improve field-level adaptation and turf quality, that is, the ability of a strain to hold up in the larger laboratory of the outside environment. For selecting field-level adaptation and quality, genotypes must be given the test of time. In some cases, the genotype that survives best will turn out to have resistance to a number of pests, and be competitive with weeds (G. W. Burton, personal communication).

In view of these concerns, the turfgrass breeding program at ARC-Fort Lauderdale emphasizes selection techniques. Since adaptation is genetically determined, and environment is the multiple impingement of management and climatic variables, it should be possible to model these factors, and use them to improve the predictability of selection. One of the important problems for plant breeders is in determining what degree of a stress factor is optimal for selecting genotypes resistant or tolerant to that stress. Methods presently being used by us include: (a) greater reliance on quantitative measurements (such as growth rate as a response to environmental stress); (b) the use of incomplete block designs for visually evaluated experiments; (c) establishment of minimal management plots for long-term adaptation studies; and (d) multivariate analysis of variance procedures to relate long-term adaptation to specific characteristics.

Conclusions

Turfgrasses are an important part of our expanding urban environment. The 370,000 ha of turf in Florida helps moderate urban areas against such dangers as hurricanes, as well as contributes to the beauty and usefulness of landscape environments. The turfgrass industry is also a major contributor to Florida's economy (4). Better grasses are rated as a high priority for Florida; only one new grass has been released in Florida in the past 15 years. The climate of Florida is unique, turfgrasses developed elsewhere in the South sometimes perform poorly here, and more grasses specifically tailored to Florida are needed.

To keep step with future changes, a germplasm resource base has been developed that is available for testing against new and virulent biotypes of diseases and insects. An ongoing program may be a better way of meeting future challenges than crash programs directed to solve the next major biological catastrophe to hit ornamental plants. Hopefully, we can develop enough information on the genetic structure of warm-season turfgrasses, so that the challenge of a new pest problem can be met by a diverse breeding population with resistance to the problem.

Turfgrasses of the 1980's will not look much different from those of today. New conditions in the availability of pesticides, fertilizer, and water will be considered in developing new grasses. Priority in the breeding program at ARC-Fort Lauderdale is placed on the recognition of genotypes requiring smaller inputs of energy, in order to maintain an attractive and durable cover for our urban areas. In addition, it is our plan to provide a greater range of options in the kinds of turfgrasses available.

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PETIOLE INJECTION OF COCONUT PALM, A METHOD TO PREVENT PERMANENT TRUNK INJURY DURING ANTIBIOTIC TREATMENT FOR LETHAL YELLOWING[1]

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Additional index words. Mycoplasma.

Abstract. **Treatment of coconut palms with trunk injections of the antibiotic oxtetracycline-HCl has come under widespread use for control of the lethal yellowing disease in Florida. The principal drawback to the treatment methods currently in use is that a permanent injury is made to the trunk at the site of injection. An alternative method of injecting the bases of leaf petioles was found to be of definite therapeutic value in diseased palms, even though high overall tissue concentrations of antibiotic were found only in the treated fronds.**

Antibiotic treatment of coconut palms (*Cocos nucifera* L) with oxytetracycline-HCl (OTC) has been extensively utilized since 1974 in Florida as a control measure for lethal yellowing (LY), a disease associated with a mycoplasmalike organism. The only treatment method found to produce con-

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sistently acceptable levels of disease control and high foliar levels of OTC in previous tests has been injection of aqueous solutions of the antibiotic directly into the trunk of the tree (1, 5). Foliar sprays and soil drenches had no effect on disease expression and produced little or no detectable OTC in foliage (3). Trunk injections, however, produced an even distribution of antibiotic throughout the foliage within 2-3 days (5); trunk injections were efficient to apply on a large scale basis in terms of labor and expense (3), and were effective in suppressing LY symptom development in diseased coconut palms (4).

