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INCIDENCE, SEVERITY AND CONTROL OF ANTHRACNOSE IN LEATHERLEAF FERN IN FLORIDA

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Abstract. **Surveys conducted at two grower meetings held in the center of the leatherleaf fern production area showed that fern anthracnose was first detected in commercial plantings of leatherleaf fern in Florida in 1993. The initial rate of spread of fern anthracnose was exponential and by 1997 all firms responding to the survey had detected the pathogen in their fern. By 1997, over half of the surveyed production acreage was infected and production losses were estimated to average 22%. Fern anthracnose appears to be difficult to control as most growers were using fungicides regularly both prior to and after infection. In 1995, growers often used low- and high-pressure, high-volume hydraulic sprayers to apply fungicides, but by 1997 most fungicides were applied using chemigation and airblast sprayers. Of several methods tried for rehabilitating ferneries severely damaged by fern anthracnose, fungicide drenching was reported to be the most effective. Incidence and damage from fern anthracnose was generally higher during the summer than during the winter and spring.**

Fern anthracnose, caused by the fungus *Colletotrichum acutatum* J. H. Simmonds, has caused serious damage to commercial leatherleaf fern plantings (Leahy et al., 1995; Strandberg et al., 1997), a crop with a wholesale sales value of over $64 million in 1996 (U.S. Dept. Agr., 1997). The purposes of the surveys reported here were to determine (1) how rapidly fern anthracnose was spreading throughout the industry, (2) what growers were doing to try to prevent and/or control the disease, and (3) how the incidence of the disease varied seasonally.

Materials and Methods

Two meetings were held in Pierson, FL (one in June 1995 and a second in January 1997) at which leatherleaf fern producers could learn about fern anthracnose and discuss its management. Pierson is located in the geographic center of the main Florida leatherleaf fern production area. Attendees were given survey forms that asked whether or not anthracnose had been detected in their ferneries, when it was first detected, what their fungal disease control programs had been before the first occurrence of this disease and what had been done to control fern anthracnose once it was detected. In addition, each respondent was asked to indicate the location(s) and size of their company and the effects of fern anthracnose on yield. At each meeting, respondents were instructed to fill out only one survey instrument per company.

To determine the seasonality of disease incidence, weekly scouting in two five-acre sections of a 20-acre commercial fernery in Seville, FL was conducted. About 150 mostly expanded but still immature fronds (growth stages 5 and 6 - see Strandberg et al., 1997) were randomly collected in each section each week and checked for the presence of fern anthracnose damage. The percentage of leaves infected in each section was determined.

Results and Discussion

Respondent information. Seventy-five companies completed the first questionnaire and 50 completed the second. Eighty percent of the 125 respondents were from Volusia County, the predominant leatherleaf fern producing county in the state. This value probably reflects the fact that 80% of the leatherleaf fern produced in Florida is grown in Volusia County (Stamps, 1994) and not that the meetings were held in Volusia County. Leatherleaf fern producers from Lake, Orange and Putnam Counties also participated in the surveys. In the second (1997) survey, the classification of respondents by the amount of leatherleaf fern production acreage they managed/owned appeared to be normally distributed (Fig. 1); the distribution for the first survey was similar. Sizes of production acreage ranged from one-half (0.2 ha) to more than 150 acres (61 + ha).

Disease incidence and severity. Fern anthracnose was first discovered in commercial leatherleaf fern in Florida in May

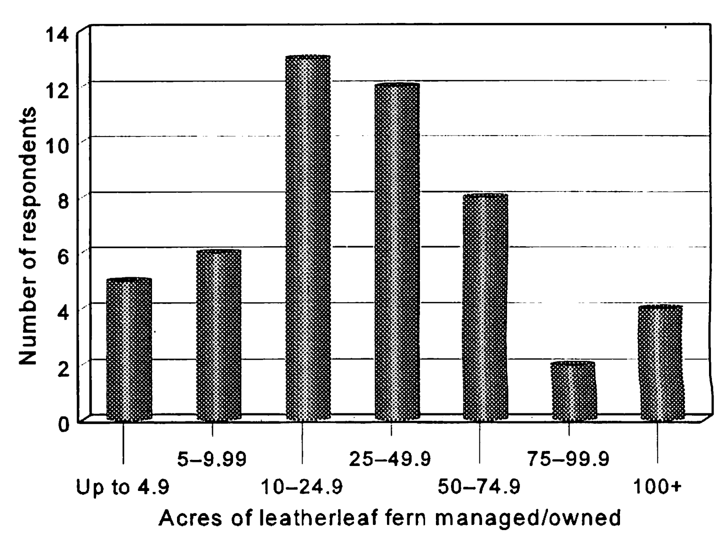

Figure 1. Leatherleaf fern acreage size distribution of producers surveyed in 1997. (1 acre = 0.4 hectare).

