We mist 30 sec each 5 min from 8:30 a.m. to 5:30 p.m. About 10 days after the cuttings are stuck, we begin to cut down the mist. Miniatures take 2-3 weeks to root, and as soon as they are rooted we start to feed them using 150 ppm N of Peter's 20-20-20 on a constant feeding program. We spray every 10 days with Phaltan, Diazinon and Manzate.

A few weeks later these plants are moved outdoors to quonset huts, and are heeled in sand about 2-3 inches deep to prevent root damage during cold weather. We continue with the same feeding and spraying program we used indoors. In late fall we cover the quonset huts with a single layer of 6 mil poly film for winter protection. At this time these plants are ready for sale.

Our sales are approximately 85% wholesale and 15% retail. For shipping, the plants are cut back to about 4 inches and wrapped in aluminum foil to prevent the soil mix from coming out of the pot. They are ready for forcing when the customer receives them; forcing takes about 6 to 9 weeks, depending upon the cultivar.

INJURY TO SELECTED PLANTS DUE TO FLUORIDE TOXICITY

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Chlorosis and necrosis of plant foliage is caused by various agents including: disease causing organisms, insects, mites, nematodes, high soil salinity and air pollutants. Occasionally, foliar problems cannot be directly attributed to these causes. Such is the case with certain plants which respond to excessive fluoride ions in irrigation water, soil solution or fertilizer. As recently as 1971 (5), the necrotic lesions which often develop on the distal portion of leaves of Cordyline terminalis propagated from terminal cuttings was reported to be of a non-pathogenic nature. Research findings at that point indicated that *Cordyline* could be propagated best if cuttings were stuck in either calcined clay (Turface) or Louisiana sedge peat, in preference to other available rooting media.

The first report of fluoride toxicity in tropical foliage plants was made by Conover and Poole (1) in late 1971. Freshly harvested cuttings of *Cordyline terminalis* 'Baby Doll' developed necrotic lesions primarily on the margin near the distal portion fo the lower leaves when the bases were immersed in tap water which contained 0.25 ppm fluoride.

Table 1. Effect of water source on foliar necrosis and fluoride content of *Cordyline terminalis* 'Baby Doll'.

Treatment	Necrosis rating[1]	Foliar F (ppm)
Distilled H_2O	1	0.2
Tap H_2O (0.25 ppm F)	2	2.8

[1] 1 = no necrosis, 5 = 100% necrosis.

Further investigations (1) revealed a positive correlation between the amount of fluoride supplied to unrooted *Cordyline* cuttings, the fluoride content of the foliage and amount of necrosis observed (Table 2).

Table 2. Necrosis and leaf fluoride of *Cordyline terminalis* 'Baby Doll' propagated in tubes containing fluoride solutions.

Fluoride Solution (ppm)	Necrosis Rating[1]	Leaf F (ppm)
0.00	1.4	2.8
0.15	3.2	6.2
0.30	4.0	11.7
0.45	4.9	13.5
0.60	5.9	16.5
0.75	6.0	17.2

[1] 1 = no necrosis, 10 = complete necrosis (dead).

The same researchers noted the importance of selecting soil amendments and fertilizer additives carefully for *Cordyline terminalis* (2). Table 3 lists the soluble fluoride content of several soil amendments. The leachate from both German peat and perlite contained relatively high levels of fluoride.

Table 3. Fluoride content of various media used for propagation and growing foliage plants.

Medium	Soluble fluoride on a dry weight basis (ppm)
Cypress shavings	0.5
Zellwood peat	1.5
Calcined clay (Turface)	2.5
Louisiana sedge peat	3.0
Pine bark	4.5
German peat	19.5
Perlite	86.0

In addition to the influence of propagation or growing medium on fluoride supply, the effect of superphosphate applications to selected media was reported (6). Normal superphosphate and concentrated superphosphate contain mean levels of 1.64 and 1.56% fluoride, respectively (3). Superphosphate at the rate of 5 pounds per cubic yard increased foliar fluoride levels and leaf necrosis. Additions of liming materials decreased leaf fluoride and necrosis caused by German peat and superphosphate (Table 4).