The major drawback to the trunk injection method is the drilling of a 3-6 mm diameter hole approximately 75 mm deep into the trunk at the injection site. Since coconut palms produce no secondary trunk growth, these holes remain indefinitely. Sap may bleed from the injection sites resulting in dark stains on the trunk (Fig. 1), and these holes may serve as sites for secondary infections. Bleeding may be prevented by plugging the injection holes, but the injury remains nonetheless. This study explored the potential use of petiole injections of OTC to control LY. Such injections do not produce a permanent injury since the injection site is naturally abscised upon the shedding of the injected frond after about one year.

Fig. 1. Stain produced by bleeding from wound incurred through trunk injection.

Methods and Results

Two tests were performed to evaluate the petiole injection technique, the first to determine the uptake and distribution of petiole injected OTC, and the second to compare petiole and trunk injections in LY diseased palms.

Oxytetracycline distribution.—Five healthy coconut palms of 1-2 m trunk height were selected for study. One frond in approximately mid-crown in each tree was selected for injection and numbered zero. Fronds above this frond (younger) were numbered positively in phyllotaxic order, spiraling up to the spear (bud) leaf which was number 5 or 6. Fronds subtending the injected frond were numbered negatively in a downward spiral. Treatment consisted of 2 grams of OTC (22.5% soluble powder, Diamond Shamrock Corp., Rahway, New Jersey, 07065, USA) dissolved in 12 ml water and injected with a Mauget™ injector (J. J. Mauget Co., Burbank, California, 91505, USA). Treatment was made as described for trunk injection (2), except the injection was made in a petiole base. It was necessary to hold the feeder tube for the injector unit with a pair of pliers when the injector unit was pushed onto the tube so that the tube was not pushed too deeply into the soft petiole tissue (Fig. 2). High pressure hydraulic injectors could not be used for petiole injections as the tissue split allowing the solution to leak out.

Antibiotic concn in leaf tissue was determined by bioassay using *Bacillus cereus* subsp. *mycoides* (Flugge) Smith as an indicator organism as described previously (5). The minimum threshold for detection of OTC in palm fronds was determined previously to be 0.5 μg/g tissue fresh weight (5). For these tests, three pinnae, one each from the basal, middle, and upper portion of each sampled frond were taken for assay at 3 and 7 days after injection. The distribution of antibiotic into foliage, as depicted in Fig. 3, was essentially restricted to the treated frond in which levels as high as 28 μg OTC per gram tissue fresh weight were detected. Oxytetracycline levels in the untreated fronds were all less than 2 μg/g tissue fresh weight. The highest levels of OTC were found after 7 days in the treated fronds.

Therapeutic efficacy.—The critical measure of petiole injection is, of course, the efficacy achieved in remitting symptom development in LY diseased palms. Twenty-four coconut palms of 2 to 10 m trunk height which were exhibiting primary (pre-yellowing) (4) symptoms of LY were selected and each was treated with 3 g OTC dissolved in 13 cc water. Twelve trees received petiole injections with the Mauget injector as described in the previous section. Six trees received trunk injections with the Mauget injector, and 6 trees received trunk injections with a hydraulic-type injector (Minute Tree™ Injector, Minute Tree Injectors Inc., Miami, Florida).

Subsequent symptom development, recorded monthly for 7 months, is summarized in Table 1. Six of the 12 petiole-treated palms ceased all symptom development after treatment and were producing healthy new growth within 3 months (complete remission), although one of these began renewed symptom production 6 months post-treatment. Four palms exhibited a partial remission after 4 months in that some yellowing symptoms continued to develop, even though new, symptom-free inflorescences were produced. Two trees showed no effect of the treatment as compared to the expected rate of symptom development in untreated palms (4). The trunk injections with the Mauget and hydraulic injectors were not obviously different from the petiole injections in therapeutic response, although the Mauget injections of the trunk appeared to have the best ratio of response in this limited test.

Fig. 2. Petiole injection technique: A-feeder tube inserted to proper depth in drilled hole, B-feeder tube held in place with pliers while injector unit is attached so that tube is not pushed into tissue.

