UNIVERSITY OF FLORIDA
EXTENSION
Institute of Food and Agricultural Sciences

CIR 1232

Florida Crop/Pest Management Profiles: Ornamentals[1]

Barbra C. Larson & O. Norman Nesheim[2]

Production Facts

- Florida is ranked second nationally in the production of ornamental plants, which includes cut flowers, flowering potted plants, hanging baskets, potted foliage plants, cut foliage (cultivated greens, florists' greens), bedding and garden plants, and woody ornamentals (1). This profile documents production only and excludes landscape maintenance, sod production and greenhouse vegetable production.

- Florida leads the country in the production of cut foliage, houseplants, gladioli and poinsettias (1).

- In 1997, the wholesale value of sales of all floriculture crops in Florida (cut flowers, potted flowering plants, houseplants, bedding/garden plants, and cut cultivated greens) accounted for 19.1 percent of the total wholesale value of floriculture crops in the nation. The wholesale value of total cut cultivated greens in Florida represented 81 percent of the total U.S. wholesale value, with the wholesale value of leatherleaf fern representing 93.7 percent of the U.S. total and the wholesale value of other cut cultivated greens representing 64.6 percent of the national total. In addition, the state's wholesale value of sales of all houseplants (potted foliage and foliage hanging baskets) accounted for 63.3 percent of the U.S. total, while sales of potted flowering plants constituted 12.3 percent of the national total, sales of bedding and garden plants represented 6.7 percent of the U.S. total, and sales of cut flowers comprised 6.5 percent of the national total wholesale value of sales (2).

- As one of the fastest growing sectors of Florida agriculture in recent years, nursery crop production typically accounts for about 18 percent of the state's farm cash receipts, including about 10 percent for foliage and floriculture. Sales of Florida nursery and greenhouse crops, excluding sod and greenhouse vegetables, exceeded $1.24 billion in 1997, according to the Census of Agriculture. A survey of Florida wholesale nurseries in 1997 indicated that sales of ornamental plants, excluding turfgrass, totaled nearly $1.46 billion. That places the ornamental industry as the second

1. This document is CIR 1232, one of a series of the Pesticide Information Office, Food Science and Human Nutrition Department, Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida. For additional Information, contact the Pesticide Information Office, University of Florida, P. O. Box 110710, Gainesville, Fl 32611-0710, (352) 392-4721. Published as CIR 1232: May, 1999. Revised: December, 2000. Please visit the EDIS Web site at http://edis.ifas.ufl.edu.

2. Barbra C. Larson, Visiting Assistant In, O. Norman Nesheim, Ph.D., professor and pesticide coordinator, Pesticide Information Office, Food Science and Human Nutrition Department, Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida, Gainesville, 32611-0710.

largest agricultural sector in Florida, recently surpassing citrus to take the second spot behind vegetables in total sales (1,3-5).

- Florida's ornamentals industry has been expanding for a number of years. Between 1989 and 1994, average sales per firm grew by 26 percent in constant dollar terms, and average employment increased by 15 percent. From 1992 to 1997, 63 percent of Florida's nursery firms experienced increased sales and 71 percent expected sales to increase over the next 5 years. Although wholesale value of total sales of floriculture crops declined slightly in 1997 to $654 million, production of potted foliage plants in Florida increased by 3 percent. Sales of bedding plants have had the greatest increase, with moderate increases in sales of potted flowering plants and foliage plants. Sales of cut cultivated greens have remained stable, and sales of cut flowers have declined (2,5).

- Foliage plants typically account for the greatest percentage of sales within the ornamental nursery industry in Florida. In 1995, a survey of ornamentals growers revealed that foliage plants represented 47 percent of total sales, with 19 percent for woody ornamentals, 12 percent for bedding plants, 10 percent for trees, 4 percent for floriculture (interpreted in the survey as cut flowers and flowering potted plants), and 1 percent for liners (6). The 1997 survey of wholesale nurseries showed that sales of tropical foliage plants or palms (estimated at $503 million) comprised 34 percent of total nursery sales, while sales of potted flowering plants or bedding plants (estimated at $251 million) represented 17 percent, sales of woody shrubs (estimated at $236 million) represented 16 percent, and sales of propagating liners, cuttings or plugs (estimated at $133 million) represented 10 percent of total nursery sales. Native Florida plants of all types generated $101 million in 1997, representing 7 percent of total nursery sales (5).

- Production area for all types of ornamental plants in Florida nurseries totaled over 38,000 acres in 1997, including greenhouses and shadehouses, open container production and field production (5).

- In 1996, 1028 growers of non_woody ornamentals maintained 374 million square feet of covered area and 9,577 acres of open area, generating over $660 million in wholesale value. Over 400 foliage growers, each with sales of over $100,000, produced plants valued at $326.8 million on 159.7 million square feet of land in 1996. Cut foliage growers (274 with sales of over $100,000) produced over 74 million bunches on 7,495 acres, with a value of nearly $97 million. Cut flower growers (18 with sales over $100,000) generated over $27 million in wholesale value on 3,413 acres. Over 200 growers produced nearly $107 million in bedding plants (78.6 million flats and pots) and $84 million in hanging flowering baskets (22.6 million pots) in 1996 (1). In 1997, foliage sales (potted and hanging baskets) exceeded $330 million. Of that total, sales of potted foliage reached $308.8 million, and sales of hanging baskets totaled $21.6 million. The state's 423 commercial growers produced foliage plants on 166.4 million square feet of land in 1997. Sales of cut greens for 1997 totaled over $85 million, with $56.5 million of that from production of leatherleaf ferns. In that year, 7,382 acres were planted to cut greens, and 4,270 of that were for leatherleaf ferns (7).

- In 1994, 33 percent of total sales in Florida's ornamental plant industry went to markets outside the state, up from 23 percent in 1989. In 1997, 39 percent of Florida nursery sales were local, 27 percent were within the state, 29 percent were national, and 5 percent were international. Florida ornamentals markets have also shifted in the last few years from dominance by landscapers toward greater sales to retailers, such as garden centers. In 1997, 28 percent of Florida's nursery sales were to other growers, 23 percent to landscapers, 15 percent to retail mass merchandisers, 10 percent to retail garden centers, 12 percent to re-wholesalers and brokers, 3 percent to property developers and managers, and 9 percent to the public (4,5).

- There has also been a trend toward a greater number of larger production firms. For example, 80 commercial operations had sales of over $1 million each in 1997, representing 67 percent of total sales, compared to 69 such growers accounting for 74 percent of sales in 1996. However, most of Florida's nursery firms remain small operations, with over half of the firms surveyed in 1997 reporting annual sales of less than $250,000, and an additional 26 percent reporting sales of less than $1 million. There were more than 4000 wholesale nursery growers registered with the Florida Department of Agriculture and Consumer Services in 1997 (4,5,7).

