Carmen Merodio and J.L. De la Plaza
Instituto del Frío (CSIC)
Ciudad Universitaria
28040 Madrid
Spain

Abstract

The effects of postharvest ethylene removal treatments on cut flowering stems of gladiolus were evaluated. "Green Keeper" was found effective in delaying flower wilting thus prolonging their vase life in white gladiolus and enhancing flower opening in pink gladiolus. Optimal conditions for treatments are discussed.

1. Introduction

The increasing production value of cut flowers in Spain, makes imperative to achieve a good keeping quality of harvested cut flowers. Moreover gladiolus is an important export crop, but after long distance transport it often reaches the consumer in a poor condition.

End of vase-life of these flowers is in direct connection with folding of the stem, wilting of the petals or discoloration of the flowers. These aspects are related to ethylene synthesis (Haley and Mayak, 1981). Involvement of ethylene in flower senescence of gladiolus was evidenced by the favourable effects of hypobaric storage (Staby et al., 1982) and treatments with ethylene synthesis inhibitors (Rudnick et al., 1986).

In the present study an attempt is made to encourage intensive flower development and to delay wilting of mature flowers by means of chemical absorption of ethylene. There are a few reports specifically concerned with these absorbants in association with flower marketing.

2. Materials and methods

Gladiolus, *Gladiolus grandiflora*, "white" and "pink" were cut in the commercial phase of harvest. The spikes were placed in vertical position into polyethylene bag into four different chambers equipped with an internal fan to promote air circulation.

Treatments were carried out at +2.5 °C, 95 % RH and exposure for periods of 10 h duration per day with white fluorescent lamps of 1000 lux irradiance. To study the

effect of ethylene removal, three different absorbants were used: Ethsorb (E), New Green Pack (NGP) and Green Keeper (GK). Commercial sachets of 5 g ethylene absorbant were included with each unit of spikes.

The color of five petals was determined by a Hunter Lab Color Difference Meter with 1 cm aperture at the equatorial diameter. For the toughness of stem, the maximum force on the force-deformation curve were determined with a Warner-Braztler shear cell incorporated in an Instron Universal Testing Machine.

Ethylene and carbon dioxide levels in the modified atmosphere were measured by gas chromatography. Samples of 1 ml of gas withdrawn from the bags were introduced into a Varian 3700 gas chromatograph equipped with a Porapak Q (80/100) column.

After 7 and 23 days in storage at +2.5 C, the spikes were transferred out of the chambers. 10 spikes per treatment were removed from storage and their vase-life analyzed at +20 C. The stems were re-cut by removing a 1 cm from the base of the stem, and they were placed in water. Vase life was considered to be finished when 50 % of the flowers on each stem had wilted.

Flower development under each treatment was noted and scored periodically. From each group of spikes the flowers at the different developmental stages were selected (Gorini and Poselello, 1972): Stage I, flower not fully open with only about 1 cm out; Stage II, flower open; Stage III, flower fully open; Stage IV, flower wilted.

3. Results

Figure 1 shows the levels of ethylene accumulated in the polyethylene bags containing the spikes with the different ethylene absorbants. In the control spikes, the maximum level of ethylene was achieved in the 4th day and then gradually declined to below 0.11 $\mu\text{l/l}$. In the sealed bags with E and NGP sachets the increase was small and the maximum levels were achieved by 5 days of storage with NGP. However, the bag with GK removed out of the atmosphere all detectable ethylene produced by the spikes, at 4 and 7 days of storage period.

Although the respiration rate of the flowers was not measured directly, we observed a lower CO_2 level in all the bags with absorbants at the end of the storage period, compared with CO_2 level in the gas without C_2H_4 absorption. These results could indicate that the removal of C_2H_4 from storage atmosphere contributed to a reduction in the respiration rate.

During the dry storage, the control spikes lost almost twofold of the fresh weight that the spikes held with different absorbants (table 1).

So, we studied ability of absorbants of ethylene to maintain turgor of spikes for a long time (days to wilt). The results in tables 1 and 2 show that in spikes with

absorbants it is possible to shear the fibers easier than in the spikes untreated.

The effect of ethylene removal on the color of petals of "white" and "pink" gladiolus is shown in tables 3 and 4. In general, the maintenance of initial color of petals during the period of storage is better in gladiolus treated with absorbants. Among the different absorbants, GK maintained more intensive the initial color of gladiolus. So, the color development was affected by the ethylene removal treatment.

On being placed in water the flowers on cut flowering gladiolus stems continue developing and wilting. Concurrently with the development (opening) of young flowers the mature flowers started to senescence.

As can be seen in tables 5 and 6, the ethylene removal incremented the extension of vase life and the number of open flowers per stem in "white" and "pink" gladiolus. So, in "white" gladiolus, by the 5th day after being placed in water, about 50 % of the control flowers had wilted, but in spikes with absorbants the end of vase-life was 2 days later. In "pink" gladiolus, in general, the development stage of stems during cold storage was slower than in "white" gladiolus.

