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Postharvest Life of *Gladiolus grandiflorus* L. cv. Jessica as Influenced by Pre-harvest Application of Gibberellic Acid and Kinetin

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Abstract

Effect of pre-harvest sprays of gibberellic acid and kinetin on postharvest life of gladiolus *cv.* Jessica was assessed. The field experiment was laid out in randomized block design, replicated thrice, with two levels of gibberellic acid (100 and 200 ppm) and kinetin (50 and,100ppm) 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 percent and 8-HQC at 200ppm as vase solution to increase the postharvest life of cut flower. The plant growth regulators significantly enhanced the postharvest life of cut gladiolus spike. Pre-soaking and foliar spray of gibberellic acid 100ppm was the best for early emergence of spike, maximum number of florets per spike, daily elongation of spike and enhanced period for elongation of spike, increased water uptake, delayed opening of basal floret, more number of florets per spike open at the time of senescence of basal floret and before stem collapse, prolonged longevity, increased total anthocyanin, carotenoid content and reduced pH of vase solution.

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. In gladiolus, spike length, number of florets per spike, size and colour of floret are some of the characters used for determining quality. Kinetin and gibbrellic acid helps in breaking dormancy, stimulates the synthesis of specific RNA for protein metabolism. Cut flowers are living actively metabolizing plant part and petals are an excellent model system for the study of fundamental senescence processes. If flowers are to provide their longest possible decorative role, controlled rate of opening or their development is needed with colour stability.

Cut flowers have complex nature that requires special attention in developing handling technique, concentration of sugar and other substances for pulsing and bud opening of cut flower. Use of floral preservatives at all stages of flower handling and marketing known to improve

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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, 2002). Although, the involvement of plant growth hormones in senescence process of flowers has been thoroughly investigated, however, the actual mechanism of action still is not clear (Bhattacharjee,1999). Therefore, the present investigation was undertaken with the objective to investigate the effect of plant growth regulators on physiological and quality parameters for enhancing postharvest life of gladiolus cv. Jessica.

MATERIALS AND METHODS

Experimental Treatments and Design

The field experiment was laid out in randomized block design, replicated thrice, with two levels of gibberellic acid (100 and 200ppm) and kinetin (50 and 100ppm) by dipping the corms overnight and foliar spray during growth period for the response as pre-harvest application at Horticulture Farm, CCS Haryana Agricultural University, Hisar. Gladiolus corms were planted at spacing of 30cm x 30cm. 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 100ppm), T_3 (pre-soaking with GA_3 200ppm), T_4 (pre-soaking with kinetin 50ppm), T_5 (pre-soaking with kinetin 100ppm), T_6 (foliar spray of GA_3 100ppm), T_7 (foliar spray of GA_3 200ppm), T_8 (foliar spray of kinetin 50ppm), T_9 (foliar spray of kinetin 100ppm), T_{10} (pre-soaking and foliar spray of GA_3 100ppm), T_{11} (pre-soaking and foliar spray of GA_3 200ppm), T_{12} (pre-soaking and foliar spray of kinetin 50ppm), T_{13} (pre-soaking and foliar spray of kinetin 100ppm). The laboratory experiment was laid out in completely randomized design, replicated thrice, with 4 percent sucrose and 8-HQC at 200ppm as vase solution to increase the postharvest life of gladiolus 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 200ppm. The pH 3.5 of the standard solution was maintained by adding citric acid. The observations were recorded on various parameters, *viz.* number of days required for spike initiation, total number of florets per spike, fresh weight of cut spike, daily fresh weight changes of cut spike, days to fresh weight changes, 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 anthocyanin, total carotenoid and pH of the vase solution. The data were recorded on five plants and the mean values of the recorded data were statistically analyzed as per Panse and Sukhatme (1995).

RESULTS AND DISCUSSION

Physiological Parameters

The data presented in Table 1 showed that the effect of various pre-harvest treatment combinations of gibberellic acid and kinetin significantly differed in physiological parameters. Earliness in spike emergence was recorded in pre-soaking and foliar spray of gibberellic acid 100ppm (63.50 days) followed by pre-soaking with gibberellic acid 100ppm (65.05 days) and pre-soaking and foliar spray of kinetin

100ppm (67.38 days). Whereas, maximum florets per spike was noticed in pre-soaking and foliar spray of gibberellic acid 100ppm (19.35) followed by foliar spray of gibberellic acid 200ppm (17.67). The similar findings were noted in gladiolus (Baskaran and Misra, 2007; Mishra et al., 2008 and Patel et al., 2010). Earliness in spike initiation may be due to the extension growth caused by increased photosynthesis with enhanced CO_2 fixation or gibberellic acid hastened the differentiation of floral primordial. Ginzburg (1974) confirmed gibberellic acid responsible for the assimilate movement towards the inflorescence at the expense of the gladiolus corm, which might have influence early emergence of gladiolus flower spike.