- The economic impact of Florida's ornamental nursery industry on the state's economy was estimated from 1997 survey results. A key measure of an industry's contribution to the economy is the value added, which is the difference between revenues and production costs, and therefore includes the value of employee wages and benefits, owner's compensation, dividends, capital outlays, and business taxes paid. While the economic value added by Florida's entire horticulture industry, including nurseries, horticulture retailers, and landscape services, was estimated at $5.424 billion, the total value added by nursery production in Florida was estimated at $1.259 billion. Florida nurseries also provided 30,650 jobs in 1997 (5).

- For ornamental nurseries surveyed in 1995, average total annual cost per square foot of growing space for all ornamental crops was $1.17. Total costs per square foot averaged $0.16 for field nurseries, $0.58 for woody container plants, $2.86 for south Florida foliage, $4.11 for flowering plants, and $4.36 for central Florida foliage. Costs of materials (including plants, seeds, containers, peat and soil, fertilizers and lime, pesticides and other chemicals, packing materials, heating fuel, and other production supplies) represented 32 percent of the dollar value produced for all types of production. Also varying by production type, total cost of materials represented 26.5 percent of value produced for woody container plants, 31.9 percent for south Florida foliage, 38.9 percent for central Florida foliage, and 43.8 percent for flowering plants (8).

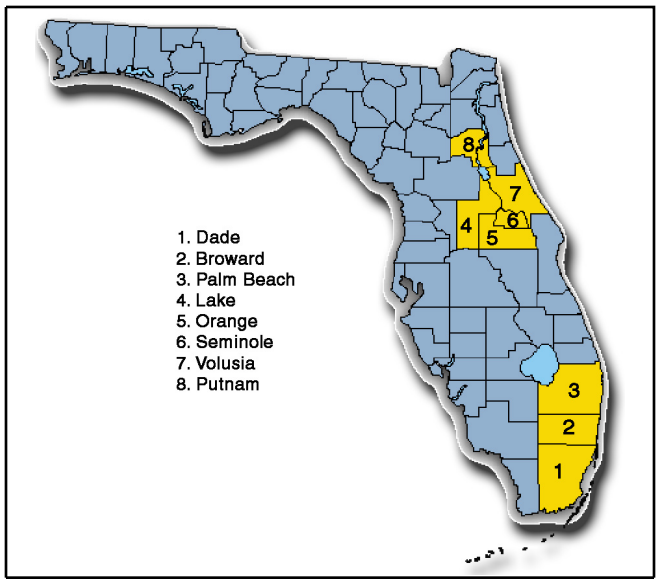
- Average value produced per square foot of growing area in 1995 was $1.18 for all types of production combined, $0.60 for woody container plants, $2.83 for south Florida foliage, $3.97 for flowering plants, and $4.29 for central Florida foliage (8).

- Sixty percent of wholesale ornamental nursery firms surveyed regarding 1995 production practices reported that pest management costs (including materials, labor and equipment) constituted 5 percent or less of their total direct production costs. For 20 percent of firms, costs for pest management comprised 16-20 percent of direct production costs, and for only 1 percent of firms were pest management costs greater than 20 percent of production costs (6). Another survey indicated that average costs of plant protection chemicals represented 2.2 percent of total costs for all types of production, 3.0 percent for container woody ornamentals, 1.6 percent for flowering plants, and 2.0 percent for central Florida foliage (8). Pesticide costs for cut cultivated greens were recently determined to be 4.2 percent of total costs (9).

Production Regions

The southeast region (Broward, Dade and Palm Beach counties) accounted for 53 percent of total Florida foliage sales in 1997, producing $175.8 million worth of foliage plants on nearly 123.9 million square feet. The second largest production area is around Apopka (Lake, Orange and Seminole counties), whose 1997 production of foliage plants ($124.1 million, using 24.8 million square feet) represented nearly 38 percent of the state's sales (7).

The cut foliage industry in Florida, which began with asparagus fern production in Apopka in the 1920s, continues to be concentrated in the central region, with the highest production in Volusia County. Growers there, together with those in Putnam and Lake counties, produce most of the cut cultivated greens in Florida (7).



Major Ornamentals Production Regions in Florida.

Production Practices

Production practices vary within the ornamental plant industry because of the diversity of plants produced and the environmental and cultural systems in which they are grown. For example, woody ornamentals (landscape trees and shrubs) are cultivated in open areas, while greenhouses or shadehouses protect most flowering and foliage plants. Approximately 35 percent of the acreage in Florida's ornamental nurseries was used to produce trees in 1995, with 26 percent for foliage, 25 percent for woody ornamentals (shrubs), 10 percent for bedding plants and floriculture, and 5 percent for liners and other crops (6). Eighty-five percent of sales in 1994 were generated as a result of container production systems, an increase from the 1989 level of 78 percent. In addition, 7 percent of 1994 sales originated from in-ground container production, 5 percent came from products whose roots were balled with burlap or other materials, and 2 percent of sales derived from bare root production. Container production in nurseries, which can continue year-round as a result of the state's mild winters, is popular in Florida for several reasons. In addition to providing more efficient use of labor and space, container production allows producers to manage soil fertility more easily. (4).

Shade management is essential in the production of many ornamental plants. For example, container grown palms produced for interior use must be either shade grown throughout the production cycle or grown in full sun for part of the cycle and shade acclimated before sale (10). Many cut foliage crops also require shade during production. Leatherleaf fern is produced under conditions of 73 percent shade. For other cut foliage crops, oak tree hammocks provide shade for about 35 percent of production, while 65 percent of production is under artificial shade structures due to limited availability of oak tree hammocks (11).

Overhead irrigation is the most common type of irrigation system in ornamental nurseries in Florida and is the principal irrigation system for approximately 80 percent of nurseries. Approximately 12 percent of nurseries primarily use drip or low volume irrigation systems, about 6 percent primarily use flood or sub-surface irrigation systems, and about 2 percent primarily use mist irrigation systems (12). Many nurseries use a combination of irrigation systems. For example, while overhead irrigation may be used on a regular basis, nurseries that carry out their own propagation generally use mist irrigation during the propagation process (13). Usually, production of woody container plants involves overhead sprinkler irrigation or drip irrigation, while bedding and potted flowering plants are often sprinkler irrigated or hand watered. While sprinklers are the best option for cut foliage production as well, they are not used to irrigate cut flowers because of disease problems that result from frequent wetting of above-ground plant parts. Seepage irrigation systems, in which water needs are controlled from below the root zone, are therefore more common in cut flower production (14).

