(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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Introduction

Demand for plant materials for use in "combinations" (groups of different foliage plants in a single container) have increased considerably in recent years. Smith (6) reported only three percent of foliage sales in 1961 were combinations, whereas this increased to nearly eleven percent by 1967. Foliage plants with good keeping qualities and bright colors are highly prized for combinations with other plants since they provide a visual focal point.

A foliage plant with excellent characteristics for combinations is *Cordyline terminalis* Kunth cv Baby Doll (hereafter referred to as Baby Doll).

This plant grows upright, roots readily and possesses foliage of a maroon color with light rose margins. Baby Doll has been available to the nursery trade for a number of years, but has not been popular because recently propagated plants of desirable size for combinations almost always exhibited foliar necrosis. Poole et al. (5) found the disorder occurred during rooting and was characterized by small, brown necrotic lesions which enlarged and coalesced until as much as 50 percent or more of lower leaves were affected. They reported that the problem was reduced when cuttings were rooted in calcined clay or Louisiana sedge peat. Symptoms resembled a bacterial or fungal infection, but this was not a factor (5).

Symptoms of elemental deficiencies of foliage plants have been discussed by Dickey and Joiner (2), but no report has been found on toxicities. Coorts (1) mentioned that nutritional toxicity symptoms freuently resemble deficiencies and, therefore, they are not easily differentiated.

Tip and interior chlorosis and necrosis of gladiolus leaves have been found due to excessive levels of fluoride in air or soil by Woltz (8, 9). He also found that airborne fluorides caused tip necrosis, while injury due to root uptake scorched the interior of gladiolus leaves rather than margins. In work with gladiolus cut-flowers, Waters (7) found that fluoride ion uptake was the major factor involved in petal deterioration.

This work summarizes experiments undertaken to determine possible relationships between necrotic symptoms of Baby Doll and fluoride levels.

Methods and Materials

Effects of a well water containing 0.25 ppm fluoride and fluoride (NaF) containing solutions were compared with distilled water during rooting of Baby Doll in solution. Soil amendments were compared when rooting was accomplished *in calcined* clay (Turface) or sphagnum peat moss. Other variables superimposed on water or media included location (either a greenhouse shaded to approximately 3000 foot candles or a well lighted laboratory with about 200 foot candles), cuttings misted or not misted with water containing 0.25 ppm fluoride and soil amendments of 0 or 10 lbs superphosphate, 5 or 10 lbs calcium sulphate or 5 or 10 lbs magnesium sulphate per cu. yd.

Cuttings selected were free of symptoms and 4 to 6 inches long with the lower 1½ inches of stems stripped of foliage prior to placing in test tubes of solutions or pots of media. Experiments consisted of single cuttings as the experimental unit and were replicated 5 times.

Foliar chlorosis and necrosis ratings were made several times for each experiment. Only final ratings taken 10 to 14 days after sticking when cuttings were well rooted are reported. Severity of foliar chlorosis and necrosis were rated as follows: 1) no chlorosis or necrosis, 2) 25 percent of leaves affected, 3) 50 percent of leaves affected, 4) 75 percent of leaves affected, and 5) all foliage necrotic.

Fluoride analyses* were made on a Technicon Auto Analyzer according to the procedure developed by Mandl et al. (3).

Results and Discussion

Cuttings rooted in distilled water, with and without mist did not develop foliar necrosis, while those in tap water had necrotic areas on 50 percent of all leaves (Table 1), indicating that the causual agent was absorbed through stems from tap water, rather than being absorbed from mist

*Fluoride analysis were obtained through the courtesy of Dr. C. D. Leonard and Dr. H. B. Graves, Agricultural Research and Education Center, Lake Alfred.

Table 1. Influence of mist and water source on necrosis of Cordyline terminalis cv Baby Doll.

Treatment		
Mist applied	Water source	Necrosis rating[1]
Yes	Well	3.2 b[2]
No	Well	3.0 b
Yes	Distilled	1.0 a
No	Distilled	1.0 a

[1]Ratings were: 1 = none, 2 = 25%, 3 = 50%, 4 = 75% and 5 = 100%.
[2]Means followed by the same letter are not significantly different at the 0.01 level.

Table 2. Effect of water source on foliar necrosis and fluoride content of Cordyline terminalis cv. Baby Doll.

Treatment	Necrosis Rating[1]	F (ppm)
Distilled water	1.0 a[2]	0.2 a
Tap water (.25 ppm F)	2.0 b	2.8 a
Distilled water + 3 ppm F	5.0 c	395.0 b

[1]Ratings were: 1 = none, 2 = 25%, 3 = 50%, 4 = 75% and 5 = 100%.
[2]Means followed by the same letter are not significantly different at the 0.01 level.

application. To prevent tap water mist from entering rooting solutions of distilled water, orchid tubes were used with seals around stems. Examination of well water analyses from the Apopka area (4) revealed water was generally of excellent quality with low total salts levels, but that fluoride ranged between 0.25 to 0.43 ppm. Woltz (8) had previously observed that fluoride moved readily in the transpirational stream.