Table 1. Effect of gibberellic acid and kinetin on physiological parameters of *Gladiolus grandiflorus* L. cv. Jessica

Treatments	No. of Days Required for Spike Initiation	Total No. of Florets per spike	Fresh Weight of Cut Spike (g)	Daily Fresh Weight Changes (g)	Days to Fresh Weight Changes	Daily Elongation of spike (mm)	Days to Elongation of spike	Length of Floret (cm)	Diameter of Floret (cm)
T_1(control)	71.00	14.96	68.45	4.33	8.12	5.61	6.08	9.53	8.86
T_2 (Pre-soaking with GA_3 100ppm)	65.05	18.97	72.54	5.14	10.37	6.76	11.58	9.95	10.05
T_3 (Pre-soaking with $GA_3$200ppm)	65.11	18.57	74.83	5.01	9.03	6.94	11.26	9.84	9.89
T_4 pre-soaking with Kinetin 50ppm)	72.44	14.82	67.10	1.10	5.30	3.74	9.71	9.83	10.04
T_5 (Pre-soaking with Kinetin 100ppm)	70.83	14.54	64.87	1.12	5.95	3.50	7.79	10.14	9.86
T_6 (Foliar Spray of GA_3 100ppm)	67.85	18.86	69.43	5.35	10.52	5.97	13.91	9.74	10.10
T_7 (Foliar Spray of GA_3 200ppm)	67.98	17.67	68.75	5.48	10.62	6.82	13.32	9.80	9.75
T_8 (Foliar Spray of Kinetin 50ppm)	69.47	14.05	65.35	2.62	6.44	4.29	10.27	10.50	10.06
T_9 (Foliar Spray of Kinetin 100ppm)	69.69	14.43	71.28	4.31	8.01	4.90	10.07	9.31	10.06
T_{10} (Pre-Soaking and Foliar Spray of GA_3 100ppm)	63.50	19.35	77.03	6.24	6.74	7.61	14.50	10.06	10.42
T_{11} (Pre-Soaking and Foliar Spray of GA_3 200ppm)	63.52	18.56	78.94	6.29	12.02	7.27	14.15	10.36	10.53
T_{12} (Pre-Soaking and Foliar Spray of Kinetin 50ppm)	68.38	14.65	61.70	3.12	6.28	4.34	13.16	10.69	10.21
T_{13} (Pre-Soaking and Foliar Spray of Kinetin 100ppm)	67.38	12.99	59.70	3.52	6.63	4.27	13.08	10.87	10.43

CD (P = 0.05)	**2.36**	**1.49**	**1.55**	**0.34**	**0.28**	**0.55**	**0.30**	**0.51**	**0.08**

Table 2. Effect of gibberellic acid and kinetin on quality parameters of *Gladiolus grandiflorus* L. cv. Jessica