Many sprinkler irrigation systems are adapted for recycling of runoff water. Approximately 15 percent of nurseries in Florida recycle or reuse 75 percent or more of their runoff water, and about 18 percent recycle over half. Although sprinkler irrigation systems have been losing popularity because of the increased use of low-volume systems and mist systems, sprinkler irrigation remains vital to the ornamental nursery industry in Florida as a means of protecting plants from cold temperatures (15,16).

Additionally, cut foliage growers commonly use irrigation systems to apply fertilizers and pesticides.

Ninety-four percent of surveyed leatherleaf fern growers in Florida have reported practicing fertigation and three-quarters reported practicing chemigation (17). For leatherleaf fern grown in shadehouses, growers have reported average number of pesticide applications per year of 19.5, 2.8, 19.6 and 2.1 for fungicides, herbicides, insecticides and nematicides, respectively. Under evergreen oak shade, the numbers of applications per year were generally lower (18). Although only a small percentage of pesticides are labeled for chemigation, this practice has become popular with cut foliage growers in Florida, because it can reduce pesticide application costs, provide greater uniformity of coverage, reduce spray drift, and minimize crop damage. However, efficacy concerns exist due to the extra low concentrations with which pesticides are applied in chemigation (19).

Pest management practices are an important component of ornamental plant production in Florida, because of both the warm, humid climate and consumer intolerance of cosmetically damaged ornamental plants.

Pest Management

The importance of regular scouting within an Integrated Pest Management (IPM) program is recognized by many ornamentals growers in Florida. A pilot program involving nursery IPM trials was begun in Manatee County several years ago to demonstrate the importance of IPM techniques and the key role that IPM scouts can play in ornamental nursery production. A training program for nursery scouts was subsequently initiated. In 1996, the first group of 11 certified IPM scouts was trained in such skills as detection of primary and secondary sites of disease infection, distinguishing nematode symptoms from other symptoms, distinguishing beneficial insects from pest insects, microscope and hand lens use, and record keeping (20,21).

A survey of Florida ornamental nursery growers reporting on their practices in 1995 revealed that 42 percent regularly scheduled activities to scout for pests, while 12 percent used systematic sampling techniques to quantify pest populations. Most firms (90 percent) reported some kind of scouting (including general observations during other tasks), and only 3 percent did not scout at all. Over two-thirds of nursery firms (68 percent) indicated that they scouted more than once a week, while 19 percent scouted weekly, 6 percent scouted once every 2 weeks, 1 percent scouted once every three weeks, and 2 percent scouted once every 4 weeks (6). A survey of 1993 practices of nursery growers in Florida indicated that frequency of scouting tends to increase with increased size of the nursery firm (12).

In addition, 71 percent of nursery growers in 1995 said that they chose pesticides least toxic to the environment, and 51 percent chose pesticides least toxic to beneficials. Thirty percent also adjusted pesticide applications to protect beneficials, 69 percent used spot treatments of pesticides, and 39 percent reported using biopesticides (6).

The most important factors considered by nursery growers in deciding whether to treat for pests include pest population level (considered by 90 percent of nursery growers in 1995), weather (considered by 68 percent of nursery growers), degree of pest damage (considered by 57 percent), changes in pest populations (considered by 55 percent), pest life stage (considered by 49 percent), projected marketing date (considered by 42 percent), treatment cost (considered by 42 percent), presence of predators and parasites (considered by 33 percent), plant disease inoculum level (considered by 30 percent) and labor availability (considered by 20 percent) (6). The 1993 survey of Florida nursery growers revealed that when deciding on specific pest management tactics, growers judge the effectiveness of the technique as most important. Other factors in declining rank order are cost, environmental impact, impact on beneficial insects, and ease of use (16).

For 80 percent of the nursery firms surveyed in 1995, the owner or family member is the person responsible for pest management decisions, while the manager is responsible in 33 percent of nurseries, the professional grower in 24 percent, a pest management specialist in 4 percent, and a consultant in 3 percent. Scouting is also carried out directly by the owner or family member for 78 percent of nursery firms and by employees for 49 percent (6).

When questioned about the relative importance of various issues in pest management in 1995, nursery firm respondents gave the highest rank to improvement in control of pests, followed in descending order by increase in salable plants, reduction in use of pesticides, lower environmental impact, lower costs of production, reduction in potential pesticide resistance, and increase in ability to work in the nursery (6).

Insect/Mite Pests

Ornamental plant growers in Florida encounter numerous arthropod pests, including aphids, scales, mealybugs, spider and broad mites, thrips, fungus gnats, armyworms, cutworms, grasshoppers, leafminers, bagworms, leafrollers, shoreflies, lacebugs, leaf feeding and boring beetles, centipedes, millipedes, sowbugs, pillbugs, slugs and snails. Although destruction of plants has been estimated at no more than 10-15 percent, any amount of pest damage on an ornamental plant can reduce its value (22).

Mites. Approximately 18 percent of total insecticide/miticide applications in Florida nurseries in 1995 targeted mites (6). Spider mites, broad mites and cyclamen mites can be pests of ornamental nursery crops. Due to their extremely small size, mite infestations often go undetected until severe damage to the plant is underway. Plant injury from broad and cyclamen mites includes curling and stunting of leaves as well as death of the shoot apex (23,24).

Spider mites are among the most common pests of ornamental nursery plants in Florida, and the twospotted spider mite (*Tetranychus urticae*), considered the number one pest of ornamentals in the state, can be a serious problem in greenhouses. Spider mites are often found on azalea, camellia, chrysanthemum, holly, citrus, ligustrum, orchid, pyracantha, rose, viburnum and bedding plants, and they can also attack interior foliage plants. Found on the lower leaf surface, mites puncture the plant tissue with their piercing mouthparts and suck the plant juices. Severe infestations cause leaves to drop and can result in the covering of leaves and even the entire plant by the silken webbing spun by this pest. The life cycle of mites under ideal conditions (about 80°F or 27°C) requires between 7 and 10 days from egg to adult, but can vary even more at other temperatures. Many overlapping generations of mites occur each year, and adult females can lay several hundred eggs during their lifetime. Damage from spider mites tends to be more severe during hot, dry weather, and the highest population levels are usually seen between April and May and between September and October (23-25).

Aphids. Approximately 17 percent of insecticide sprays by ornamental nurseries in 1995 were intended for the management of aphid populations (6). Aphids infest most ornamental nursery plants and are commonly found on camellia, crape myrtle, gardenia, hibiscus, ixora, oleander, palm, rose, and most bedding and foliage plants. Common aphid pests in ornamental nurseries in Florida include the green peach aphid (*Myzus persicae*), the cotton aphid (*Aphis gossypii*), and the spirea aphid (*Aphis spiraecola*). These soft-bodied insects are frequently found in groups on stems or lower leaf surfaces, especially on young plant tissue. Aphid feeding causes leaves to curl and flower buds to harden, distorting flowers. In addition to direct feeding damage, aphids can be vectors of plant viruses, and the sooty mold that grows on their excreted honeydew can reduce product quality (25-27).

