EFFECT OF FLUORIDE AND A FLORAL PRESERVATIVE ON QUALITY OF CUT GLADIOLUS

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ABSTRACT

The influence of soluble fluoride and a floral preservative (600 ppm 8-hydroxyquinoline citrate + 4% sucrose) on floret opening and quality of cut gladiolus was investigated using several cultivars. All cultivars evaluated showed distinct petal margin deterioration and necrosis at 1 ppm F. Many cultivars showed distinct petal margin discoloration and deterioration with accompanying bract and leaf margin deterioration in 4 days at 0.25 ppm fluoride. Colored flowering cultivars showed more fluoride injury than white or yellow flowering cultivars.

Petal margin deterioration was most severe when spikes were continuously exposed to water containing fluoride. Florets on 'Victory' spikes held in water containing fluoride did not open as fully as those on spikes held in water.

Floral preservative increased the number of open flowers and sustained floret quality. However, the preservative did not overcome the deleterious effects of fluoride in vase water.

INTRODUCTION

The effects of gaseous fluoride on flower and corm yields of gladiolus have been determined (1, 2, 3, 11, 12). Little information is available on effects of fluoride in vase water on principal gladiolus cultivars grown in Florida. Soluble fluorides in vase water are extremely toxic to gladiolus (7, 8, 9, 13). This is particularly important in Florida where natural fluoride content in water is relatively high (6, 8). The problem might become critical in other sections of the country since fluoride is now being added to municipal water supplies to prevent human dental caries. Spierings (7) has shown that fluoridated drinking water may damage cut gladiolus.

Woltz et al (12) and Waters (8, 9) have described the symptoms of fluoride toxicity on cut gladiolus. Symptoms include (a) deterioration of the petal margin, first appearing as bleached, water-soaked areas which later dehydrate and become necrotic, (b) failure of florets to open and develop normal, (c) floret sheath (bract) burn, (d) brown stem lesions in severe cases, and (e) leaf scorch. Woltz et al (12) used the term "scorch" to refer to the damage induced by fluoride to leaf margins.

Waters (9) showed that for each increase of 1 ppm fluoride in vase water quality rating of gladiolus spikes decreased about 20%. He showed that spikes exposed to well water containing fluoride for 1 day developed symptoms similar to those spikes held in distilled water containing fluoride (8). Woltz et al (13) demonstrated that some gladiolus cultivars exposed to as little as 0.25 ppm fluoride showed toxicity symptoms on leaves, bracts, and petals.

Waters (8) attempted unsuccessfully to overcome the deleterious effect of fluoride on cut gladiolus by fortifying various well waters with a commercial flower preservative.

At the site of fluoride injury in gladiolus the level of fluoride is elevated (7). Spierings (7) stated that fluoride moves in the transpirational stream. The water is transpired from the leaf and bract surface but the fluoride is retained and accumulates. Woltz (11) showed conclusively that fluoride is translocated in the transpirational stream. He demonstrated that by forcing the transpirational stream in a definite pathway he could alter the development of leaf scorch.

This report summarizes three experiments designed to evaluate the effects of low amounts of soluble fluoride and a flower preservative (8-hydroxyquinoline citrate + sucrose) on toxicity in several cultivars of cut gladiolus.

METHODS AND MATERIALS

For each experiment spikes were harvested in tight-bud stage, graded for uniformity of length and number of florets. Spikes were placed in solutions soon after harvest. In all experiments spikes were held in styrene plastic containers (8-

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inch diameter by 14 inch high). Three spikes were placed in a container with 2 containers per treatment. Distilled water was used as a control and for preparing solutions in Experiment 1. Deionized water was used for Experiments 2 and 3. Fluoride was provided as sodium fluoride. Spikes were held in a laboratory at 74°F ± 2° in continuous light at 200 ft-c supplied by cool white fluorescent lights.

Experiment 1. Spikes of 'Beverly Ann', 'Minaret', 'Hopman's Glory', 'White Friendship', 'Spic and Span', 'Traveler', 'Trophy', and 'Valeria' were harvested and handled as previously outlined. These spikes were selected as representatives of the principal commercial cultivars grown in Florida

Table 1. Degree of scorch (injury) on florets, bracts, and leaves of several gladiolus cultivars held in varying concentrations of fluoride in vase water for 4 days.