Treatments	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 /Spike Open at the time of Senescence of Basal Floret	No. of Florets/Spike Open Before Stem Collapse	Longevity (Days)	Total Anthocyanin (mg/g)	Total Carotenoid (mg/g)	pH
T_1(control)	4.59	8.03	2.08	6.30	4.57	4.45	12.28	0.26	0.73	4.17
T_2 (Pre-soaking with GA_3 100ppm)	9.16	4.88	3.17	8.27	5.43	6.24	15.32	1.14	1.34	3.91
T_3 (Pre-soaking with $GA_3$200ppm)	9.06	4.58	3.08	8.43	5.40	5.73	14.93	1.09	1.24	3.96
T_4 pre-soaking with Kinetin 50ppm)	6.99	3.74	2.68	7.84	5.13	5.11	13.38	0.44	1.11	4.03
T_5 (Pre-soaking with Kinetin 100ppm)	5.28	4.11	4.33	8.05	4.83	5.01	12.61	0.35	1.09	4.06
T_6 (Foliar Spray of GA_3 100ppm)	9.28	4.93	5.05	9.44	7.27	7.15	16.34	1.67	2.47	3.85
T_7 (Foliar Spray of GA_3 200ppm)	9.68	5.07	4.25	9.84	7.16	6.90	16.21	1.48	2.24	3.88
T_8 (Foliar Spray of Kinetin 50ppm)	5.30	3.91	3.17	9.14	5.29	5.84	14.49	0.59	1.19	4.00
T_9 (Foliar Spray of Kinetin 100ppm)	6.08	4.20	3.15	10.20	5.18	5.21	14.04	0.59	1.16	4.01
T_{10} (Pre-Soaking and Foliar Spray of GA_3 100ppm)	12.93	5.36	6.00	9.13	8.03	8.13	16.70	1.72	4.25	3.55
T_{11} (Pre-Soaking and Foliar Spray of GA_3 200ppm)	11.12	5.40	5.30	9.14	7.37	7.72	16.51	1.68	3.44	3.71
T_{12} (Pre-Soaking and Foliar Spray of Kinetin 50ppm)	5.10	4.89	3.93	10.13	7.07	6.27	16.06	1.27	1.46	3.93
T_{13} (Pre-Soaking and Foliar Spray of Kinetin 100ppm)	5.81	5.50	3.27	10.08	6.69	6.24	15.43	1.26	1.39	3.93
CD (P = 0.05)	**0.40**	**0.31**	**0.16**	**0.34**	**0.31**	**0.35**	**1.53**	**0.36**	**0.10**	**0.17**

Significant differences in fresh weight of cut spike under all treatments were noticed. Maximum fresh weight of cut spike was recorded under pre-soaking and foliar sprays of gibberellic acid 200ppm (78.94g) followed by pre-soaking and foliar spray of gibberellic acid 100ppm (77.03g). Earliness in spike emergence, maximum florets per spike and fresh weight of spike at the time of harvesting might be due to increased rate of photosynthesis (Singh et al., 2008). However, significant daily fresh weight changes (6.29g) and prolonged days to fresh weight changes (12.02 days) was recorded with pre-soaking and foliar sprays of gibberellic acid 200ppm followed by foliar spray of gibberellic acid

200ppm. Padmalatha et al. (2013) also revealed that gibberellic acid is responsible for maximum spike length and weight, number of florets per spike and spike vase life of gladiolus.

Daily elongation of the cut-flower spike and period was significantly increased in pre-soaking and foliar spray of gibberellic acid 100ppm (7.61mm and 14.50 days). While, increased length of floret (10.87cm) was associated with pre-soaking and foliar spray of kinetin (100ppm). These results corroborate with the findings of Nagarjuna and Gowda (1998) in tuberose. Increased elongation of spike may be attributed due to more water uptake but increased rate of elongation was observed over a certain period after that elongation was sustained might be due to high water potential maintained within the xylem vessels of cut spike or cells attained maximum enlargement.

Maximum diameter of basal floret (10.53cm) was observed in pre-soaking and foliar spray of gibberellic acid 200ppm followed by pre-soaking and foliar spray of gibberellic acid 100ppm (10.42cm) and the minimum diameter of basal floret was recorded in control (8.86cm). The increased rate of elongation of spike and diameter of basal floret was also observed by Sharma and Singh (2006). Length and diameter of flower might have enhanced due to increase in the length of petals and pedicel (Carpenter and Carlson, 1970, Gabryszewska, 2010), while decreased floret size associated with control may be due to the result of increase in viscosity of vase solution and decreased transpiration rate due to presence of sugar.

Quality parameters

The data presented in Table 2 revealed that significant increase in water uptake and water loss was associated with all treatment combinations. Pre-soaking and foliar spray of gibberellic acid 100ppm was the most effective in increasing the water uptake (12.93ml/spike/day) followed by pre-soaking and foliar spray of gibberellic acid 200ppm (11.12ml/spike/day and reducing the water loss (3.74ml/spike/day) in pre-soaking with kinetin 50ppm. 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 and inclusion of 8-HQC prevent wilting due to an anti transpirant activity (Danaee et al., 2011) and desiccation of the flower stems by inhibiting vascular blockage and allowed greater water conductivity (Larson and Cromarty, 1967).

