survived and/or grew poorly and did not produce an acceptable stand), and averaged at the end of each season.

Results and Discussion

On 24 Dec. 1983, the temperature suddenly dropped to 22°F, killing all the tender annuals and damaging the more cold hardy ones. Lisianthus and snapdragons survived this temperature drop. Wind reached 50 to 55 mph in Oct. 1984, resulting in severe leaf injury to most plants.

Coleus were planted every season. In all plantings, coleus plants survived less than two months. New Guinea impatiens also lived less than two months. The same held true for red salvia. Torenia survived less than two weeks. Plants that were killed by the freeze were replanted four weeks later. Results of the evaluations on bedding plants are tabulated in Table 1.

It is obvious that many of the popular bedding plants marketed today are not suitable for beach front areas exposed to the elements and irrigated with low quality irrigation water. Almost 70 percent of Florida residents live within five miles of the coastal area of the peninsula. Therefore, most of the bedding plant consumers are using bedding plants within close proximity of the coast, where both salt spray may be prevalent as well as low quality water caused by salt intrusion in these areas. As the results indicate, it is of extreme importance that these tests be continued and duplicated for several years to evaluate more accurately what bedding plants can be grown in coastal areas in Florida with success and which ones will be less of a success when grown under the same conditions.

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BORON NUTRITION IN FLORIDA ORNAMENTALS

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Abstract. **The role of boron in plant nutrition has long been established. Florida soils are normally quite deficient in boron. Therefore, deficiencies of this element are common in Florida plants, with deficiency symptoms varying greatly from species to species. Deficiency symptoms in various Florida ornamentals are discussed, including plants in the landscape as well as ornamental nurseries. Critical levels of boron in deficient plant species are discussed, as well as effective measures for curing and preventing boron deficiencies. Symptoms and sources of boron toxicity in Florida plants are outlined, as are critical levels of toxicity in leaf tissue of various species.**

The research involving the role of boron as an essential plant nutrient is extensive (2). It is known to be associated with translocation and utilization of sugars and starches, amino acid synthesis, calcium absorption, transport of nitrogen and phosphorus, and regulation of carbohydrate metabolism. The element is considered essential for all plants, and is commonly used in ornamental plant production and maintenance in Florida.

Boron differs from the other known essential trace elements in several ways. It is generally found in lower concentrations in leaf tissue than iron or manganese, but in larger concentrations than zinc, copper, or molybdenum. The main way in which boron stands out from the other trace elements is that the range between deficiency and toxicity levels in plants is very narrow. Using the Azomethine H method (7) of boron analysis on the most recent, fully-matured leaf tissue, most plants become deficient at somewhere between 15 and 25 ppm. However, toxicity begins to occur in most species between 75 and 100 ppm (Table 1). Thus, the range between deficiency and toxicity levels for boron is only from 60 to 75 ppm for most species. Such ranges of "safe levels" are much wider for most of the other trace elements.

This narrow range between deficiency and toxicity makes it difficult for growers to maintain proper boron levels in their crops. Indeed, nutritional aberrations in boron nutrition are quite commonly encountered in diagnostic work, and involve a wide variety of ornamental species.

Another difference between boron and other trace elements is that boron leaches fairly easily from most soils. Florida soils are very commonly deficient in boron, presumably because of high rainfall, high pH, and low exchange capacities. Land that has been farmed intensively for many years often shows an abundance of trace ele-

Table 1. Ornamental species sensitive to boron toxicity.

Species	Leaf analysis ranges		
	Deficient (ppm)	Normal (ppm)	Toxic (ppm)
Aechmea fasciata Lindl.	0-15	25-50	76+
Aglaonema sp. Schott	0-15	25-50	76+
Anthurium sp. Schott	0-15	25-50	76+
Araucaria heterophylla Salisb	0- 9	15-40	66+
Brassaia actinophylla Endl.	0-14	20-60	101+
Dieffenbachia sp. Schott	0-14	20-50	76+
Dracaena deremensis Engl. cv. Janet Craig	0-10	16-50	101+
Dracaena deremensis Engl. cv. Warneckii	0-10	18-50	101+
Dracaena fragrans (L.) Ker-Gawl	0-10	20-50	101+
Dracaena marginata Lam.	0-14	18-50	101+
Epipremnum aureum Linden & Andre	0-14	20-50	76+
Euphorbia pulcherrima Willd. Ex Klotzch	0-19	30-250	351+
Ligustrum lucidum Ait.	0-15	20-60	101+
Maranta leuconeura E. Morr	0-19	25-50	76+
Murraya paniculata L.	0-14	20-75	101+
Rhododendron sp. L.	0-19	25-50	101+
Rosa sp. L.	0-24	30-60	126+
Rumohra adiantiformis G. Forst	0-14	20-50	76+
Viburnum sp. L.	0-15	20-75	101+
Yucca elephantipes Regel	0-11	18-40	61+