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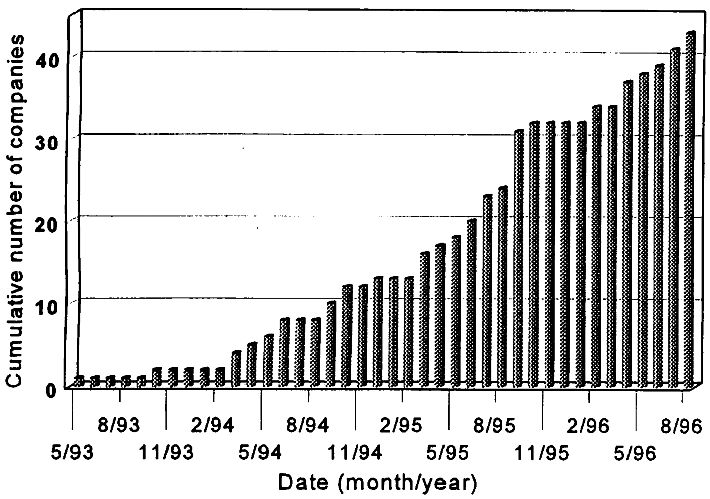

Figure 2. Cumulative number of companies reporting infection with anthracnose based on date of first observance of symptoms (1997 survey). For the first two years the increase was exponential ($\ln(y) = -0.3 + 0.14\,x$, $r^2 = 0.95$), then it became linear ($y = -12.9 + 1.4\,x$, $r^2 = 0.86$). x = months after the first detection (May 1993).

1993. Sixty percent of the companies that filled out the 1995 survey reported this disease had been positively diagnosed in at least one of their ferneries. By 1997, all companies completing the survey had detected the disease in their fern. These percentages may be artificially high because persons experiencing the anthracnose problem would be more likely to attend the meetings where the surveys were handed out than those that did not have the problem. However, extension agents and growers in leatherleaf fern production areas have reported that very few growers have not had a problem with fern anthracnose. This is probably because the pathogen is so easily spread. In fact, for the first two years after fern anthracnose was detected in Florida, the spread of the disease was exponential (Fig. 2). After that, the increase became linear with 1.4 new firms detecting fern anthracnose each month.

In 1995, the percentage of growers with positively diagnosed anthracnose problems increased linearly by company size categories (Fig. 3). This phenomenon could be due to a number of factors such as more movement of people (consultants, cutters, delivery persons, weeders, etc.) among ferneries of larger versus smaller growers, or simply, with greater acreage, the chance of infection is increased (i.e., providing a larger target that is more likely to be inoculated by movement of contaminated animals or water and/or to provide areas with the proper environmental conditions for disease development).

By 1997, growers reported that over half (53.7%) of their leatherleaf fern production was infested with fern anthracnose and that declines in production ranged from none to 50%. The overall average reduction in production attributed to fern anthracnose was estimated to be 22%.

Disease seasonality. New incidences of fern anthracnose infestations were reported by the survey respondents for every month of the year except January. The occurrence of new outbreaks of anthracnose appears to slow down (plateau) during the winter months (Fig. 2). Scouting results of disease incidence support this observation (Fig. 4). Disease incidence, as measured by the percentage of sampled fronds infected with fern anthracnose, declined during the winter, began to rise as temperatures increased, was high throughout the wet summer, and peaked in late summer.

Disease control. In the 1995 survey, 73% of the responding growers answered that they had been applying fungicides on a regular basis just prior to the first signs of infestation. Twenty-seven growers had been using chlorothalonil (Daconil™, Echo®, Thalonil™), 13 mancozeb (Dithane®, Fore®), 11 thiophanate-methyl (3336, Domain®, Fungo® Flo, Systec 1998®), and one each carbamate (Ferbam®) and benomyl (Benlate®). This, and the finding that all companies in the 1997 survey had positively identified fern anthracnose in their fern, suggests that fern anthracnose is difficult to control with traditional application methods and fungicide use rates and frequencies. This is most likely related to the dense leatherleaf fern canopies that make effective fungicide application to emerging fronds difficult and provide ideal environments for pathogen and disease development.