Cultivars	Fluoride concentration (ppm) 0	0.25	0.5	1	2	4
			Floret scorch (mm)[1]			
Hopman's Glory	0	0	0	1	4	3
White Friendship	0	0	0	2	4	6
Minaret	0	2	3	5	8	8
Beverly Ann	0	0	0	4	7	9
Traveler	0	0	0	5	8	10
Spic and Span	0	1	1	1	4	11
Trophy	0	1	2	5	15	13
Valeria	0	1	1	3	7	15
			Bract scorch (mm)[1]			
Hopman's Glory	0	0	0	1	2	18
White Friendship	0	8	7	17	26	33
Minaret	0	2	5	12	39	35
Beverly Ann	0	2	6	11	10	27
Traveler	0	3	2	2	9	23
Spic and Span	0	7	4	11	20	43
Trophy	0	6	7	12	26	25
Valeria	0	3	16	19	32	56
			Leaf scorch (mm)[1]			
Hopman's Glory	0	5	26	60	104	194
White Friendship	0	4	21	34	41	95
Minaret	0	5	6	35	126	153
Beverly Ann	0	0	4	38	53	70
Traveler	0	3	16	7	8	51
Spic and Span	0	0	9	11	31	62
Trophy	0	0	0	24	46	30
Valeria	0	30	33	64	125	156

[1]Injury at margins of florets, bracts, and leaves. Scorch is measured in mm from tissue margin to undamaged area.

[2]Each figure represents the mean of 6 measurements.

(10). Spikes were placed in 0, 0.25, 0.5, 1, 2 or 4 ppm fluoride solutions. After a 4-day exposure, the amount of "scorch" on leaves, bracts, and florets was measured. The discoloration or necrosis was measured linearly from margin of the damaged respective plant part to the undamaged area.

Experiment 2. Spikes of 'Victory', a cultivar with poor floret opening from tight bud, were harvested in tight-bud stage and handled as previously outlined. Spikes were held in water or exposed to a 3 ppm fluoride solution for 1, 2, or 3 hours. Spikes were also exposed continuously to 3 ppm fluoride solution. After 4 days the degree of fluoride injury was determined on basal floret. Injury was recorded on a 1-to-4 scale with 1 = no injury, 2 = incipient injury (1-2 mm scorch), 3 = moderate injury (3-5 mm scorch), and 4 = severe injury (more than 6 mm scorch). Total number of florets opened per spike was recorded after 5 days.

Experiment 3. Spikes of 'Peter Pears', 'T-590', and 'Spic and Span' were harvested and handled as previously described. Spikes of each cultivar were held in water or 600 ppm 8-hydroxyquinoline citrate plus 4% sucrose (8-HQC + S) (4, 5) factorially arranged with 0.0 or 3 ppm fluoride. Fluoride injury was determined on basal florets after 3 days in same manner as in Experiment 2. Numbers of florets opened per spike were recorded after 3, 4, and 5 days.

Results

Experiment 1. All cultivars tested had leaf, bract, and floret scorch when spikes were held in 1 ppm fluoride (Table 1). Florets in spikes of 'Minaret', 'Spic and Span', 'Trophy', and 'Valeria' had slight scorch when held in 0.25 ppm fluoride. Florets on spikes of 'Hopman's Glory', White Friendship', 'Beverly Ann', and 'Traveler' were injured at 1 ppm fluoride or greater. Florets on spikes of colored cultivars 'Valeria' (scarlet), 'Trophy' (lavender), 'Beverly Ann' (lavender), 'Traveler' (rose), and 'Minaret' (Salmon), 'Spic and Span' (pink) had more injury at 4 ppm fluoride than florets on spikes from white or yellow cultivars 'White Friendship', 'Hopman's Glory' (yellow). Florets on the dark colored cultivars developed a blue cast in the tissue adjacent to the deteriorating margins.

All cultivars tested, except 'Hopman's Glory' had bract scorch at 0.25 ppm. Bracts on 'Hopman's Glory' were not injured until the fluoride concentration was 1 ppm or greater. All cultivars had severe bract scorch when spikes were held in 4 ppm fluoride.

Leaves on spikes of 'Hopman's Glory', 'White Friendship', 'Minaret', 'Traveler', and 'Valeria' were slightly injured when held in 0.25 ppm fluoride. Leaf injury was not observed on spikes of 'Trophy' until the concentration of fluoride was 1

Table 2. Incidence of injury and opening of florets on cut 'Victory' gladiolus spikes exposed to 3 ppm fluoride (F) in vase water for varying periods.

Treatments	Fluoride injury[1]	No. florets open at senescence of basal floret	Total no. florets open after 5 days
Control (water)	1.0[2]	3.6	3.9
Exposed to 3 ppm F for 1 hr, then water	1.3	3.9	4.0
Exposed to 3 ppm F for 2 hr, then water	1.9	3.6	3.9
Exposed to 3 ppm F for 3 hr, then water	1.9	3.7	4.3
Exposed to 3 ppm F continuously	4.0	2.4	2.7

[1]Injury evaluated after 4 days. 1 = no injury, 2 = incipient injury (1-2 mm scorch), 3 = moderate injury (3-5 mm scorch), 4 = severe injury (more than 6 mm scorch).