Table 2. Ornamental species more tolerant to boron.[z]

Species	Leaf analysis ranges Deficient (ppm)	Normal (ppm)	Toxic (ppm)
Allamanda cathartica L.	0-19	25-75	76+
Bucida buceras L.	0-17	25-75	126+
Carissa grandiflora E. H. Mey	0-19	25-100	126+
Dianthus caryophyllus L.	0-24	30-100	135+
Gladiolus X *hortulanus* L. H. Bailey	0-20	25-100	201+
Hibiscus rosa- sinensis L.	0-19	25-100	151+
Ixora coccinea L.	0-19	25-100	126+
Pelargonium X *hortorum*	0-17	30-250	501+

[z]These values are the result of our working with leaf analyses over the years, and are not based on empirical research.

ments, but boron generally fails to accumulate. Organic matter does not seem to affect boron availability a great deal.

In most Florida ornamentals, boron deficiency occurs in the young leaves. Leaves are often thin, weak, small, and deformed. In some cases they may be cupped and brittle (5). Early stages of deficiency may result in weak foliage and reduction in dry weight without any distortion or decreased growth. Severe deficiencies result in extreme distortion, dieback, and even death.

Early symptoms of boron deficiency in *Yucca elephantipes* and *Dracaena marginata* include drooping and loss of stiffness in the young leaves. More severe deficiency results in distortion. *Dracaena marginata* often show low levels of foliar boron when they exhibit the disorder known "flecking" in the new leaf tips, and such plants often respond to boron sprays. *Pleomele reflexa* and *Antirrhinum majus* exhibit weak, brittle stems near the bud when deficient, often snapping off easily. *Ficus benjamina* has a weak, unthrifty look, with thinner leaves and longer internodes than usual. The symptom known as "notching" on *Dracaena deremensis* Engl. cv. Warneckii normally responds to boron sprays (unpublished). Cultivars of *Ficus decora* show extremely small, thin, distorted emerging foliage. Many foliage plants will exhibit weak, deformed growth, while flowering species display poor flower quality and reduced bloom count.

Since boron is so involved with carbohydrate metabolism, many people have noted a tendency toward more boron deficiency symptoms when light intensity is reduced. The classic example is boron deficiency symptoms being more pronounced on the north side of the greenhouse in winter in northern greenhouse rose operations. The relationship between light intensity and boron deficiency seems to hold in Florida as well, as symptoms in foliage plants are more common under reduced light.

When boron deficiencies occur, foliar boron sprays are often used to alleviate symptoms. Sprays of Solubor at 2-4 oz/100 gallons or Borax at 4-8 oz/100 gallons are commonly used by growers. The spray is normally repeated once or twice at weekly intervals. The distorted leaves are typically not improved, but subsequent foliage usually returns to normal. Boron toxicity typically occurs in older leaves, as a progressive chlorosis and necrosis from the leaf margin and tip inward. Susceptibility to fluoride injury in plants tends to be related to leaf morphology to some extent, with plants with long, tapered, pointed leaves tending toward sensitivity. With boron toxicity, leaf morphology of a species appears to have little correlation to sensitivity. Boron toxicity frequently worsens steadily with plant age, with the margins becoming increasingly necrotic. Mild or early symptoms may show only marginal *chlorosis or spotting*.

Cultivars of *Dracaena deremensis* are extremely susceptible to excess boron. Early symptoms include yellow or orange spots near the leaf tips, which rapidly result in progressive tip and marginal necrosis. Similar marginal chlorosis occurs with toxicity in *Aechme fasciata, Anthurium sp, Ligustrum sp, Rosa sp,* and *Yucca elephantipes.* As opposed to fluoride toxicity, plants with boron toxicity tend to have a distinct line between necrotic and healthy tissue (6). Notable exceptions to this observation include the toxicity symptoms of *Brassaia actinophylla* and *Murraya paniculata,* where large areas of marginal chlorosis occur, followed by smaller areas of necrosis. Knauss (4) astutely observed that boron toxicity symptoms vary somewhat with venation and leaf morphology.

Common sources of excess boron are irrigation water and soluble and dry fertilizers. Irrigation water containing greater than 0.25-0.30 ppm boron will tend to induce toxicity symptoms in sensitive plants. Sea water contains an average of 4.6 ppm boron (1). Where salt intrusion affects irrigation wells, boron toxicity is likely. The author suspects that some of the burn symptoms attributed to salt water injury may in actuality result from boron accumulation.