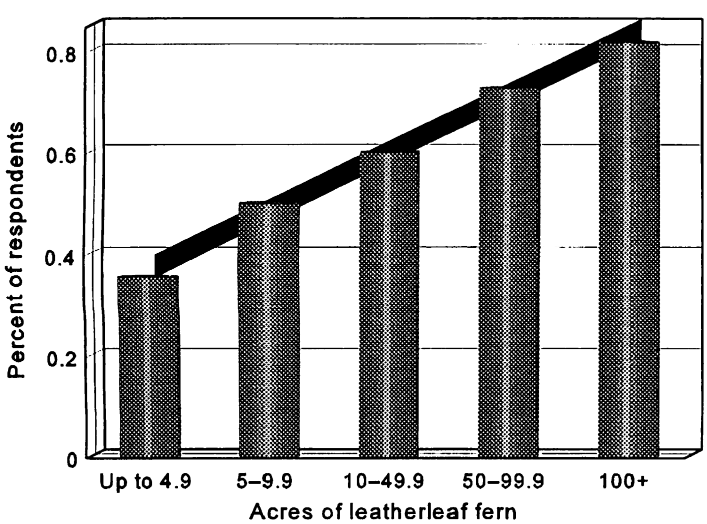

Figure 3. The percentage incidence of leatherleaf fern anthracnose increased with increasing company acreage in production (1995 survey).

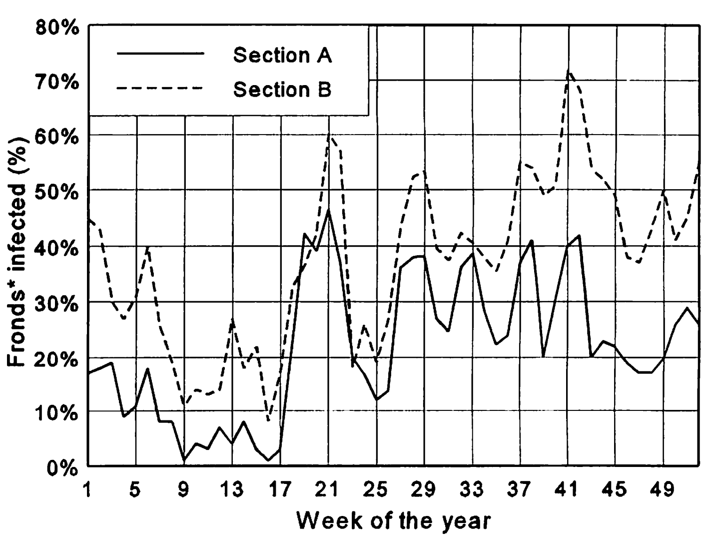

Figure 4. Seasonal changes in fern anthracnose incidence in two five-acre sections of a 20-acre commercial fernery.

When growers in the 1997 survey were asked to list the chemicals that they thought provided at least partial control of fern anthracnose, many of the above products were listed and only two growers indicated that no chemicals were effective. Mancozeb products (Dithane®, Manzate®, Penncozeb®, Protect) were listed most frequently (86% of respondents). Chlorothalonil products (Daconil, Echo®, Thalonil™) were the second most frequently (68%) listed materials. Although it is not labeled for use on leatherleaf fern, tebuconazole (Folicur®) was listed by 58% as being at least partially effective. Thiophanate-methyl (3336, Topsin® M), fenbuconazole (Enable®) and propiconazole (Banner®) were listed by 50%, 36% and 30% of the respondents, respectively. The latter two chemicals are demethylation-inhibiting fungicides like tebuconazole, but only Banner® has labeling that allows its legal use (at user's risk) on leatherleaf fern. Other chemicals listed as being efficacious by 10% or more of respondents were captan (Captan), chloroneb (Chloroneb, Terraneb), neem oil extract (Triact™) and sulfur. Chemicals listed by less than 10% of growers were alcohol, benomyl (Benlate®), copper hydroxide (Kocide®), ferbam (Carbamate®), fosetyl-aluminum (Aliette®), *Gliocladium* (SoilGard™), iprodione (26019), metalaxyl (Ridomil®), metiram (Polyram®), myclobutanil (Systhane®), PCNB (Terraclor®), quanternary ammonium (Zepamine), sodium hypochlorite (bleach) and triforine (Triforine).