[2]Each figure represents the mean of 6 measurements.

ppm or greater, whereas, leaf injury occurred on spikes of 'Beverly Ann' and 'Spic and Span' at 0.5 ppm fluoride.

Experiment 2. 'Victory' spikes exposed to 3 ppm fluoride solution for 1 hr had incipient petal injury (Table 2). Petal injury was directly related to time of exposure. Exposing spikes to 3 ppm fluoride for 1-3 hrs did not reduce floret opening or number of florets opened at time of senescence of basal floret. However, floret opening on spikes continuously exposed to 3 ppm fluoride was severely reduced.

Experiment 3. Spikes of the cultivars 'Peter Pears', 'T-590', and 'Spic and Span' did not open in a similar manner (Table 3). Spikes of 'Peter Pears' and 'T-590' held in 3 ppm fluoride for 5 days had as many open florets as spikes held in water. Floret opening on 'Spic and Span' spikes held in 3 ppm fluoride was reduced at 3 and 4 days but had similar floret opening as spikes held in water after 5 days. 'Peter Pears' spikes had the most open florets followed respectively by 'Spic and Span' and 'T-590' spikes.

Spikes of all 3 cultivars had more open florets when held in 8-HQC + S than water (Fig. 1). Adding fluoride to 8-HQC + S did not reduce the number of open florets on 'Peter Pears' or 'T-590' spikes but did reduce floret opening on 'Spic and Span' spikes. Florets that developed on spikes held in 8-HQC + S and fluoride were not as large as florets developed in 8-HQC + S alone. Florets on spikes held in 8-HQC + S with fluoride reflexed inward resulting in a smaller diameter (Fig. 2).

None of the 3 cultivars developed visible fluoride injury in water or 8-HQC + S (Table 4). In 3 ppm fluoride in water or in 8-HQC + S. incidence of injury was similar. 'Peter Pears'

Table 3. Influence of fluoride and 600 ppm 8-hydroxyquinoline citrate plus 4% sucrose on floret opening of 'Peter Pears', 'T-590', and 'Spic and Span' gladiolus after 3, 4, and 5 days.

Treatments	Number florets open per spike after 3 days	4 days	5 days
		Peter Pears	
Water	2.8[1]	5.2	7.2
Water + 3 ppm F	3.3	5.5	7.3
600 ppm 8-HQC + 4% Sucrose	3.5	5.8	8.0
600 ppm 8-HQC + 4% Sucrose + 3 ppm F	4.3	6.2	9.2
		T-590	
Water	0.8	1.2	3.7
Water + 3 ppm F	1.2	2.5	3.5
600 ppm 8-HQC + 4% Sucrose	1.8	3.7	5.0
600 ppm 8-HQC + 4% Sucrose + 3 ppm F	2.2	3.7	4.7
		Spic and Span	
Water	1.2	3.5	5.7
Water + 3 ppm F	0.5	2.7	5.2
600 ppm 8-HQC + 4% Sucrose	3.5	5.5	6.8
600 ppm 8-HQC + 4% Sucrose + 3 ppm F	1.5	2.8	4.3

[1]Each figure represents the mean of 6 measurements.

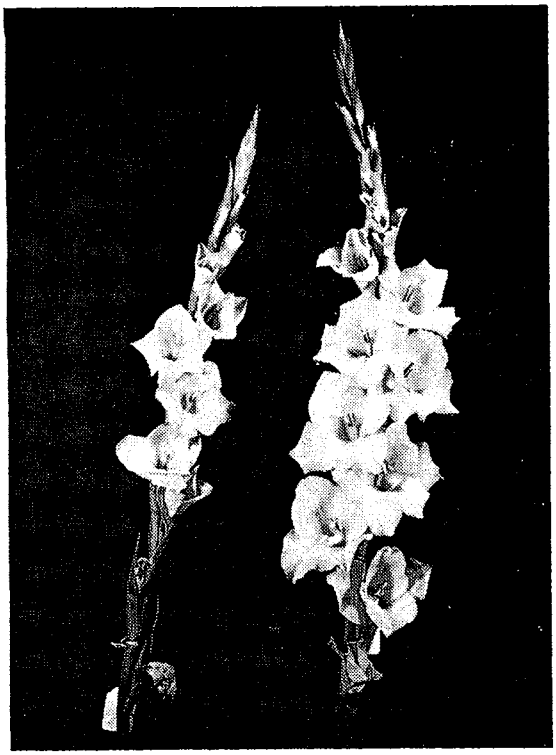

Figure 1.—'Peter Pears' gladiolus spikes held in water (left) or 600 ppm 8-HQC + 4% S (right). Spikes harvested as tight buds. Picture taken after 5 days.

