliar spray of kinetin 50 ppm + AM was the most effective in increasing the water uptake (10.83 ml/spike/day) and reducing the water loss (3.07 ml/spike/day). Increased water uptake and minimum water loss might be due to presence of sucrose in holding solution that provides energy, act as anti-desiccant for greater water conductivity, reduced bacterial growth in holding solution (Danaee *et al.*, 7).

All the plant growth regulators in association with AM significantly increased the time required for opening of basal floret as compared to control (2.02 days). Delayed period for opening of basal floret (5.56 days), senescence of basal floret (10.36 days) and maximum number of florets per spike at the time of senescence of basal floret (9.25) was observed under pre-soaking and foliar spray of kinetin 50 ppm + AM. Opened florets per spike were prolonged by all the treatment combinations except foliar spray of kinetin 50 ppm + AM (4.25) and foliar spray of kinetin 100 ppm + AM (4.20). Increased number of florets per spike was most pronounced under pre-soaking and foliar spray of kinetin 50 ppm + AM (9.28) followed by pre-soaking and foliar spray of kinetin 100 ppm + AM (8.24). Longevity of the cut-flowers was significantly increased by pre-soaking and foliar spray of kinetin 50 ppm + AM (17.45 days) over control. Extended life of cut flowers might be due to the result of anti-bacterial properties of quinoline salts resulted more water absorption. Similar findings were reported by Bharathi and Kumar (4) for prolonging vase-life of cut tuberose spikes.

The data presented in Tables 3 and 4 represents the bio-chemical parameters that affect the longevity of cut-flowers as fresh and at petal senescence. In fully open fresh petal, pre-soaking and foliar spray of kinetin 50 ppm + AM was the most effective in

Table 1. Effect of arbuscular mycorrhiza, gibberellic acid and kinetin on growth parameters of gladiolus cv. Jessica.

Treatment	Days taken for sprouting of corms	Plant height (cm)	No. of days required for spike initiation	Total No. of florets per spike	Fresh weight of cut spike (g)	Daily elongation of spike (mm)	Days to elongation of spike	Floret length (cm)	Floret dia. (cm)
T_1 (control)	18.45	60.76	75.03	12.49	56.85	3.42	5.02	8.97	7.98
T_2 (Pre-soaking with GA_3 100 ppm + AM)	13.91	70.11	73.41	13.44	66.90	6.48	5.61	9.46	9.11
T_3 (Pre-soaking with GA_3 100 ppm + AM)	14.43	69.43	73.90	13.33	66.54	5.99	5.27	9.3	9.01
T_4 (Pre-soaking with kinetin 50 ppm + AM)	12.64	72.24	68.20	14.47	69.13	6.80	7.89	9.52	9.32
T_5 (Pre-soaking with kinetin 100 ppm + AM)	12.94	71.47	69.16	13.59	68.80	6.79	6.98	9.48	9.29
T_6 (Foliar spray of GA_3 100 ppm + AM)	16.51	69.12	71.10	15.44	64.40	8.77	11.25	9.59	9.47
T_7 (Foliar spray of GA_3 200 ppm + AM)	16.93	67.75	72.03	15.05	62.56	8.72	8.57	9.56	9.37
T_8 (Foliar spray of kinetin 50 ppm + AM)	17.74	67.47	73.37	13.27	61.42	5.67	5.20	9.11	8.89
T_9 (Foliar spray of kinetin 100 ppm + AM)	17.98	67.16	74.34	12.69	58.13	3.89	5.11	9.02	8.00
T_{10} (Pre-soaking and foliar spray of GA_3 100 ppm + AM)	13.20	70.74	70.00	17.71	68.48	11.32	12.11	9.64	9.82
T_{11} (Pre-soaking and foliar spray of GA_3 200 ppm + AM)	13.34	70.68	70.84	15.50	67.68	10.26	11.65	9.62	9.48
T_{12} (Pre-soaking and foliar spray of kinetin 50 ppm + AM)	11.62	75.64	66.10	18.60	74.65	15.01	13.00	11.18	10.65
T_{13} (Pre-soaking and foliar spray of kinetin 100 ppm + AM)	12.53	72.72	67.58	18.24	73.08	13.48	12.35	9.85	9.91
CD (P = 0.05)	1.39	1.70	3.50	0.63	2.34	1.33	0.37	0.45	0.76

Table 2. Effect of arbuscular mycorrhiza, gibberellic acid and kinetin on quality parameters of gladiolus cv. Jessica