Table 4. Effects of soil amendments on pH of German peat and necrosis and foliar F of *Cordyline terminalis* 'Baby Doll'.

Superphosphate		Liming Material (lb/yd^3)	pH	Necrosis rating[1]	Tissue F (ppm)
0		0	4.1	3.8	27
0	$Ca(OH)_2$	2.5	5.4	4.2	26
0	$Ca(OH)_2$	5.0	5.8	4.4	23
0	Dolomite	5.0	5.2	4.5	26
0	Dolomite	10.0	5.6	4.7	27
5		0		10.0	137
5	$Ca(OH)_2$	2.5	4.6	6.6	40
5	$Ca(OH)_2$	5.0	5.4	4.5	31
5	Dolomite	5.0	4.4	8.1	53
5	Dolomite	10.0	4.8	7.5	43

[1] 1 = no necrosis, 10 = complete necrosis (dead).

An experiment was designed to determine the influence of time after harvesting *Cordyline* cuttings prior to exposure to fluoride solutions on the quality of the rooted cuttings. Harvested cuttings were held for periods up to 7 days with bases immersed in deionized water prior to transferring them to a 1 ppm fluoride solution. Table 5 indicates that approximately 4 days after harvest, terminal cuttings develop a selective mechanism which reduces the rate of fluoride uptake. This transition is associated with wound healing and root development.

Table 5. Leaf fluoride and grade of *Cordyline terminalis* terminal cuttings as influenced by time prior to exposure to a one ppm fluoride solution[1].

Measurement	Days in Deionized Water					
	0	1	2	4	7	10
Leaf F (ppm)	11.3	8.7	7.7	6.7	4.7	4.0
Grade[2]	5.0	5.0	4.0	2.0	2.0	1.0

[1] Samples collected on 10th day.
[2] 1 = no necrosis, 10 = complete necrosis (dead).

Since perlite is an important amendment for propagation media, it was felt that possibly the fluoride could be reduced by leaching prior to use for propagation. An experiment was designed to recover leachate from new perlite samples obtained from two sources. Each perlite sample was sequentially leached 5 times with deionized water in a ratio of 1 part perlite to 10 parts water by volume. After the leachate was recovered, tip cuttings of *Cordyline* were placed in the solutions for a period of 2 weeks and then evaluated (Table 6).

Table 6. Influence of sequential leaching of perlite on fluoride toxicity of *Cordyline terminalis* rooted in perlite leachate.

Treatment and Perlite Source	Necrosis rating[1] Leachate number 0	1	2	3	4
Deionized Water	1.0	—	—	—	—
Perlite (Source A)	—	4.7	2.5	1.5	1.0
Perlite (Source B)	—	4.5	1.7	1.3	1.0

[1] 1 = no necrosis, 5 = severe necrosis.

Data on the rooted cuttings suggest that after new perlite has been thoroughly leached, it is safe for use as an amendment in propagation media and soil mixes for fluoride-sensitive plants.

Following the work on *Cordyline*, researchers at the Agriculutral Research Center, Apopka began investigating a different pattern of chlorosis and necrosis which appears frequently on leaves of *Dracaena deremensis* 'Warneckii' (7). Necrotic spots develop in the white portions of the foliage near the tip with occasional lesions along the margin. The time required for development of necrotic spots on *D. deremensis* 'Warneckii' terminal cuttings was approximately 8 weeks when soluble fluoride was available in the propagation medium. The use of intermittent mist reduced the intensity of leaf necrosis although it did not reduce the leaf fluoride level in most treatments. The exact mechanism of retarding the development of fluoride toxicity through the use of intermittent mist is not well understood but it is believed to change the pattern of fluoride accumulation in the foliage which occurs when cuttings transpire rapidly.