Discussion

Even though the OTC residue determinations presented in Fig. 3 indicate that high overall tissue levels of OTC were obtained in only the single treated frond, petiole injection appeared to be as therapeutically effective as trunk injection. Large scale tests reported previously (4) achieved a rate of complete remission of 50% in trunk-injected diseased trees treated in the pre-yellowing stages of LY, equivalent to the response to petiole injection observed in these tests.

It has been determined that trunk injection will produce uniform foliar levels of OTC (1, 5); therefore it is interesting that petiole injection is equivalent to trunk injection in therapeutic response. The pattern of distribution of OTC after either trunk or petiole injection is indicative of a xylem pathway for initial translocation. To be effective against a phloem delimited mycoplasmalike organism the OTC must get into the phloem. The fact that petiole injection is therapeutically effective is evidence that after OTC moves into the leaf and is distributed throughout the apoplast by way of the transpiration stream, it is then transferred, either actively or passively, into the phloem and exported from the leaf in a systemic manner. This transfer must take place within the tissues of the leaf.

The petiole injection technique was found to be effective therapeutically against lethal yellowing. This technique is significant in that it eliminates the permanent injury associated with trunk injections. Although petiole injection will be difficult to apply to tall trees by individual home-

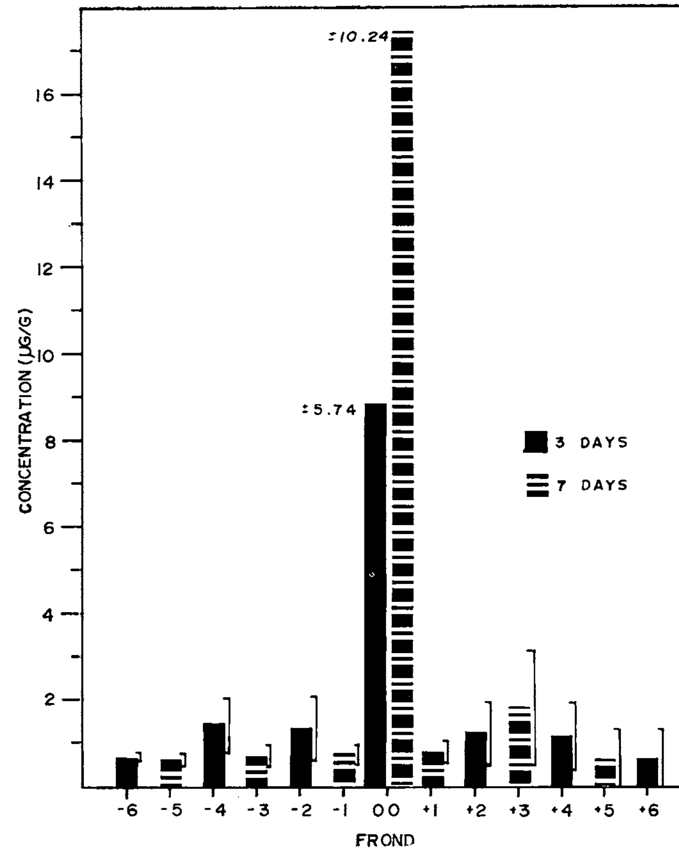

Fig. 3. Foliar concns of oxytetracycline in coconut fronds above (+) and below (—) the single petiole-injected frond of each tree. Mean of 5 treated palms. Brackets represent standard deviations.

Table 1. Therapeutic efficacy of three injection methods in lethal yellowing diseased coconut palms, determined 4 and 7 months after treatment. Complete remission denotes a total cessation of symptom development and resumption of healthy new growth. Partial remission denotes resumption of healthy new growth while yellowing symptoms continue to develop in older growth.