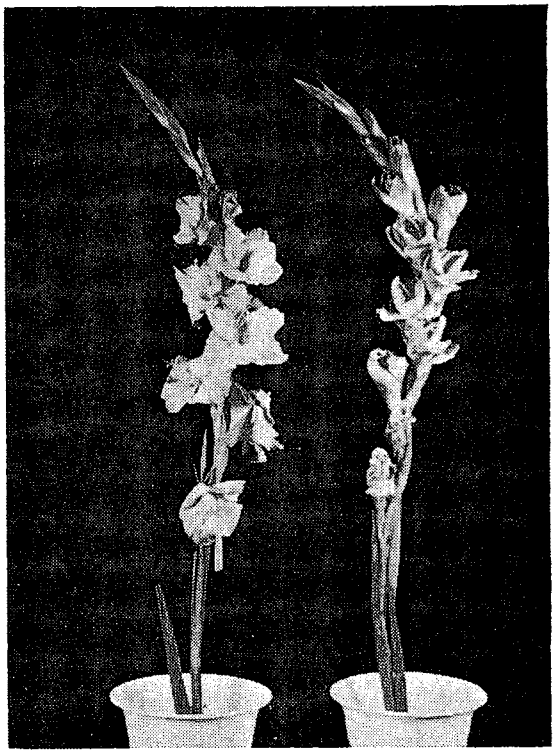

Figure 2.—'Spic and Span' gladiolus spikes held in water. (left) or 600 ppm 8-HQC + 4% S + 3 ppm fluoride (right.) Spikes harvested as tight buds. Picture taken after 5 days.

Table 4. Influence of fluoride and 600 ppm 8-hydroxyquinoline citrate plus 4% sucrose on floret injury (scorch) of 'Peter Pears', 'T-590', and 'Spic and Span' gladiolus[1].

	Cultivar			Solution mean
	Peter Pears	T-590	Spic and Span	
		Injury[1]		
Water	1.0[2]	1.0	1.0	1.0
Water + 3 ppm F	3.5	1.5	3.7	2.9
600 ppm 8-HQC + 4% S	1.0	1.0	1.0	1.0
600 ppm 8-HQC + 4% S + 3 ppm F	3.7	1.7	2.5	2.6
Cultivar means	2.3	1.3	2.0	

[1]Injury evaluated after 3 days. 1 = no injury, 2 = incipient injury, 3 = moderate injury, 4 = severe injury.

[2]Each figure represents the mean of 6 measurements.

(orange florets) and 'Spic and Span' (pink florets) had greater incidence of injury than 'T-590' (yellow florets).

Discussion

Although floret opening was improved slightly by 8-HQC + S, fluoride toxicity was not prevented. Injury was evaluated on the basal florets; but, each additional floret opened on spikes held in 8-HQC + S with fluoride had scorch symptoms. Thus the total injury per spike held in 8-HQC + S with fluoride was greater than in water alone. The 8-HQC + S increases water movement in cut gladiolus spikes (4). Presumably more fluoride was translocated and accumulated (7) with the increased water movement caused by 8-HQC + S.

A solution of 1 ppm fluoride induced scorch on leaves, bracts, and florets of all cultivars tested. Fluoride injury was more severe in colored florets than in white or yellow florets. The higher the fluoride concentration, the greater the injury to leaves, bracts, and florets. Spikes of some cultivars were injured at low levels of fluoride (0.25-0.5 ppm). 'Victory' spikes exposed to as little as 3 ppm F for 1 hr had incipient floret scorch. The waters generally available in principal flower growing areas of Florida are high in fluoride (6, 8). Holding spikes of some cultivars in these waters for short periods could conceivably predispose the flowers to fluoride injury in retail florists shops or consumers' homes.

The fluoride toxicity problem on cut gladiolus might become increasingly important as more municipalities add fluoride to their water supplies.

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INFLUENCE OF FLUORIDE ON FOLIAR NECROSIS OF CORDYLINE TERMINALIS CV BABY DOLL DURING PROPAGATION

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Abstract

The colorful ornamental foliage plant, *Cordyline terminalis* Kunth cv Baby Doll, is easily rooted, but develops slight to severe foliar necrosis during propagation which affects salability. Development of additional necrotic areas ceases after about two weeks when plants have developed good root systems.

Experiments at the Agricultural Research Center — Apopka have shown that fluoride in soil or water caused necrosis during rooting. Severity of injury depended on level of fluoride, type of propagating medium and environmental conditions. This Cordyline is particularly sensitive to fluoride and is injured by levels of 0.25 ppm or greater in solutions.

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