Aphid colonies are usually comprised of all females, able to reproduce without mating and without laying eggs. Each female can give birth to a total of between 50 and 100 nymphs, which mature and begin reproducing in 6-8 days. As a result, aphid populations can increase very rapidly, leading to many generations each year. Highest aphid numbers are generally observed in the early spring and throughout the summer, but they can be a problem throughout the year. Aphid infestations are often more severe on shaded plants (26,27).

Whiteflies. Whiteflies, the target of 16 percent of insecticide sprays in ornamental nurseries in 1995, frequently infest allamanda, citrus, crape myrtle, ferns, gardenia, hibiscus, ligustrum, viburnum, and many bedding, flowering and foliage plants (6,26). For years, the citrus whitefly (*Dialeurodes citri*) was the major whitefly species infesting ornamental plants in Florida. However, the silverleaf whitefly (*Bemisia argentifolii*) has recently become the most

serious whitefly on ornamental plants, particularly in central and south Florida. With over 500 plant species serving as its host, the most common ornamentals attacked in Florida include hibiscus, purple and white lantana, poinsettia, gerbera daisy, aphelandra, redbud and crossandra. Chemical control of silverleaf whitefly is complicated by the pest's ability to develop resistance to many insecticides (28-30).

While adult whiteflies have wings and are covered with a powdery wax, the immatures (nymphs) are flat, oval and somewhat transparent, remaining on the underside of leaves. The whitefly life cycle lasts between 3 and 6 weeks, depending on the temperature. Eggs are deposited on the underside of leaves, and after 4 to 12 days hatch into active nymphs called crawlers. The crawlers choose a feeding site, settle on the leaf, insert their mouthparts, and remain sedentary throughout the nymphal stage. During severe infestations, nymphs may cover the lower surfaces of leaves. After molting 3 times, the whitefly enters the pupal stage, and after about 30 days have passed since the egg stage (at 80°F or 27°C), it matures to an adult. The life cycle for the silverleaf whitefly is as short as 21 days at 80°F, and there are overlapping generations of whiteflies in Florida. While immature whiteflies are confined to the underside of leaves, the small, white adults can be found anywhere on the plant, scattering in short flights when disturbed (25,28,29).

Like other plant-feeding insects with piercing-sucking mouthparts, whiteflies remove plant juices. Leaves therefore become pale or spotted as a result of whitefly damage. Like aphids and scales, whiteflies excrete honeydew, upon which black sooty mold grows. The silverleaf whitefly can efficiently transmit several plant viruses, but no virus transmission to ornamental plants is presently known to occur in Florida (28,29).

Scales and Mealybugs. Scale insects, the target of 12 percent of insecticide sprays by Florida ornamental nurseries in 1995, can be serious pests of many ornamental plants (6). Armored scales, soft scales and mealybugs are general types of scale-related insects, all of which secrete a waxy covering over their bodies to protect themselves. The waxy covering is directly attached to the body of soft scales, while armored scales live and feed beneath the protected covering but are not attached to it. While males are free-living, adult females remain beneath the covering, laying their eggs there. The only mobile stage for immature scales is the newly-hatched crawler stage. Crawlers move about on the plant, settling after finding an appropriate feeding spot. They then insert their mouthparts into the plant to begin removing plant juices. Some armored scales reach the adult stage within 6 weeks, while others require a year (31,32).

The most common scale insects on Florida ornamentals include brown scale (*Coccus hersperidium*), false oleander scale (*Pseudaulacaspis cockerelli*, also called the magnolia white scale), Florida wax scale (*Ceroplastes floridensis*), green scale (*Coccus viridis*), tea scale (*Fiorinia theae*), Florida red scale (*Chrysomphalus aonidum*), and black thread scale. The white peach scale (*Pseudaulacaspis pentagona*) is a pest of a number of woody ornamentals. Since control of scale insects becomes more difficult as they mature, the unprotected crawler stage should be targeted. Hatching of scale eggs usually coincides with spring growth flushes (10,31).

A major problem on greenhouse and interiorscape plants, mealybugs are also small, soft-bodied insects covered with waxy threads. They complete their life cycle in about 30 days at 80°F (27°C), but it may take up to 8 to 10 weeks under cooler conditions. Host plants include azalea, coleus, croton, cactus, rose, bedding plants and many foliage plants. Unlike the armored and soft scale insects to which they are related, mealybugs are able to move around on the plant throughout their lives. Adults and immatures usually congregate together, and the waxy deposits that cover them protect them from insecticide applications. In addition to feeding on plant juices with their piercing-sucking mouthparts, soft scales and mealybugs damage the plants by excreting honeydew, upon which the black sooty mold fungus grows. Ornamental plants with sooty mold can grow more slowly and are unattractive to the consumer (31,32).

Caterpillars. The various caterpillars attacking ornamental plants were the targets of 11 percent of insecticide sprays by growers in 1995 (6). Some of the caterpillars that feed on ornamental plants in Florida include armyworms, the azalea caterpillar, the fall webworm, the palm leaf skeletonizer, the tussock moth, the oleander caterpillar, the bagworm, the banana moth, the Florida fern caterpillar and the leatherleaf fern borer. Armyworms (*Spodoptera* spp.) are active from spring until the fall, with populations in Florida peaking from June through September. They prefer to feed on foliage and can chew large holes in leaves of host plants (33). The azalea caterpillar (*Datana major*) skeletonizes leaves when the caterpillars are younger and completely destroys them when older. Fall webworm (*Hyphantria cunea*) larvae feed on the leaf surface for 4 to 6 weeks after hatching from the egg. They construct webs between branches, within which many caterpillars may be found feeding. The palm leaf skeletonizer (*Homaledra sabalella*) feeds beneath a silk web woven on the underside of palm leaves. Feeding on only the surface of the leaf, this caterpillar leaves skeletonized patches that become covered with its fecal pellets. Tussock moth (*Orgyia leucostigma*) caterpillars hatch in late spring, feeding on shade trees, and a second generation develops from late August to early September (34). Feeding solely on the oleander plant, oleander caterpillars (*Syntomeida epilais*) have 3 generations each year. The young caterpillars feed on new oleander shoots, skeletonizing the tissue (eating between the major and minor leaf veins), while older, larger caterpillars can substantially defoliate the plant (35). Bagworms (*Thyridopteryx ephemeraeformis*) are general feeders. They use small pieces of twigs and leaf material to construct a bag, within which the caterpillar remains, protruding out to feed on foliage (34). The banana moth (*Oponona sacchari*) caterpillar, a serious pest of ornamentals in Florida, destroys *Chamaedorea* species palms by tunneling through their stems. Researchers have estimated that up to 10 generations per year of the pest could be produced by populations under greenhouse conditions (36). The Florida fern caterpillar (*Callopistria floridensis*) can feed on a variety of ferns but is particularly a problem on leatherleaf fern (37). The larvae of the leatherleaf fern borer (*Undulambia polystichalis*) also feed on leatherleaf fern (38).

