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Postharvest quality of gladiolus (*Gladiolus* (Tourn) L.) cut spike as affected by variable temperature and elevated carbon dioxide regimes

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ABSTRACT

Gladiolus (*Gladiolus* (Tourn) L.) is an important bulbous cut flower crop, known for its longer vase life and exhaustive range of colours. Gladiolus cultivars American Beauty and Snow Princess were grown at different temperature and carbon dioxide (CO_2) levels under phytotron condition at Indian Agricultural Research Institute, New Delhi (India) during 2009-2010. Temperature treatments given were 20/18 ºC (control), 26/24 ºC and 30/26 ºC (day/night) while CO_2 treatments studied were 400 ppm (control), 700 ppm and 900 ppm. The results indicated that at higher temperature, there was significant reduction in fresh weight of cut spike at harvest. Senescence was accelerated by increased temperature. There were small differences in vase life, in which the gladiolus plants grown at 20/18 ºC lasted significantly longer (12.40 day) than plants grown at 26/24 ºC (9.53 day) in cultivar Snow Princess. Spike length, water uptake and diameter of first and third florets decreased with increase in temperature level. At 30/26ºC temperature, spike initiation did not take place in both the cultivars studied. Different CO_2 levels had significant effect on fresh weight and vase life of cut spikes. As CO_2 concentration increased, there was significant increase in fresh weight of cut spike. The maximum fresh weight of cut spike (73.07 g) was obtained in 700 ppm CO_2 concentration. Spike length was increased with increase in the CO_2 concentration. Vase life was also increased as the CO_2 concentration increased and maximum was observed in 700 ppm (12.97 day).

Key words : Carbon dioxide, gladiolus, postharvest, temperature.

INTRODUCTION

Gladiolus (*Gladiolus* (Tourn) L.) is an easy-to-grow bulbous flower crop and especially valued for its use in floral arrangements. It is a very popular cut flower in both domestic as well as international trade. Gladiolus is among the top ranking cut flower crop in our country and its production in the recent years has increased rapidly. Cut flower market is highly competitive and only very high quality flowers that meet specific standards can find buyers. On many occasions cut flower production is felt less as compared to demand. Moreover, 40 to 50 per cent flowers are damaged during pre-harvest, harvest and post-harvest stages due to environmental factors and physical damage. The rise in global atmospheric carbon dioxide (CO_2) has been well documented. Carbon dioxide enrichment has been shown to increase growth of rice (Baker *et al*., 1990) and other crops (Cure and Acock,1986; Kimball, 1983). The combined effects of elevated CO_2 concentration and temperature may affect the growth and development of above and below the soil surface parts of gladiolus. Idso *et al.* (1987) reported that the proportional yield increase due to elevated CO_2 concentration, are often much larger under warmer temperatures.

Postharvest factors like storage temperature, light, humidity, use of floral preservative solution and damage during transport and storage, are the major factors which are responsible for the quality of flowers in markets. Besides these post-harvest factors, some pre-harvest factors are also important as these are also equally responsible for the quality of flowers. The pre-harvest factors like temperature at growing season, light, humidity, CO_2 concentration and incidence of disease and pest are most important. Keeping these points in view, the present study was undertaken to find out the effect of CO_2 enrichment and different temperature regimes on postharvest quality of gladiolus cvs. American Beauty and Snow Princess under phytotron conditions.

MATERIALS AND METHODS

The present study was conducted at the Division of Floriculture and Landscaping and National Phytotron Facility, Indian Agricultural Research Institute, New Delhi, during 2009-2010. Two commercial cultivars of gladiolus viz., American Beauty and Snow Princess were used for this study. Cut spikes grown under variable CO_2 and temperature treatments were harvested from the growth chambers. The closed plant growth chambers were maintained day and night with given regimes of temperature of 26/22 ºC and 30/26 ºC while 20/18 ºC day and night temperatures were kept as control. The elevated CO_2 concentrations were maintained day and night by inputting CO_2 from the pure CO_2 cylinder which is artificially supplied. This way, the elevated CO_2 concentrations were kept 700 ppm and 900 ppm higher than the ambient day and night time. Ambient concentration of (400 ppm) CO_2 was kept as control.The spikes were harvested from the growth chambers by using sharp knife when basal floret just showed colour and immediately put in the bucket containing water and were brought to the Post-Graduate Laboratory of Division of Floriculture and Landscaping, IARI, New Delhi. After that the basal portion of cut spikes was re-cut at 2 cm from the point of previous cut. Selected spikes were kept one each in the 200-ml glass test tube containing 20 per cent sucrose as vase solution. For both the experiments, 20 per cent sucrose was used at ambient temperature of 21 ±2 ºC coupled with 75 per cent relative humidity.