Poole and Conover (6) pointed out that dry or soluble fertilizers containing fairly normal boron levels can induce boron toxicity when applied under the intense fertility regimes common in Florida nurseries. In the case of dry fertilizers, our lab work (unpublished) indicates that boron is frequently found in higher concentrations than appear on the label (The Florida fertilizer tag shows a guaranteed minimum analysis). Also, current fertilizer blending practices make it difficult to evenly distribute a tiny ammount of boron in a ton of fertilizer. Therefore, growers of boron-sensitive crops in Florida should consider leaving boron out of their fertilizer altogether. It is emphasized that such a change be considered only on sensitive crops, as boron deficiency is just as common in Florida as toxicity.

Of course, being an essential nutrient, eliminating boron from fertilizer can easily lead to deficiencies. Under such circumstances, using occassional foliar boron sprays at the rates indicated previously work well at reducing deficiency symptoms with minimal risk of toxicity. In sensitive plants, soil-applied boron accumulates in tips of older leaves and becomes toxic. When applied as a foliar spray, much of the boron is absorbed by new foliage, where it can prevent deficiencies without translocating to older leaves and causing toxicities. In other words, foliar boron sprays can be used quite safely at conservative rates, even on sensitive plants.

Hydrated lime has been recommended as a soil drench to reduce toxicity symptoms by raising pH and calcium levels. Caution should be exercised, however, as our tests (unpublished) indicate very high levels of both boron and fluoride in several commercial hydrated lime sources. Other published recommendations include removal of injured tissue (3), spraying copper sulfate and lime water, and adding gypsum to the soil. These recommendations provide some relief of symptom progression. Under

Florida conditions, when growers encounter excess boron, it is perhaps more important to eliminate any future applications of boron in any form, and to leach the soil thoroughly several times. These simple measures, in conjunction with the above-mentioned recommendations, can provide significant reduction in symptom development for growers of boron-sensitive ornamentals.

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FERTILITY AND FERTILIERS

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Abstract. **World human populations are dependent on soil fertility for food. Great civilizations developed in areas of natural fertility or where the land was renourished by natural flooding that brought and deposited on the land rich upland soil.**

Soil destruction is associated with the downfall of some of the same civilizations which good soils had helped to build. Manure, leguminous plants, ashes and sulfur soil amendments were utilized in Greek and Roman farming. Experimentation led to the use of additional materials for improved soil fertility. By the year 1900 there were about sixteen fertilizer materials in use. World War I (1918) created normal fertilizer material shortages. Following that war new products became available. In 1936 there were over 50 materials for fertilizer available.

Initially single materials were applied to the soil. The commercial blendings of materials for a complete N-P-K mix became an industry as the number of materials and increased knowledge of crop requirements became known. Sophistication in fertilizer manufacturing continues to add new products of greater agronomic value.

Man originally supported himself through hunting for food and body covering to protect his body from the elements. The meat of the animals he killed provided his food along with certain plant materials that were edible. Man at this age led a nomadic existence moving from place to place seeking his necessities for life. Certain geographical areas produced a greater abundance of man's necessities. These areas had a greater natural fertility and man learned how to manage the growth of desirable plants for human and animal subsistance.

The new life of crop production reduced the time man spent seeking food and clothing. With greater time available his power of thought became more dominant and he created what we call civilization. The first great civilizations were established about 5,000 years ago (2). These civilizations developed in the fertile crescent shaped region in Asia. The area began at the Mediterranean Sea, stretched between the Tigris Euphrates Rivers and ended at the Persian Gulf.

In civilizations or metropolitan areas where the time spent in producing food by the population was reduced, the trading of goods became a greater factor. The later civilizations were in Egypt along the Nile River. The annual flooding of the river banks renourished the soil by the soil brought down by the water and deposited along the river banks. In the course of time man found he could increase the productivity of soils by adding certain materials to the existing soils. This process was the beginning of fertilizing practices. Through fertilizing practices civilization could exist beyond those areas that had natural fertility.

In some of the early fertile areas the nutrients were consumed and the land became waste or non-productive for plant growth. Civilizations in areas where the soil became unfertile or non-productive have disappeared long ago. The initial fertilizer practices were pretty rudimentary. Man observed that by adding manures, fish and animal wastes to the soil he could maintain productivity. These ingredients gave the soil a renewable nitrogen supply. Ashes were often added to the soil. Ashes gave potash to the soil. Experimentation by the Greeks and Romans with sulfur and lime gave greater soil productivity.

Soil management or the way soil was manipulatd became a factor in maintaining soil productivity. In northern Europe, where the manor system used crop rotation, the soils responded with better productivity. The westward population movement in the United States was caused by soil destruction.

From the Atlantic costal areas that were originally colonized populations moved westward to virgin fertile soils leaving behind them fallow unproductive lands. Some growers were determined to stay put and improve the fertility of the soil through the addition of amendments and practicing soil management to protect the soil from destruction by the natural elements of weather.