All the plant growth regulators significantly increased the time required for opening of basal floret as compared to control (2.08 days). Delayed period for opening of basal floret (6.00days) and maximum number of florets per spike open at the time of senescence of basal floret (8.03) was observed under pre-soaking and foliar spray of gibberellic acid 100ppm. However, increased days for senescence of basal floret (10.20 days) were noticed under foliar spray of kinetin 100ppm. All the treatment combinations prolonged opened florets per spike before stem collapse over control (4.45). Increased number of opened florets per spike before stem collapse was most pronounced under pre-soaking and foliar spray of gibberellic acid 100ppm (8.13) followed by pre-soaking and foliar spray of gibberellic acid 200ppm (7.72) and foliar spray of gibberellic acid 100ppm (7.15). Enhancement in quality parameters may be due to the improved water balance in flowers throughout the vase life by closing the stomata and reducing water loss (Marousky, 1968).

Longevity of the cut-flowers was significantly increased by pre-soaking and foliar spray of gibberellic acid 100ppm (16.70 days) over control (12.28 days). Extended life of cut flowers might be due to the result of anti-bacterial properties of quinoline salts resulted more water absorption. Bharathi and Kumar (2009) reported the similar findings for prolonging vase life of cut tuberose spikes and Umrao et al. (2007) for spike durability in gladiolus. The improvement in vase life may also be due to the translocation of sugar from vase solution via cut spike stem and accumulation in the florets, increases their osmotic concentration and improve their ability to absorb water and maintain turgidity (Halevy, 1976). The main effects of applied sugar on flower longevity results from their contribution to their osmotic adjustment of the flowers and also helps in maintaining mitochondrial structure and function (Kaltaler and Steponkus, 1976), delaying the onset of senescence (Mayak et al., 1975) and maintaining the carbohydrate pool in petal (Rogers, 1973). The inclusion of 8-HQC in vase solution extends the vase life, are considered to be the reduction of vascular blockage, increase in water uptake and lowering of water loss through transpiration (Marousky 1968) and also helps in the acidification of vase solution due to presence of citrate ion which maintains the optimum pH. Thus, Waters (1966) indicated that no absolute method of measuring spike quality have been established, however, gladiolus longevity and other quality can be measured as floret opening and senescence as well as fresh weight and the effect of gibberellic acid on translocation of assimilates, extended vase life and delayed senescence may result from direct effect of gibberellic acid on cell senescence associated process which may prevent membrane permeability and subsequent leakage of electrolytes. Saeed et al. (2014) concluded that gibberellic acid applied at lower concentrations renders greater beneficial effects on vase life quality, membrane stability and antioxidant activities in gladiolus cut spike and higher application rates cause no improvement in the flower longevity.

Anthocyanin and Carotenoid Content

The amount of pigment content and changes in pH of the vase solution significantly affect the longevity of cut-flowers. The total anthocyanin and carotenoid contents were increased significantly irrespective of the treatment combinations over control. Improved anthocyanin (1.72mg/g) and total carotenoid (4.25mg/g) content was observed in pre-soaking and foliar spray of gibberellic acid 100ppm. These results are in close conformity with the findings of Suneetha and Kumar (1998). Enhanced pigmentation in petal might be due to higher concentration of pelargonidin (Davies et al., 1993). The induction of anthocyanin synthesis requires the presence of sugar in the medium and sugars may serve as specific signals for the activation of specific genes, as cellular osmotic regulators, or as general energy source of carbon metabolism in the developing flower (Delila et al., 1997).

Changes in pH

Change of pH over the initial standard value 3.5 under various treatment combinations including control registered a considerable increase in pH. Maximum pH was noticed under control (4.17) which was significantly higher than all other treatment combinations. Pre-soaking and foliar application of gibberellic acid 100ppm showed most pronounced response with respect to reduction in pH (3.55) followed by pre-soaking and foliar application of gibberellic acid 200ppm (3.71) and foliar application of gibberellic acid 100ppm (3.85). Low pH throughout the vase-life might prevent bacterial growth, increases water conductivity of stems and inhibits vascular blockage resulted the increased longevity. A strongly acid condition may inhibit endogenous enzyme essential for the stem plugging process as well as inhibit microbial growth. These results are in line with the findings of Marousky (1971).

CONCLUSION

During entire experimentation, the pre-harvest application of kinetin and gibberellic acid with various combinations showed better response for enhancing postharvest life of cut gladiolus spike. The changes occurred in the cut-flower, when placed in standard solution of 8-HQC (200ppm) + sucrose (4 per cent) during vase life and the factors are more responsible for its better longevity. The quality parameters, physiological and bio-chemical changes during vase-life were significantly influenced by the treatment combination *viz.* pre-soaking and foliar spray of gibberellic acid 100ppm and were responsible for the enhancement of postharvest life of cut flowers of gladiolus.

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