The frequency with which products were listed is not necessarily an indicator of their relative efficacy in controlling this pathogen. Some products may have been listed more often than others simply because of availability, labeling, price or common usage for general disease control. Other products may have been listed infrequently because they were not widely distributed and/or were new in the market. Furthermore, some products listed as used by growers may not be legal to use on leatherleaf fern. Benomyl is an example of a product that is not labeled for use on leatherleaf fern (or any ornamental crops) and is not particularly effective in controlling fern anthracnose. Interestingly, benomyl is used by plant pathologists to make semiselective media to isolate *C. acutatum.* The benomyl inhibits other fungi from growing on the media while allowing *C. acutatum* to grow and sporulate (Bernstein et al., 1995; Norman and Strandberg, 1997).

When asked in 1997 how the chemicals were applied, the most common methods by far were chemigation and airblast sprayers; only 6.1% of the companies used high-pressure hydraulic sprayers (Fig. 5). By contrast, in 1995 low- and high-pressure (high volume) sprayers were used by 19.1 and 38.3 of the respondents. These changes may have been due to several factors such as the relatively high cost and time required to apply chemicals using pressurized hydraulic sprayers, changes to fungicide labels that allowed chemigation applications, and improvements in managing the disease using conventional cut foliage industry pesticide delivery systems (airblast sprayers and irrigation systems).

Disease eradication efforts. Of the several methods employed by leatherleaf fern producers to eradicate fern anthracnose, mowing and chemical drenches were the ones most commonly used and drenching was considered the most effective (Fig. 6). Burning and mowing cause significant production losses because the plants must recover from defoliation, and that can take months. Drenching does not cause similar losses. Other eradication methods cited by growers were spot spraying, frequent fungicide treatments, hand spraying in areas immediately after harvesting, and cutting out infected fronds by hand. All of these methods are expensive and labor intensive. Some of these methods may not be very effective; in fact, only 6% of the growers reporting in 1997 indicated that they had any ferneries that were anthracnose free.

Conclusions. The survey and scouting results indicate that (1) a significant number of companies have detected leatherleaf fern anthracnose in their ferneries, (2) companies with larger production areas of leatherleaf fern were more likely to have the problem initially, (3) fern anthracnose disease spreads readily, (4) damage severity is highest during the summer (June-Sept.) and lower during the winter and spring, (5) preventative applications of some labeled fungicides or application without specific control strategies may not effectively prevent infection, (6) production losses due to this disease are very significant, and (7) eradication of fern anthracnose is difficult and potentially expensive due to materials and labor costs and possible temporary yield losses associated with certain methods.

Much more needs to be learned about anthracnose of leatherleaf fern so that effective and economical control methods can be developed. What fungicides can be applied

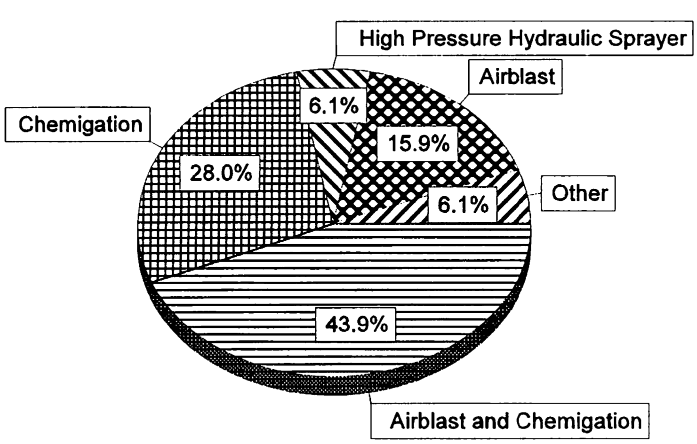

Figure 5. Methods used to apply chemicals for leatherleaf fern anthracnose control in 1997. (Airblast = airblast sprayer).