Treatment	Water uptake (ml/ spike/ day)	Water loss (ml/spike/ day)	Time required for opening of basal floret (days)	No. of days to senescence of basal floret	No. of florets / Open spike at the time of senescence of basal floret	No. of florets/ open spike before stem collapse	Longevity (days)
T_1 (control)	3.80	3.18	2.02	6.25	3.96	4.16	7.18
T_2 (Pre-soaking with GA_3 100 ppm + AM)	7.37	5.77	3.66	7.03	4.32	6.18	9.50
T_3 (Pre-soaking with GA_3 100 ppm + AM)	7.18	5.71	3.43	6.86	4.27	5.26	9.39
T_4 (Pre-soaking with kinetin 50 ppm + AM)	7.84	5.78	4.38	7.44	5.12	7.32	12.66
T_5 (Pre-soaking with kinetin 100 ppm + AM)	7.76	5.60	4.17	6.91	4.66	6.85	11.15
T_6 (Foliar spray of GA_3 100 ppm + AM)	8.75	4.62	4.64	8.59	6.36	8.02	14.24
T_7 (Foliar spray of GA_3 200 ppm + AM)	8.63	5.04	4.54	8.22	5.28	7.73	14.03
T_8 (Foliar spray of kinetin 50 ppm + AM)	4.98	4.72	3.2	6.86	4.14	4.25	9.08
T_9 (Foliar spray of kinetin 100ppm + AM)	4.11	3.61	2.32	6.55	4.08	4.20	7.77
T_{10} (Pre-soaking and foliar spray of GA_3 100 ppm + AM)	9.59	3.64	4.84	9.38	6.60	8.12	15.23
T_{11} (Pre-soaking and foliar spray of GA_3 200 ppm + AM)	9.34	4.3	4.67	9.29	6.31	8.07	15.16
T_{12} (Pre-soaking and foliar spray of kinetin 50 ppm + AM)	10.83	3.07	5.56	10.36	9.25	9.28	17.45
T_{13} (Pre-soaking and foliar spray of kinetin 100 ppm + AM)	9.95	3.56	4.95	9.40	7.85	8.24	17.02
CD (P = 0.05)	0.66	0.48	0.40	0.64	0.23	0.34	0.36

Table 3. Effect of arbuscular mycorrhiza, gibberellic acid and kinetin on biochemical changes in petal of gladiolus cv. Jessica.

Treatment	Total proteins (mg/g)		Reducing sugar (mg/g)		Non-reducing sugar (mg/g)		Total carbohydrates (mg/g)	
	Fresh	Senescence	Fresh	Senescence	Fresh	Senescence	Fresh	Senescence
T_1 (control)	59.34	38.48	10.60	6.91	6.18	26.07	17.10	34.35
T_2 (Pre-soaking with GA_3 100 ppm + AM)	51.89	46.75	13.01	10.04	3.36	11.22	16.55	21.85
T_3 (Pre-soaking with GA_3 100 ppm + AM)	52.81	45.74	11.51	8.19	3.69	14.22	15.39	23.16
T_4 (Pre-soaking with kinetin 50 ppm + AM)	51.23	45.49	14.56	11.48	3.35	7.71	18.09	19.60
T_5 (Pre-soaking with kinetin 100 ppm + AM)	53.55	45.77	14.08	11.24	3.69	10.19	17.96	21.97
T_6 (Foliar spray of GA_3 100 ppm + AM)	52.35	46.52	16.81	12.45	3.29	6.34	20.27	19.12
T_7 (Foliar spray of GA_3 200 ppm + AM)	52.44	46.62	14.72	12.45	3.14	7.65	18.02	20.54
T_8 (Foliar spray of kinetin 50 ppm + AM)	48.97	46.30	10.60	7.79	3.78	14.67	14.58	23.23
T_9 (Foliar spray of kinetin 100ppm + AM)	55.48	46.53	10.60	7.38	5.89	20.32	16.80	28.77
T_{10} (Pre-soaking and foliar spray of GA_3 100 ppm + AM)	49.18	46.37	19.06	13.97	2.27	5.63	21.45	19.90
T_{11} (Pre-soaking and foliar spray of GA_3 200 ppm + AM)	57.04	46.59	17.19	12.93	2.83	6.34	20.17	18.62
T_{12} (Pre-soaking and foliar spray of kinetin 50 ppm + AM)	54.05	50.55	21.34	15.02	1.91	3.48	23.35	18.60
T_{13} (Pre-soaking and foliar spray of kinetin 100 ppm + AM)	51.52	49.45	19.59	14.54	2.15	4.11	21.85	18.14
CD (P = 0.05)	1.15	0.56	0.93	0.56	0.69	0.42	0.98	0.68

Table 4. Effect of arbuscular mycorrhiza, gibberellic acid and kinetin on biochemical changes in petal of gladiolus cv. Jessica.