Thrips. A number of thrips species can infest ornamental plants in Florida, damaging both foliage and flowers. In addition, thrips are the primary vector of tomato spotted wilt virus that affects many greenhouse and bedding plants (39). The Florida flower thrips (*Frankliniella bispinosa*), the western flower thrips (*Frankliniella occidentalis*) and the gladiolus thrips (*Thrips simplex*) are the most important flower and bud feeders, while foliage is most commonly attacked by the red-banded thrips (*Selenothrips rubrocinctus*), the cuban-laurel thrips (*Gynaikothrips ficorum*), and the greenhouse thrips (*Heliothrips haemorrhoidalis*) (40). Eight percent of insecticide sprays in Florida ornamental nurseries in 1995 were applied to manage thrips (6).

Thrips complete their life cycle in 2 to 4 weeks and have many generations per year. They feed by scraping plant tissue with their rasping-sucking mouthparts and removing plant juices, primarily from young buds or shoots. Feeding causes the surrounding tissue to dry out, and infected flowers can be deformed or discolored. Populations of thrips are highest during the spring months (24,40).

Leafminers. Leafminers, most commonly larvae of small black and yellow flies and occasionally of moths, tunnel between the upper and lower leaf surfaces as they feed on the inner leaf tissue. The mines they leave can be either serpentine mines, which wind around the leaf, or blotch mines, which increase in size uniformly. Damage to the plant is usually not serious, but cosmetic damage can affect salability of ornamentals. Leafminer problems tend to be greater in the southern half of the state, where leafminers can continue to develop throughout the year (41).

Serpentine miners are the most common throughout Florida, and among ornamental plants, their preferred hosts include azalea, bougainvillea, ixora, hollies, lantana, chrysanthemum, and boxwood. Adults insert eggs into the underside of the leaf, and after hatching a few days later, the larvae begin to mine through the leaf. The mines increase in size as the larvae grow, and when mature, larvae enter the pupal stage either on the outer leaf surface or in the soil. Within 7 to 14 days, the next generation of adults appears, and many generations can occur

annually. Leafminer populations tend to increase under warm, dry conditions. Control is difficult because during most of their life cycle, these insects are protected by the leaf epidermis (41). Leafminers were the target of 4 percent of insecticide sprays by ornamental nurseries in Florida in 1995 (6).

Borers. Boring insects were the target of 2 percent of insecticide sprays by nurseries in 1995 (6). Many species of borers, most of which are beetles and some of which are moths, either burrow deep into the wood, enter just under the bark, feed in the plant's root crown, or remain on smaller twigs and shoot tips to feed. The Asian twig borer (*Xylosandrus compactus*) is one example of a borer that attacks several trees in Florida, particularly dogwood, redbud and magnolia. Dogwoods are also susceptible to the dogwood twig borer (*Obrea tripunctata*) and flatheaded borers. Another important borer in Florida ornamentals is an introduced ambrosia beetle, *Xylosandrus crassiusculus*, which attacks hardwoods like oaks and *Prunus* sp. in north Florida. The red oak borer (*Enaphalodes rufulus*) can infest weakened or damaged oaks, especially laurel and water oaks. The landscape plant sea grape is often attacked by sea grape borer caterpillars, which may kill shoot tips as they burrow down into the shoot. Borers seen occasionally in Florida include the Australian pine borer, the flatheaded apple tree borer, the red-headed ash borer, and the peach tree borer. Borer attack is more likely to occur when trees and plants are already weakened, such as by drought, soil compaction, mechanical wounds or stress from transplanting. Borer management must be preventative, because once the insects are under the bark, they are difficult to control (25,39,42).

Fungus Gnats. Fungus gnats (commonly *Bradysia* spp.) are tiny flies whose larvae are found in the soil, where they feed on decaying material and plant roots. Each adult female can lay up to 120 eggs on the soil surface, and eggs hatch in 4 to 7 days. The larval stage lasts between 8 and 20 days, depending on temperature, and the pupal stage between 3 and 5 days. Seedlings are especially susceptible to fungus gnat damage, and although adults do not damage the plant, they can be offensive to consumers. In addition, feeding damage can leave roots more susceptible to disease. Although fungus gnats can be found at low densities in nurseries all year round, their population levels increase the most under hot, rainy conditions. Fungus gnats can infest nursery plants by flying short distances from outside the production area or by being transported in contaminated soil. When control becomes necessary, insecticide drenches are usually applied to the soil, targeting the larval stage (43).

Lace Bugs. An occasional pest on Florida ornamental plants, lace bugs can attack azalea, hawthorn, lantana, oak, pyracantha and sycamore, among others. Damage can be seen as whitish speckling on the upper leaf surface, due to feeding of the insect from the underside of the leaf. Severe infestations on shrubs may result in leaf droppage, reduced growth, and death of the plant. Even during light infestations, feeding damage can produce unsightly marks on leaves. Lace bug eggs are deposited on the lower leaf surface, where the nymphs, upon hatching, use their piercing-sucking mouthparts to withdraw plant juices. After five molts, they mature to the adult stage. The life cycle from egg to adult is completed in about 30 days, and there are 3 to 5 generations each year in Florida (24,44).

Chemical Control

Nursery firms used an average of 5.8 different insecticides in 1995. South Florida nurseries tend to use more insecticides (average of 6.4 per nursery firm) than those in other parts of the state. There is also variation within production system types (average of 6.8 insecticides used in greenhouses, 5.5 in container production, and 4.9 in field production), as well as within crop types (average of 8.6 insecticides used to produce bedding plants, 7.1 for floriculture (cut flowers and flowering potted plants), 6.1 for foliage, 6.0 for liners, 5.5 for woody ornamentals, 5.2 for trees, and 4.3 for other crop types) (6). In a separate survey, leatherleaf fern growers have reported applying insecticides an average of 19.6 times per year (18).

Acephate (Orthene), diazinon (Diazinon), and abamectin (Avid) were the most frequently reported insecticides used by nurseries during 1995, followed in decreasing order of use by dienochlor (Pentac Aquaflow, which is no longer available), *Bacillus thuringiensis* (Javelin/Dipel), carbaryl

(Sevin/Sevimol), dimethoate (Cygon), insecticidal soaps, horticultural oils, bifenthrin (Talstar), malathion (Malathion), chlorpyrifos (Dursban), tau-fluvalinate (Mavrik Aquaflow), imidacloprid (Merit), fenpropathrin (Tame), endosulfan (Thiodan), dicofol (Kelthane), azadirachtin (Azatin/Margosan-O), and kinoprene (Enstar). Insecticides used by less than 10 percent of nurseries, in decreasing order of use, include lindane (Lindane), oxamyl (Oxamyl/Vydate), fenoxycarb (Logic/Precision), diflubenzuron (Dimilin), bendiocarb (Dycarb/Turcam), disulfoton (Di-Syston), permethrin (Ambush/Pounce), cyfluthrin (Baythroid/Tempo), fenamiphos (Nemacur), chinomethionate (Morestan), ethoprop (Mocap), oxydemeton-methyl (Metasystox), methiocarb (Mesurol), and carbofuran (Furadan) (6).