Observations on different parameters were recorded daily and whenever necessary. The cut spikes kept in the test tube containing 20 per cent sucrose as vase solution were observed every day for senescence and the total period of vase life was noted. The total number of days, when half of the florets on a spike wilted, was recorded as vase life. Floret diameter (cm) was measured from the first floret and the third floret on two perpendicular axis and average of two values was taken. Water uptake (ml) was measured as the difference in the amount of water in test tube from the initial to the final quantity. The fresh weight of cut spike (g) at harvest, on third day of vase life and at senescence was recorded using digital weighing balance. Care was taken that the cut ends of spikes were dipped in the water during weighing operation. Increase in spike length (cm) was measured. The difference in length of spike from initial to the senescence stage was considered as the increase in spike length. Data were statistically analysed and are presented in Tables 1 to 6.

RESULTS AND DISCUSSION

Perusal of data presented in Table 1 clearly indicated significant difference in different temperature regime treatments on fresh weight of individual spikes. There was complete absence of emergence of spike in temperature treatment T_3 (30/24 ºC day/night). The highest weight of individual spike among the treatments was obtained with treatment T_1 (59.40 g) followed by treatment T_2 (57.20 g). The genotypes did not differ significantly with respect to the fresh weight of cut spike. The highest weight of individual spike was found in treatment

T_1 (59.41g) with cultivar Snow Princess followed by treatment T_1 (59.39g) with cultivar American Beauty. The lowest weight of individual spike was found to be in treatment T_2 (56.68g) in cultivar Snow Princess. As there was increase in the temperature, there was significant reduction in fresh weight of spike. Adachi *et al*. (1999) in chrysanthemum cv. Shuho-no-chikara reported that in cut flowers, high temperatures trigger rapid increases and then subsequent decreases in fresh weight, dry weight and sugar content and promote rapid senescence in the capitula. This may be the possible reason for decrease in fresh weight of gladiolus spike at harvest.

It is evident from Tables 1 and 2 that there was significant variation in change of fresh weight of cut spikes at 3rd day, 6th day and at senescence stages. Increment of fresh weight of spike was recorded upto 6th day in both the studied cultivars and then decreases at the senescence. The maximum fresh weight of cut spike was observed at 3rd day in control treatment (20/18 ºC) in cv. American Beauty (73.02g) followed significantly by cv. Snow Princess (70.63g) in the same treatment. The fresh weight of cut spike started declining at 6th day as compared to 3rd day. More fresh weight of spike was observed in cv. American Beauty (65.42g), which was non- significant as compared to cv. Snow Princess (64.20g) in the same treatment. At senescence there was significant reduction in fresh weight of spike. Maximum fresh weight of cut spike was recorded in cv. Snow Princess (46.72g) in control treatment (20/18 ºC) while minimum fresh weight was observed in cv. American Beauty (73.02g) in treatment T_2 (26/24 ºC). Temperature had significant effect on fresh weight of cut spike in all the stages. As temperature increased from control treatment (20/18 ºC) to 26/24 ºC there was reduction in fresh weight of spike. Increase in fresh weight was maximum on third day, over fresh weight at harvest and sixth day weight however, reduced on the senescence day. These changes in fresh weight may be due to continuous increase in the senescence process. This may also be due to difference in pattern of respiration and ethylene production of cut spikes (Serek *et al*., 1994). Water consumption of cut spike varied markedly in different temperature regimes. In higher temperature regimes, water uptake was significantly increased. The highest water uptake (Table 3) was recorded in cv. Snow Princess (77.70 ml) in T_2 treatment (26/24 ºC) followed by the same cultivar under control treatment (20/

Table 1. Effect of different temperature regimes on fresh weight of gladiolus cut spike at different days interval

	Initial fresh weight of cut spike (g)				Fresh weight of cut spike at 3rd day (g)				Fresh weight of cut spike at 6th day (g)			
Treatment	T_1	T_2	T_3	Mean	T_1	T_2	T_3	Mean	T_1	T_2	T_3	Mean
American Beauty	59.39	57.51	0.00	58.45	73.02	68.11	0.00	70.57	65.42	62.89	0.00	64.15
Snow Princess	59.41	56.68	0.00	58.05	70.63	68.55	0.00	69.59	64.20	61.94	0.00	63.07
Mean	59.40	57.10	0.00	-	71.83	68.33	0.00	-	64.81	62.42	0.00	-
CD (P=0.05)												
	Treatment (T)			1.03				2.03				0.98
	Genotype (G)			1.01				1.01				NS
	T × G			1.21				2.46				1.80