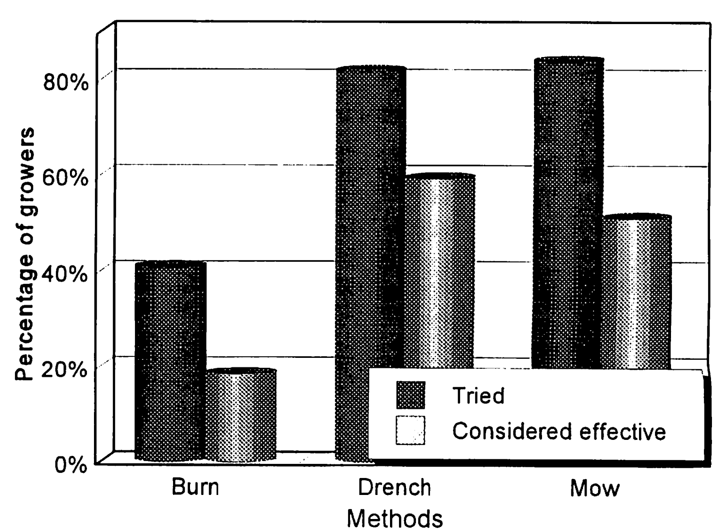

Figure 6. Methods tried by growers to eradicate anthracnose in leatherleaf fern and growers' assessment of the efficacy of the method.

to best control this pathogen? At what rate, by what method(s), and at what frequency should fungicides be applied? What environmental factors promote or inhibit the growth of the pathogen? Are there management practices that can prevent ferneries from becoming infected or that can help suppress disease development? These and other questions must be answered for leatherleaf fern anthracnose control to become an economic reality.

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EFFECTS OF ROSE MOSAIC DISEASE ON PERFORMANCE OF HYBRID TEA ROSES IN FLORIDA

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Abstract. **A bed of 'Double Delight' Hybrid Tea rose (*Rosa* hybrid) grafted to 'Dr. Huey' rootstock, was grown in the Florida Southern College rose garden. Some plants were graft-inoculated with a mild strain of prunus necrotic ringspot virus (PNRSV) and others with a severe strain of apple mosaic virus (ApMV), the two major causes of rose mosaic disease. Virus-infected plants produced fewer flowers and shorter stems than did healthy controls, on the spring growth flush. Other growth flushes throughout the season did not show significant differences between treatments and control. No spread of either virus occurred over the 4-year period. During the fourth year, most of the ApMV-infected bushes died.**

Rose mosaic is a disease of cultivated roses caused by prunus necrotic ringspot virus (PNRSV) and/or apple mosaic virus (ApMV), in the United States. Arabis mosaic virus (AMV) is also a possibility in other areas of the world, but it is not believed to exist in US-grown roses. PNRSV and ApMV are naturally occurring diseases of fruit trees such as cherry, peach, and apple, and they are contagious among those species, spreading via pollen. They are not believed to occur naturally in roses; however, the viruses will survive in a rose bush and cause rose mosaic, if a plant is infected by budding or grafting infected wood into it. There have been some lively debates over exactly how mosaic spreads in roses. Aphids, thrips, pruning shears, contaminated soil, root contact and pollen have all been suggested (Cochran, 1988; Davidson, 1988; Horst, 1983; Manners, 1988). Many growers continue to believe that mosaic can be transmitted by one or more of these means. Yet there has never been any proof of such contagion. In extensive research over many years, none of these methods has ever been demonstrated to occur in roses. As far as is known, the American forms of rose mosaic never spread from bush to bush in a garden. The only demonstrated method of infection is in the grafting process, and a healthy budded or grafted bush should remain free of mosaic for life (Harwood, 1991; Manners, 1988).

Another unsubstantiated opinion, often expressed among commercial and hobbyist rosarians, is that rose mosaic does no significant damage to a rose, other than a few mottled leaves from time to time. Since rose mosaic is not deadly, often shows no foliage symptoms, and may not be obviously detrimental, it is easy to see how one might assume that the disease is not doing significant damage. This idea persists despite published reports from England (Thomas, 1981, 1982) that mosaic causes reduced flower production, poorer flower quality, reduced plant survival, reduced cold-hardiness, more difficulty in transplanting, and reduced rates of budding success. Unpublished research in California has also demonstrated reduced flower production and flower quality (George Nyland, personal communication).

Rose cultivars can be freed of the viruses causing rose mosaic by heat-therapy. Florida Southern College's heat-therapy program was previously described in these Proceedings (Manners, 1985).

The research described in this paper was designed to provide data on the effects of rose mosaic on outdoor-grown, Hybrid Tea roses in Florida. We were interested in the effects of mosaic on the growth, productivity, and quality of infected bushes over several seasons. Too, we thought it would be a good opportunity to provide further data on the already heavily studied subject of rose mosaic's lack of contagion in a rose garden.