Three treatments were established with cuttings in test tube solutions of 1) distilled water, 2) tap water and 3) 3 ppm fluoride to initially check the possibility of fluoride damage to Baby Doll. Cuttings in distilled water were normal after seven

Table 3. Effects of fluoride concentration and environment on necrosis rating and tissue fluoride content of Cordyline terminalis cv. Baby Doll.

Fluoride Concentration (ppm) in solution	Greenhouse		Air Conditioned Laboratory	
	Necrosis[1] Rating	F[2] (ppm)	Necrosis Rating	F (ppm)
0.00	1.0 a[3]	2.2	1.0 a	1.8
0.05	1.3 a	1.6	1.0 a	1.4
0.10	1.7 a	5.0	1.3 a	1.2
0.20	1.7 a	4.6	1.7 ab	1.4
0.50	3.3 b	8.8	2.3 b	4.6

[1]Ratings were: 1 = none, 2 = 25%, 3 = 50%, 4 = 75% and 5 = 100%.
[2]Single samples, as replications were combined to obtain sufficient tissue for analysis.
[3]Means followed by the same letter are not significantly different at the 0.01 level.

days, those in tap water had 25 percent leaves necrotic and those in 3 ppm fluoride were dead (Table 2). Levels of fluoride in tissue also increased as necrotic symptoms became more severe. Two experiments were initiated with five levels of fluoride from 0 to 0.5 ppm, one each under laboratory and greenhouse conditions to aid in defining levels of fluoride toxic to this crop (Table 3). Generally, the highest fluoride level was necessary to cause necrosis under greenhouse and laboratory conditions. Correlation coefficients between necrosis rating and tissue fluoride level in the greenhouse were 0.9561 and in the laboratory 0.8080. Fluoride levels as low as 0.25 ppm in solution damaged gladiolus florets and 1.5 ppm injured rose petals in work reported by Woltz et al. (10).

Higher degrees of foliar necrosis and levels of tissue fluoride occurred in cuttings rooted in sphagnum peat then calcined clay, especially when superphosphate was added to the propagation medium (Figure 1). Close correlation of fluoride level and necrosis rating is demonstrated in Figure 1 where interactions between media and superphosphate occurred for both factors. Apparently calcined clay is capable of preventing uptake of water soluble fluoride, whereas sphagnum peat does not have the same capability. Applications of $CaSo_4$ and $MgSO_4$ had no effect on necrosis rating or fluoride in tissue of Baby Doll in either media, with or without superphosphate. Therefore, indications were that neither Ca nor Mg ions were capable of immobolizing, fluoride in the media used which had a pH range of 4.5 to 5.0 for peat and 6.0 to 6.5 for calcined clay. Woltz (9) has previously discussed benefits of increasing pH in reducing fluoride injury of gladiolus grown in sandy soils.

These data establish that fluoride toxicity is one factor capable of inducing necrosis of Baby Doll during rooting. The fact that fluoride levels of 0.25 ppm and possibly lower cause economic losses with Baby Doll indicate that this crop should be classed as one of the most sensitive to fluoride. Extreme sensitivity is indicated by the very low foliar fluoride levels capable of causing necrosis.

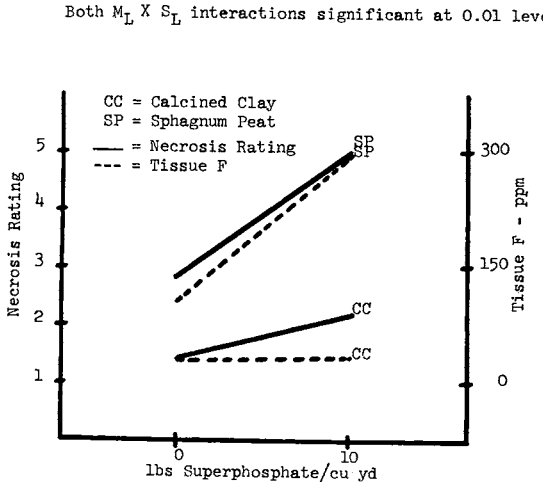

Figure 1.—Interactions of media and superphosphate on foliar necrosis and fluoride level of Cordyline terminalis cv. Baby Doll: Necrosis ratings are 1=none, 2=25%, 3=50%, 4=75%, 5=100%.

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