T_1: 20/18 °C (control) day/night temperature, T_2: 26/24 °C; T_3: 30/26 °C; NS : Non Signifiant

Table 2. Effect of different temperature regimes on fresh weight of cut spike at senescence, water uptake and increase in spike length of gladiolus cut spike

	Fresh weight of cut spike (g) at senescence				Water uptake (ml)				Increase in spike length (cm)			
Treatment	T_1	T_2	T_3	Mean	T_1	T_2	T_3	Mean	T_1	T_2	T_3	Mean
American Beauty	41.31	36.11	0.00	38.71	70.67	72.70	0.00	71.68	4.26	3.80	0.00	4.03
Snow Princess	46.72	42.37	0.00	44.55	76.87	77.70	0.00	77.28	4.34	3.54	0.00	3.94
Mean	44.02	39.24	0.00	-	73.77	75.20	0.00	-	4.30	3.67	0.00	-
CD (P=0.05)												
	Treatment (T)			2.14				1.11				0.09
	Genotype (G)			1.01				0.95				NS
	T × G			1.97				1.48				0.47

T_1: 20/18 °C (control) day/night temperature, T_2: 26/24 °C; T_3: 30/26 °C; NS : Non Signifiant

Table 3. Effect of different temperature regimes on diameter of first and third floret and vase life of gladiolus cut spike

	Diameter of first floret (cm)				Diameter of third floret (cm)				Vase-life (day)			
Treatment	T_1	T_2	T_3	Mean	T_1	T_2	T_3	Mean	T_1	T_2	T_3	Mean
American Beauty	11.67	10.69	0.00	11.18	10.40	9.57	0.00	9.98	12.13	9.87	0.00	11.00
Snow Princess	12.01	10.31	0.00	11.16	10.12	9.36	0.00	9.74	12.40	9.53	0.00	10.96
Mean	11.84	10.50	0.00	-	10.26	9.47	0.00	-	12.27	9.70	0.00	-
CD (P=0.05)												
	Treatment (T)			0.06				0.22				0.45
	Genotype (G)			0.08				0.01				NS
	T × G			0.40				0.38				0.62

T_1: 20/18 °C (control) day/night temperature, T_2: 26/24 °C; T_3: 30/26 °C; NS : Non Signifiant

18 ºC) (76.87 ml). Compared to fresh weight of spike at harvest there was significant increase in uptake of water in T_2 treatment (26/24 ºC). Similar results were reported by Siegelman *et al*., (1958) and Coorts, (1973), where they suggested that high temperature accelerates respiratory activities and consumption of water and carbohydrates in cut flowers. There was variation in increment of cut spike length. Maximum increment was observed in control treatment (20/18 ºC), but as temperature increases in T2 treatment (26/24 ºC), there was increment in cut spike length but it was found meager compared to the control. Celikel and Karacaly (1995) reported longest longevity of flower during autumn and shortest during summer in carnation. Vase life of spikes showed significant variation under different temperature regimes. The longest vase life was observed in cv. Snow Princess (12.40 day) in control treatment (20/18 ºC). The lowest vase life was observed in T_2 treatment (9.53 day) in cv. Snow Princess. Similar results were reported by Leonard *et al.* (1995) in potted carnation. Increased longevity in response to decreasing temperatures have also been documented for

potted crocus, hyacinth, iris, muscari, narcissus and tulip (Nell *et al*., 1992).

Diameter of first floret (Table 3) in cut spikes of gladiolus cultivars ranged from 10.69 to 12.01 cm. The maximum floret diameter was observed in cv. Snow Princess in control treatment followed by cv. American Beauty. Diameter of third floret in cut spikes was smaller than that of first floret in both the cultivars studied. The diameter of third floret (Table 3) in cut spikes ranged from 9.36 to 10.40 cm. The maximum third floret size was recorded in control treatment (10.40) in cv. American Beauty, while minimum floret diameter was found in cv. Snow Princess in T_2 treatment (9.36 cm) followed by cultivar American Beauty (9.57 cm) in same treatment. In this experiment, diameter of basal floret was found maximum as compared to other terminal florets. It may be due to the presence of sufficient amount of reserved carbohydrates in basal floret than less developed terminal florets (Ferrira *et al*., 1986)