Acephate (Orthene) - (REI of 24 hours). Acephate is an organophosphate insecticide used as a foliar spray against aphids, mealybugs, scales and thrips. It also has miticidal activity. Acephate was used by 59 percent of Florida ornamental nurseries in 1995 (6).

Diazinon (Diazinon) - (REI of 12 hours). Diazinon is another organophosphate insecticide used in ornamental nurseries to control aphids, scales, fungus gnats, mealybugs, thrips, leaf beetles, and leafminers, in addition to having miticidal activity. Diazinon was used by 43 percent of Florida nurseries in 1995 (6).

Abamectin (Avid) - (REI of 12 hours). Abamectin is derived from the soil bacterium *Streptomyces avermitilis*. It was used by 43 percent of nurseries in the state to manage mites and leafminers in 1995 (6).

Bacillus Thuringiensis (Javelin/Dipel) - (REI of 12 hours). *Bacillus thuringiensis* (*B.t.*) is a soil bacterium that acts as a stomach poison in susceptible insect larvae. Considered an ideal pest management tool because of its specificity to lepidopterous insect pests and lack of toxicity to natural enemies, it was used by 32 percent of Florida nurseries in 1995 for the management of various caterpillars, including armyworms, loopers and cutworms (6).

Carbaryl (Sevin/Sevimol) - (REI of 12 hours). Carbaryl is a broad-spectrum carbamate insecticide that works as both a contact and stomach poison. Carbaryl is used to manage leaf-feeding beetles, caterpillars, armyworms, loopers, cutworms, centipedes, millipedes, sowbugs and pillbugs. It was used by 32 percent of nurseries in the state in 1995 (6).

Dimethoate (Cygon) - (REI of 48 hours). Dimethoate is another organophosphate insecticide used against aphids, thrips, scales, mealybugs and leafminers. Dimethoate has miticidal activity as well. It was used by 32 percent of nurseries in Florida in 1995 (6).

Insecticidal Soaps (M-Pede) - (REI of 12 hours). Insecticidal soaps were used by 30 percent of nurseries in the state in 1995 for the management of mites, aphids and whiteflies (6). Phytotoxicity may occur if insecticidal soaps are applied repeatedly.

Horticultural Oils (Sunspray Ultra-Fine) - (REI of 4 hours). Horticultural oils were used by 29 percent of Florida nurseries in 1995 against mites, scales and whiteflies (6).

Bifenthrin (Talstar) - (REI of 12 hours). Bifenthrin is a pyrethroid insecticide and acaricide used in the management of aphids, *Diaprepes* root weevils, mites, whiteflies, mealybugs, armyworms, loopers, cutworms, and more recently fire ants. Twenty-eight percent of Florida nurseries used bifenthrin in 1995 (6).

Malathion (Malathion) - (REI of 12 hours). Malathion, a broad-spectrum organophosphate insecticide, was used by 27 percent of Florida nurseries in 1995, primarily for the management of aphids (6).

Chlorpyrifos (Dursban) - (REI of 12 hours). Another broad-spectrum organophosphate insecticide, chlorpyrifos was used by 27 percent of nurseries in the state in 1995 to manage aphids, scales, thrips, mealybugs, grasshoppers and borers (6).

Tau-fluvalinate (Mavrik Aquaflow) - (REI of 12 hours). Tau-fluvalinate is used to manage aphids,

mites, thrips and mealybugs. Twenty-four percent of nurseries in Florida applied it in 1995 (6).

Imidacloprid (Merit/Marathon) - (REI of 12 hours). Imidacloprid is a systemic, chloro-nicotinyl insecticide used by 18 percent of nurseries in Florida in 1995 for the management of thrips and whiteflies (6). In efficacy tests of several chemical controls for the silverleaf whitefly on poinsetta, hibiscus and lantana in Florida, imidacloprid was found to be the most effective in reducing whitefly populations (30).

Fenpropathrin (Tame) - (REI of 24 hours). Fenpropathrin is used to manage aphids, whiteflies and mites. It was applied by 17 percent of nurseries in the state in 1995 (6).

Endosulfan (Thiodan) - (REI of 24 hours). Endosulfan, a cyclodiene chlorinated hydrocarbon insecticide and acaracide, is used to manage aphids, whiteflies and mites. Seventeen percent of Florida nurseries used it in 1995 (6).

Dicofol (Kelthane) - (REI of 12 hours). Dicofol is an organochlorine miticide used by 14 percent of Florida nurseries in 1995 (6).

Azadirachtin (Azatin/Margosan-O) - (REI of 4 hours). Azadirachtin, a tetranortriterpenoid compound derived from neem tree extract that acts as an insect growth regulator, is used to manage whiteflies, aphids, thrips, fungus gnats, caterpillars, beetles, mealybugs, and leafminers. Twelve percent of Florida nurseries used azadirachtin in 1995, primarily for whitefly management (6). In insecticide efficacy tests conducted in Florida in 1994, azadirachtin did not differ from the nontreated check in reducing populations of the silverleaf whitefly on poinsettia (30). However, it had previously been shown to effectively control whitefly nymphs, but not adults or eggs, on poinsettia (45).

Kinoprene (Enstar) - (REI of 4 hours). Kinoprene was used by 10 percent of nurseries in the state in 1995 for the management of scales, whiteflies and mealybugs (6).

Use of Chemicals in IPM Programs

Eighty-three percent of nursery firms claimed to apply insect control measures in 1995 after detecting the presence of pests, while 45 percent made prescheduled applications. Some nurseries therefore utilized both scouting and scheduled applications (6).

Use of Chemicals in Resistance Management Programs

Seventy-five percent of nursery growers describing their production practices in 1995 claimed to alternate pesticides to avoid chemical resistance (6).

Cultural Control

The most practical cultural control practices recommended for nursery production of ornamentals involve preventative measures. For example, the use of physical barriers such as screening on greenhouse vents and doorways has been found to be useful in reducing the introduction of insect pests. Inspecting all incoming plant material and assuring that only pest-free seeds and cuttings are used can further reduce potential infestations. Removal of plant debris and control of potential pest-harboring weeds in and around the production area are also important practices, as is overall adequate sanitation. For example, making sure that stored potting media and pots are dry can reduce fungus gnat problems in greenhouses (46).