Location and Type of Injection	No. Trees	Complete Remission 4 mo	7 mo	Partial Remission 4 mo	7 mo	No Effect 4 mo	7 mo
petiole-Mauget	12	6	5	4	5	2	2
trunk-Mauget	6	4	2	1	3	1[z]	1
trunk-hydraulic	6	2	1	4	4	0	1

[z]Injector knocked off tree within 24 hours of treatment by falling frond.

owners, many street and park plantings of coconut palms in Florida are trimmed regularly by municipal maintenance crews. The petiole injection could be applied conveniently to such trees at the time of trimming. Treatment should be repeated at 3-4 month intervals to maintain remission. The petiole injection technique might also be investigated as a means of applying exogenous nutrients in cases of mineral deficiencies in coconut and other palms.

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EVALUATION OF CALLISTEMON SPECIES FOR NORTH FLORIDA[1]

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Additional index words. Cold injury.

Abstract. **In 1974, seeds of over 20 species of** Callistemon **R. Br. were obtained from the Los Angeles Arboretum. The seedlings were grown in containers under field conditions in Gainesville, Florida. During the winter of 1976-1977, the plants were exposed to 42 nights of freezing temp. Mortality rates of 100% were observed with** C. viminalis, **and** C. pinifolius, **whereas** C. paludosus (C. salignus **var** australis), C. violaceus **and** C. brachyandrus **exhibited little or no cold damage.**

Callistemon have long been admired as landscape plants for tropical and subtropical areas. Their showy flowers are in a spike varying in color from white to cream to orange-red to red with long exserted stamens making them resemble a bottlebrush. The plant size, form and foliage texture vary greatly among species. Some species rarely grow taller than 6 ft. (ca. 2 m), while others grow as tall as 20 ft. (ca. 6 m). The graceful weeping form of *Callistemon viminalis* differs greatly from the stiff rigid upright form of *C. rigidus.* The leaves of some species are sword-like while leaves of other species are thin and needle-like.

Although the *Callistemons* are valuable landscape plants, there is little information in the literature on the cold hardiness of individual species. Therefore, this study was undertakened to determine cold hardiness of 20 species of *Callistemons.*

Materials and Methods

Seed of 20 species of *Callistemon* were obtained from the Los Angeles Arboretum in 1974 and germinated in the Ornamental Horticulture greenhouses at Gainesville, Florida. The seedlings were transplanted into 3 inch (7.5 cm) pots when they reached the two leaf stage. There after, they were maintained under standard nursery cultural practices.

In the fall of 1976, 20 plants of each species (Table 1) were planted in 2 gallon (8 liters) black plastic nursery containers and set outdoors on a white gravel bed in full sun. The plants ranged in height from 18 to 36 inches (45 to 90 cm).

Table 1. Effects of low temperature on degree of injury or survival of *Callistemon spp.* R. Br.

Species	Damage Rating[z]
violaceus	1.0
sieberii	1.0
jeffersii	1.0
hortensis	1.0
brachyandrus	1.0
semperflorens	1.2
speciosus	1.2
paludosus	1.3
acuminatus	1.6
citrinus	1.8
rigidus	2.0
pityoides	2.4
linearis	2.8
falcatus	3.0
rosea	3.0
saugaus	3.1
comboynensis	3.1
formusus	3.6
pinifolus	5.0
viminalis	5.0

[z]Rating 1.0—no damage; 2.0—slight damage to some leaves; 3.0—moderate damage—up to 50% of plant damaged; 4.0—heavy damage—up to 90% of plant damaged; 5.0—plants dead.

The plants were exposed to 42 nights of 32° F (0° C) or below with the lowest temp recorded being 19° F (−7° C). Some nights the plants were exposed to 12 or more hours of freezing temp.

The plants were observed all winter and were rated for damage on April 1, 1977, when new growth had developed. The rating system used was (1) no damage; (2) slight damage to some leaves; (3) moderate damage—up to 50% of plant injured; (4) heavy damage—up to 90% of plant damaged and (5) plants dead.

Results and Discussion

The winter of 1976-77 was one of the coldest winters on record. There were 42 nights of freezing temperatures as compared to the previous record of 33 days in 1975-76 and prior to that time the record for north Florida had been 24 days of temperature of freezing or below. The winter of 1976-77 did not have as low a temperature as 1962-63 when

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