In another report, the influence of light intensity on the development of necrotic spots on the foliage of *D. deremensis* 'Warneckii' was shown (2). Plants grown under 60 and 80% shade had less than half the number of blemished leaves as those grown under 40% shade.

Other studies have shown that marginal necrosis often found on *Dracaena deremensis* 'Janet Craig' (8) and *Chlorophytum comosum* (9) can be induced by additions of normal superphosphate. Recommendations listed below are directly applicable to plants in the genera: *Chlorophytum*, *Cordyline* and *Dracaena*. Other species and cultivars in the families: *Agavaceae*, *Liliaceae* and *Marantaceae* are suspected to be sensitive to fluoride (4).

Recommendations for minimizing fluoride phytotoxicity when propagating and growing fluoride-sensitive plants are as follows:

1. Avoid use of superphosphate as a fertilizer. Phosphorus should be supplied from other sources.
2. Use water which contains less than 0.25 ppm fluoride. Remember that municipal water treatment often includes the addition of 1.0 ppm fluoride to reduce the incidence of tooth decay.
3. Use soil components which contain low levels of fluoride. Of those materials tested, perlite contained the most fluoride followed by German peat. It is suggested that perlite be preleached before incorporation with other amendments.
4. Adjust the soil pH between 6.0 and 6.5. Within this range fluorides are not as freely available to the plant as when the pH is lower. Additions of 3 to 10 pounds per cubic yard of limestone or dolomitic limestone at the time of soil preparation is usually sufficient. Additions of up to 1 pound of hydrated lime per cubic yard can be used on plants which have been potted.
5. Avoid environments which accelerate the rate of transpiration and subsequent uptake of fluoride. These adverse factors include high light intensities, excessive air movement and high temperatures.

LITERATURE CITED

1. Conover, C.A. and R.T. Poole. 1971. Influence of fluoride on foliar necrosis of *Cordyline terminalis* cv. Baby Doll during propagation. *Proc. Fla. State Hort. Soc.* 84:380-383.
2. Conover, C.A. and R.T. Poole. 1973. Factors influencing notching and necrosis of *Dracaena deremensis* 'Warneckii' foliage. *Proc. Trop. Reg., Am. Soc. Hort. Sci.* 17:378-384.
3. Farm Chemicals, Dictionary of Plant Foods. Meister Publishing Company. Willoughby, Ohio. p. 6-120.
4. Henley, R.W. 1974. A review of fluoride research on tropical foliage plants. Fla. Foliage Grower 11(7):1-4.
5. Poole. R.T., D.B. McConnell and J.F. Knauss. 1971. Leaf necrosis of *Dracaena* 'Baby Doll'. Fla. Foliage Grower 8(1):13.
6. Poole, R.T. and C.A. Conover. 1973. Fluoride induced necrosis of *Cordyline terminalis* Kunth 'Baby Doll' as influenced by medium and pH. *J. Am. Soc. Hort. Sci.* 98(5):447-448.
7. Poole, R.T. and C.A. Conover. 1974. Foliar chlorosis of *Dracaena deremensis* Engler cv. Warneckii cuttings induced by fluoride. *HortScience* 9(4):378-379.
8. Poole, R.T. and C.A. Conover. 1975. Fluoride induced necrosis of *Dracaena deremensis* Engler cv. Janet Craig. *HortScience* 10(4):376-377.
9. Poole, R.T. and C.A. Conover. 1975. Influence of culture on tipburn of spider plant, *Chlorophytum comosum* (Thumb.) Bak. *Proc. Fla. State Hort. Soc.* 88:441-443.
10. Poole, R.T. and C.A. Conover. 1975. Influence of propagation media and amendments on fluoride toxicity of *Cordyline terminalis* 'Baby Doll'. Fluoride 8(2):85-92.