Treatment	Starch (mg/g)		Phenol (mg/g)		Total anthocyanins (mg/g)		Total carotenoids (mg/g)		pH at petal senescence (std. pH 3.5)
	Fresh	Senescence	Fresh	Senescence	Fresh	Senescence	Fresh	Senescence	
T_1(control)	1.09	0.46	1.95	2.32	0.62	0.32	0.81	0.75	4.34
T_2 (Pre-soaking with GA_3 100 ppm + AM)	2.31	0.88	1.49	1.92	0.82	0.52	1.37	1.10	4.04
T_3 (Pre-soaking with GA_3 100 ppm + AM)	2.14	0.87	1.55	1.92	0.77	0.47	1.34	0.85	4.07
T_4 (Pre-soaking with kinetin 50 ppm + AM)	2.51	0.95	1.41	1.76	0.85	0.74	1.42	1.00	4.02
T_5 (Pre-soaking with kinetin 100 ppm + AM)	2.51	0.92	1.43	1.76	0.85	0.50	1.39	0.99	4.11
T_6 (Foliar spray of GA_3 100 ppm + AM)	2.88	1.08	1.33	1.67	0.97	0.91	1.42	1.12	3.99
T_7 (Foliar spray of GA_3 200 ppm + AM)	2.79	1.00	1.37	1.67	0.91	0.90	1.42	0.93	3.96
T_8 (Foliar spray of kinetin 50 ppm + AM)	2.14	0.65	1.60	2.14	0.77	0.40	1.21	0.92	4.18
T_9 (Foliar spray of kinetin 100ppm + VAM)	1.67	0.60	1.69	2.20	0.63	0.37	1.19	0.82	4.12
T_{10} (Pre-soaking and foliar spray of GA_3 100 ppm + AM)	3.38	1.13	1.28	1.41	1.05	1.02	2.53	1.22	3.84
T_{11} (Pre-soaking and foliar spray of GA_3 200 ppm + AM)	3.05	1.11	1.32	1.58	1.00	0.99	1.75	0.90	3.94
T_{12} (Pre-soaking and foliar spray of kinetin 50 ppm + AM)	3.54	1.34	1.14	1.17	1.71	1.12	3.54	1.27	3.49
T_{13} (Pre-soaking and foliar spray of kinetin 100 ppm + AM)	3.44	1.19	1.21	1.39	1.21	1.03	2.69	0.89	3.76
CD (P = 0.05)	0.47	0.31	0.14	0.28	0.29	0.07	0.08	0.18	0.18

enhancing the protein content (54.05 mg/g) except control. Increased protein content may be ascribed through specific activities of the protein and RNA which is maintained in the presence of kinetin. Majority of the plant growth regulators in association with AM was found effective in enhancing the reducing sugar. Reducing sugar (21.34 mg/g) and total carbohydrates content (23.35 mg/g) was found maximum in pre-soaking and foliar spray of kinetin 50 ppm + AM. Increased reducing sugar and total carbohydrates content might be due to more absorption of sucrose in petal that rapidly converted into reducing sugar (Li *et al.*, 10). Maximum starch (3.54 mg/g) and minimum phenol (1.14 mg/g) content was noticed in pre-soaking and foliar spray of kinetin 50 ppm + AM. Total anthocyanins content increased significantly irrespective of the treatment combinations. Improved anthocyanins (1.71 mg/g) and total carotenoids (3.54 mg/g) content was observed in pre-soaking and foliar spray of kinetin 50 ppm + AM. Enhanced pigmentation in petal might be due to higher concentration of pelargonidin (Davies *et al*., 8). However, reduced level of total proteins (50.55 mg/g), reducing sugar (15.02 mg/g), carbohydrates (18.60 mg/g), starch (1.34 mg/g), anthocyanins (1.12 mg/g) and total carotenoids (1.27 mg/g) content and increased level of non-reducing sugar (3.48 mg/g) and total phenols (1.17 mg/g) content was observed in pre-soaking and foliar spray of kinetin 50 ppm + AM at the time of petal senescence. Decrease in reducing sugar during petal senescence might be due to translocation from the perianth to other organs (Yammane, 17). Reduced level of starch content might be due to hydrolysis of starch during petal senescence. Whereas, increased level of phenols might be due to their leakage from the vacuole and their consequent interaction with remaining functional elements of the cells (Liebermann and Baile, 11). The total anthocyanins and carotenoids contents and their constituents decreased during petal senescence due to increase in pH of the standard vase solution. Increase of pH in vase solution resulted in accumulation of NH_3 and limit the carbohydrate content in the petal tissue which is responsible for low pigmentation.

Change of pH over the initial standard value 3.5 under various treatments are presented in Table 4 showed that all the treatments including control registered a considerable increase in pH. However, maximum pH 4.34 was noticed under control, which was significantly higher than all other treatments. Pre-soaking and foliar application in combination with AM particularly under kinetin gave the most pronounced response with respect to reduction in pH. Low pH throughout the vase-life might prevent bacterial growth, increased water conductivity of stems and inhibited vascular blockage resulting in increased longevity.

During entire experimentation, lower concentration of kinetin and gibberellic acid in association with arbuscular mycorrhiza incorporation within the soil vicinity provided better response than their higher doses. The changes occurred in the cut-flower, when placed in standard solution of 8-HQC (200 ppm) + sucrose (4%) during vase-life and the factors are more responsible for its better longevity. The plant growth, flowering parameters, physiological and bio-chemical changes during vase-life were significantly increased by the treatment combination, *viz*., pre-soaking and foliar spray of kinetin 50 ppm + AM followed by pre-soaking and foliar spray of gibberellic acid 100 ppm + AM and pre-soaking with kinetin 50 ppm + AM. Reduced level of total proteins, reducing sugar, starch, total anthocyanins and carotenoids content and increased level of non-reducing sugar, and total phenols content was noticed during petal senescence as compared to fresh, fully grown petals. These findings highlight the probable cause of petal senescence during vase-life.

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