It is known that a prolonged cold storage may result in failure of buds of some species to open (Anserwadekar and Patil, 1986). We found, as shown in tables 7 and 8, that after 23 days of cold storage the ethylene removal has effects on the flowering during the vase life in both "pink" and "white" gladiolus.

4. Conclusions

Ethylene removal from storage atmosphere contributed to a reduction in the respiration rate and in a weight loss of fresh spikes. A correlation has been observed between ethylene content and stem rigidification. Ethylene removal was effective in retarding ethylene evolution, color development of petals and the enhancement of more intensive flower opening in both "white" and "pink" gladiolus. Differences between cultivars in their sensitivity to ethylene has been observed.

References

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Figure 1 Ethylene concentrations in the bags with different ethylene-scrubbers (□ Ethysorb, Δ New Green Pack, ○ Green Keeper) or without absorbant (●), during storage of "white" and "pink" gladiolus, at +2.5 °C, 95 % RH

Table 4 - Color in "pink" gladiolus after 7 days at +2.5 °C
95 % RH. Values are means of ten replicates

Treatment	L	a	b	$(a^2+b^2)^{\frac{1}{2}}$	L/a
Initial	53.46	34.05	9.66	35.39	1.57
No removal	69.24	9.52	8.77	12.94	7.27
E	62.17	21.42	9.08	23.27	2.89
NGP	58.63	27.74	10.63	29.71	2.11
GK	57.24	31.00	10.03	32.58	1.84

Table 5 - Effect of different ethylene absorbants on the
flowering stage of "white" gladiolus at the 5th
day of vase-life. Spikes were stored during 7
days at +2.5 °C, then placed in water at +20 °C

Treatment	Stage				Flowers opened (%)
	I	II	III	IV	
No removal	16.18	6.62	8.09	50.74	81.63
E	16.67	3.47	4.86	41.67	66.67
NGP	18.98	4.38	5.84	44.52	73.72
GK	18.33	10.83	5.83	28.33	63.32

Table 6 - Effect of different ethylene absorbants on the
flowering stage of "pink" gladiolus at the 5th
day of vase-life. Spikes were stored during 7 days
at +2.5 °C, then placed in water at +20 °C

Treatment	Stage				Flowers opened (%)
	I	II	III	IV	
No removal	28.44	0.00	6.42	29.36	64.22
E	29.91	3.42	4.27	28.21	65.81
NGP	25.42	4.14	5.08	27.97	62.61
GK	19.13	11.30	6.09	29.56	66.08

Table 1 - Effect of different ethylene absorbants on weight loss of fresh spikes of "white" gladiolus and its toughness, after 7 days at +2.5 °C, 95 % RH

Treatment	Weight loss (%)	Toughness (kg)
No removal ethylene	0.644	4.00
Ethysorb	0.287	3.50
New Green Pack	0.462	3.30
Green Keeper	0.686	2.20

Table 2 - Effect of different ethylene absorbants on weight loss and the toughness of fresh spikes of "pink" gladiolus, after 7 days at +2.5 °C, 95 % RH

Treatment	Weight loss (%)	Toughness (kg)
No removal ethylene	0.966	5.20
Ethysorb	0.581	3.40
New Green Pack	0.504	2.80
Green Keeper	0.483	3.70

Table 3 - Color in "white" gladiolus after 7 days at +2.5°C 95 % RH. Values are means of ten replicates

Treatment	L	a	b	$(a^2+b^2)^{\frac{1}{2}}$	L/b
Initial	76.39	-3.64	12.98	13.48	5.88
No removal	76.14	-1.29	4.50	4.68	16.92
E	75.52	-0.66	3.46	3.52	21.82
NGP	74.85	-1.68	4.23	4.55	17.70
GK	74.86	-2.91	8.39	8.88	8.92

Table 7 - Effect of different ethylene absorbants on flowering stage of "white" gladiolus after 6 days of vase-life. Spikes were stored during 23 days at + 2.5 °C, then placed in water at +20 °C. Results are from ten spikes

Treatment	Stage				Flowers opened (%)
	I	II	III	IV	
No removal	39.36	0.00	0.00	50.00	89.36
E	29.23	0.00	0.00	60.00	89.23
NGP	41.30	1.09	0.00	51.09	93.48
GK	33.33	6.31	0.00	58.56	98.20

Table 8 - Effect of different ethylene absorbants on flowering stage of "pink" gladiolus after 6 days of vase-life. Spikes were stored during 23 days at + 2.5 °C, then placed in water at +20 °C. Results are from ten spikes

Treatment	Stage				Flowers opened (%)
	I	II	III	IV	
No removal	26.32	0.00	0.00	41.23	67.55
E	27.03	0.00	0.00	42.34	69.37
NGP	36.80	0.00	0.00	51.75	88.55
GK	22.34	5.32	2.13	52.13	81.92