In the second experiment, significant increase in fresh weight of cut spike was obtained as the CO_2 concentration increased upto 700 ppm and further rise to 900 ppm led to reduction in fresh weight of cut spike (Table 4). Similar results were reported by Van Labeke and Dambre (1998) in alstroemeria, where flower stem weight decreased significantly with 900 ppm enrichment of CO_2. There was significant variation in change in fresh weight at 3rd day, 6th day and at senescence stages. The maximum cut spike weight at 3rd day was obtained in 700 ppm CO_2 concentration. Similarly, at 700 ppm CO_2 concentration, there was significant increase in cut spike weight in cv. American Beauty (77.69g) at 6th day after harvest. There was significant reduction in fresh weight of cut spike in 6th day compared to 3rd day after harvest. At senescence, there was significant reduction of weight over freshly harvested spike (Table 5). The minimum weight at senescence was observed in cv. American Beauty (50.31g) in control treatment (400 ppm) but higher weight of spike at senescence was observed at 700 ppm and 900 ppm CO_2 concentrations. The maximum water uptake was found in 700 and 900 ppm CO_2 concentrations over control (400 ppm). The significant difference was found in water uptake with different concentrations of CC_2. The maximum water uptake was recorded in 700 ppm treatment in cv. Snow Princess (Table 5). However, lowest water uptake was found in cv. American Beauty (76.73 ml) in control treatment (400 ppm). Cultivars also showed significant variation in water uptake and cv. Snow Princess reported highest uptake of water. There was

Table 4. Effect of different CO_2 levels on fresh weight of gladiolus cut spike at different days interval

	Initial fresh weight of cut spike (g)				Fresh weight of cut spike at 3rd day (g)				Fresh weight of cut spike at 6th day (g)			
Treatment	T_1	T_2	T_3	Mean	T_1	T_2	T_3	Mean	T_1	T_2	T_3	Mean
American Beauty	65.77	72.52	69.11	69.13	76.07	82.30	79.19	79.19	71.61	77.69	74.55	74.62
Snow Princess	67.42	73.62	70.27	70.4	75.94	80.76	78.16	78.29	70.1	76.48	73.65	73.41
Mean	66.60	73.07	69.69	-	76.01	81.53	78.68	-	70.86	77.08	74.1	-
CD (P=0.05)												
	Treatment (T)			1.75				2.11				1.03

Table 5. Effect of different CO_2 levels on fresh weight of cut spike at senescence, water uptake and increase in spike length of gladiolus cut spike

	Fresh weight of cut spike (g) at senescence				Water uptake (ml)				Increase in spike length (cm)			
Treatment	T_1	T_2	T_3	Mean	T_1	T_2	T_3	Mean	T_1	T_2	T_3	Mean
American Beauty	50.31	57.37	51.37	53.01	76.73	84.37	80.9	80.66	3.47	4.24	3.75	3.82
Snow Princess	57.49	62.22	60.03	59.91	85.57	88.53	85.93	86.68	4.33	4.85	4.71	4.63
Mean	53.9	59.79	55.70	-	81.15	86.45	83.42	-	3.90	4.54	4.23	-
CD (P=0.05)												
	Treatment (T)			2.51				2.87				0.13
	Genotype (G)			1.35				1.45				0.08
	T × G			3.52				4.32				0.34

T_1: 400 ppm (control); T_2: 700 ppm; T_3: 900 ppm; NS : Non Signifiant

Table 6. Effect of different CO_2 levels on vase life of cut spike of gladiolus

	Vase-life (days)			
Treatment	T_1	T_2	T_3	Mean
American Beauty	10.87	13.20	12.00	12.02
Snow Princess	10.73	12.73	11.60	11.68
Mean	10.80	12.97	11.80	-
CD (P=0.05)				
	Treatment (T)			0.78
	Genotype (G)			NS
	T × G			1.73

T_1: 20/18 °C (control) day/night temperature, T_2: 26/24 °C; T_3: 30/26 °C; NS : Non Signifiant

significant variation in increment of cut spike length with increased CO_2 concentration. The maximum increment of spike length was observed in 700 ppm CO_2 concentration followed by 900 ppm CO_2 concentration (Table 6). Cultivar Snow Princess showed highest increment of cut spike length in treatment 700 ppm CO_2 concentration. (4.85 cm), while lowest increment was found in cv. American Beauty (3.47 cm) in control treatment (400 ppm). Thus it is concluded that temperature and CO_2 significantly affected the post harvest life of cut spike of gladiolus. Increased temperature in growing season is harmful for vase life, while increased CO_2 helps increase the vase life.

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