Appropriate monitoring to ensure early detection of pests is especially important in ornamental nursery production. UV light traps for moths (the immature forms of which can be pests on many ornamentals) and yellow sticky traps for whiteflies, thrips, aphids, leafminer flies and fungus gnats are effective monitoring devices. Also, indicator plants are a helpful management tool in early detection. Highly susceptible plants likely to be infested first are placed in the nursery to attract and monitor specific pests (46). Once insect pests are detected, additional cultural controls can be employed, such as adjusting timing, amount and method of irrigation, regulating humidity levels, maintaining appropriate fertilization and selectively pruning plants (47).

Nursery growers surveyed about their 1995 production practices reported a number of cultural pest management tactics. Practices included removing infested plant material (used by 83 percent of nurseries), inspecting incoming plant stock (74 percent of nurseries), managing irrigation to reduce pests (69 percent of nurseries), using pest resistant varieties (52 percent), keeping pest activity records (35 percent), adjusting fertilization rates (26 percent), excluding pests with screening or barriers (21 percent), and monitoring pest levels with pheromone traps or colored boards (13 percent) (6).

Biological Control

Twospotted spider mites, the principal spider mite pest of ornamentals in Florida, have been effectively controlled in greenhouses and shadehouses by the predatory mite *Phytoseiulus persimilis*. A number of factors are essential to the success of predatory mite releases, including proper timing of release, existence of appropriate environmental conditions in the greenhouse, and adequate numbers of mites released. The most important, however, is the judicious selection of chemical controls in the management of other pests, since many nonselective insecticides, miticides and even fungicides can disrupt the activity of predatory mites (48). For example, the predatory mites *Neoseiulus collegae* and *Phytoseiulus macropilis* have been reported to survive low rates of abamectin but to be very susceptible to fenpropathrin, dicofol, bifenthrin and fluvalinate (49).

Several nursery growers in Manatee County participated in IPM trials involving the release of predatory mites (*Phytoseiulus persimilis*) to control twospotted spider mites on container-grown areca palms and crotons. By combining careful selection of pesticides (using insecticidal soap, for example) with the use of additional predators (lacewing larvae and ladybugs) to control aphid populations, they succeeded in reducing miticide applications by 87 to 92 percent on croton and eliminating them completely on areca palms (50). Inundative releases of the predatory mite *Neoseiulus barkeri* have been effective in reducing damage from the broad mite *Polyphagotarsonemus latus* at The Land, EPCOT Center (22).

Parasitic nematodes have been effective to some extent in controlling the banana moth. Soil applications of the insect pathogenic nematodes *Steinernema feltiae* and *Heterorhabditis heliothidis* have been shown to produce high mortality of banana moth larvae, and the nematodes can persist in the soil for up to 6 weeks (10,36). Products containing steinernematid and heterorhabditid nematodes have been developed that target a number of insect pests on ornamentals, including fungus gnats, leafminers, armyworms, stem borers and cutworms (51). Some success has been achieved with the biological control of fungus gnats in Florida nurseries with the use of beneficial nematodes (52). However, additional research is necessary to make nematode-based products competitive with chemical pesticides in terms of economics and efficacy (51).

Parasitic wasps naturally control populations of many scale insects in Florida, and scale crawlers often fall prey to beneficial insects. Likewise, natural populations of parasitic wasps that attack fungus gnats may become established in greenhouses in the absence of broad-spectrum insecticide use (31,43). The predatory mite *Hypoaspis miles* has shown promise in Florida greenhouses for control of fungus gnats as well. The mite, which completes its life cycle very quickly (one generation takes only 10 days), also feeds on thrips and springtails in the soil. It is not recommended, however, when fungus gnat populations are very high (52). The oleander caterpillar has been found to have a number of natural enemies in Florida, including the tachinid flies *Chetogena floridensis* and *Lespesia aletiae*, the wasp parasite *Brachymeria incerta*, and the stinkbug *Podisus maculiventris* (53).

Additionally, the wasp parasite *Prospaltella lahorensis* efficiently attacks nymphs of the citrus whitefly (*Dialeurodes citri*), an important pest of ornamental plants in Florida. The parasite, released in Gainesville and Winter Haven in 1977, is capable of complete control of the citrus whitefly but is not compatible with chemical controls**.** However, *Prospaltella lahorensis* is not able to control populations of the silverleaf whitefly (29,54). There are several parasitic wasps that naturally manage silverleaf whitefly populations, such as *Encarsia* or *Eretmocerus* species. *Delphastus* beetles, native

predators of whiteflies in Florida, are available from insectaries as a biocontrol agent, primarily for greenhouse production. In addition, a native strain of the fungus *Paecilomyces fumosoroseus* has been found to be highly effective against whiteflies, as well as spider mites and aphids. A commercial formulation is available in Europe and an application has been submitted to EPA for registration in the U.S. (55).

Mealybugs, important pests of ornamental plants in Florida, are considered good candidates for biological control programs. However, releases of parasites in commercial nurseries have not been successful, primarily as a result of misidentifications of the specific mealybug pests present. Aphids, like mealybugs, have many natural control agents that are often present in greenhouses. Collections of the aphids *Myzus persicae* and *Aphis gossypii* from central Florida greenhouses have shown that both are naturally parasitized. However, the parasites are themselves parasitized by other wasps, whose presence limits the effectiveness of natural biological control of the aphids. Therefore, the use of parasites in the management of aphids in Florida greenhouses appears to be limited (22). No biological control programs have been developed for any insect pests of commercial flower crops, and given the very low damage thresholds, there is little future potential in that area (56).

While 30 percent of surveyed nursery firms reported identifying beneficial insects, 15 percent also said that they released biological control agents in 1995, most frequently against mites. Predatory mites were the most common biocontrol agent, used by 9 percent of nurseries. Others include beneficial wasps (used by 3 percent of nurseries), beneficial nematodes (used by 3 percent of nurseries), beneficial fungi (used by 3 percent), lady beetles (used by 2 percent), lacewings (used by 2 percent), minute pirate bugs (used by 1 percent) and delphastus beetles (used by 1 percent). Other biological control targets include whiteflies, aphids, mealybugs, fungus gnats, scales, thrips, caterpillars, banana moths, shoreflies, and beetles. Biological control was used most frequently against pests on palms and other tropical foliage plants, as well as some woody ornamentals and flowering plants. The average area in which biological control agents were released was 2.7 acres, and the maximum reported area was 25 acres (6).

Disease Management

Disease Pathogens

Diseases affecting the production of ornamental plants in Florida include leafspots and blights (caused by *Alternaria*, *Ascochyta*, *Bipolaris*, *Botrytis*, *Cercospora*, *Colletotrichum*, Corynespora, Cylindrocladium, *Diplocarpon*, *Drecholera*, *Entomosporium*, *Exserohilum*, *Fusarium*, *Helminthosporium*, *Ovulinia*, *Phomopsis*, *Ramularia*, *Sclerotinia*, and *Septoria*), root, stem and crown rots (caused by *Cylindrocladium*, *Rhizoctonia*, *Fusarium*, *Botrytis*, *Sclerotinia*, *Thielaviopsis*, *Phythophthora* and *Pythium*), damping-off, *Penicillium* blue mold, bacterial spots (caused by *Erwinia*, *Pseudomonas*, and *Xanthomonas*), powdery mildew, rusts and downy mildew (65). Due to the wide range of ornamental plant species cultivated in Florida, disease management for a given nursery may encompass a range of diseases throughout the year. A few representative diseases of ornamental plants are discussed below.

***Rhizoctonia* Diseases.** Diseases caused by species of the fungus *Rhizoctonia* constitute one of the major groups of diseases affecting ornamentals in Florida (66). *Rhizoctonia* is a soil-borne pathogen that can produce damping-off, rots and aerial leaf blights on a variety of ornamental plants. *Rhizoctonia* can affect both foliage and bedding plants, especially under cool, wet conditions. Reddish-brown lesions on the roots are among the first symptoms of disease. These lesions can cause young plants to rot at the soil line, and severe root infection can produce wilting in older plants. Aerial blights can occasionally occur on foliage, after infected soil splashes onto above-ground plant parts. Once on foliage, the pathogen can spread in water to nearby plants. Aerial symptoms of *Rhizoctonia* diseases are more common during the summer months in Florida and can develop rapidly. PCNB and thiophanate-methyl are considered moderately effective in managing *Rhizoctonia* diseases, but the most effective management is through prevention, particularly the

use of disease-free potting medium and other sanitation practices (67-69).

Bacterial Diseases (principally caused by species of *Erwinia*, *Pseudomonas* and *Xanthomonas*). Bacterial diseases are another important group of diseases that affect many types of ornamental plants throughout Florida, causing significant losses. Bacteria can produce leaf spots, blights and root and stem rots on ornamental plants. Symptoms of bacterial leaf spots generally start as water soaked lesions, sometimes with a yellow border, which spread rapidly on foliage. The centers of the lesions may fall out under wet conditions. Bacteria move throughout production areas primarily in flowing water, such as rain or irrigation water. Once splashed onto a plant, the bacteria enter and infect the plant through wounds or natural openings. Bacterial diseases are therefore most difficult to control when plants are exposed to rainfall or overhead irrigation. There are few effective control measures for bacterial diseases on ornamental plants. No bactericides provide adequate control of *Erwinia* diseases, although copper-containing compounds may be somewhat effective in the management of some *Xanthomonas* and *Pseudomonas* diseases. However, copper compounds may produce a phytotoxic response or leave unsightly residues on foliage. Antibiotics such as streptomycin can be applied as foliar sprays, but in addition to the high cost, bacterial populations usually develop resistance within a few months (66,67,70,71).

***Phytophthora/pythium* Diseases**. Diseases caused by the soil-borne pathogens *Phytophthora* and *Pythium* are among the most common diseases of ornamental plants. While *Pythium* species attack mainly plant roots, *Phytophthora* spp. can cause damping-off and seedling blights as well as aerial leaf spots and stem, crown and root rots. Some examples of diseases caused by these pathogens on Florida ornamentals include *Phytophthora* stem rot of zebra plant, *Phytophthora* stem rot and aerial blight of vinca, and *Pythium* root rot of schefflera (72).

***Helminthosporium*-complex Leaf Spots on Palm** (caused by E*xserohilum rostratum*, *Bipolaris* spp. and *Phaeotrichoconis crotalariae*). Leaf spots caused by the *Helminthosporium*-complex fungi can affect a range of palms, leaving dark lesions on the foliage that significantly reduce salability. Color and shape of lesions varies by the specific pathogen and the reaction of each palm species. Spores of the fungi are carried by wind or distributed in splashing water, such as that generated by overhead irrigation. Once infection occurs, disease development is enhanced by moist conditions (73).

Fern Anthracnose (caused by *Colletotrichum* acutatum). Recently becoming a serious disease on leatherleaf fern, holly fern and true ferns, anthracnose, caused by the fungus *Colletotrichum acutatum*, is difficult to control once established. The disease was first observed in 1993, and by September of 1995 it was reported by at least half of all fern growers in Florida and was affecting between 30 and 40 percent of leatherleaf fern acreage. When infection occurs, yield of marketable fronds (leaves) can drop to close to zero. Infected fronds appear burned and are unable to develop normally. Development of the disease is faster under hot and humid conditions. The fungal spores are easily spread in water, but can also be transported in a dry form by wind, or on tools, clothing, animals or infected ferns. The pathogen can survive in infected plant debris or in the soil (74).

Botrytis Blight of English Ivy (caused by *Botrytis cinerea*). *Botrytis* blight produces tan to brown colored lesions on ivy foliage. Masses of brown spores develop within the lesions, causing infected tissue to appear fuzzy. Ivy plants that are growing in humid conditions or that have been damaged by cold or chemical injury are more susceptible to *Botrytis* blight (75).

Chemical Control

Ninety percent of nursery firms reported using at least one fungicide against disease pathogens, and an average of 4.2 different fungicides was reported to be used in 1995. The average varied somewhat among plant type (3.4 for trees, 3.9 for woody ornamentals, 4.8 for liners, and 4.9 each for foliage and floriculture). In a separate survey, leatherleaf fern growers have reported applying fungicides an average of 19.5 times per year. The most commonly applied fungicides in 1995 were metalaxyl (Subdue), copper (Kocide), mancozeb (Dithane/Fore/Protect), and chlorothalonil

(Bravo/Daconil/Exotherm/Echo/Thalonil). Others applied by many nurseries are fosetyl aluminum (Aliette), etridiazole + thiophanate methyl (Banrot), iprodione (Chipco 26019), thiophanate-methyl (Cleary 3336/Fungo/Sys Tec 1998), mancozeb + thiophanate-methyl (Zyban/Duosan), ethazole (Terrazole/Truban), propiconazole (Banner), and PCNB (Terraclor), in decreasing order. Fungicides used by fewer than 10 percent of nurseries include triadimefon (Bayleton/Strike), triflumizole (Terraguard), and dazomet (Basamid) (6,18).

Metalaxyl (Subdue) - (REI of 12 hours). Metalaxyl is a systemic, benzenoid fungicide used as a soil treatment in the control of root rots caused by the soil-borne pathogens *Phythopthora* and *Pythium*, as a seed treatment to control damping-off, and as a foliar spray for bedding, foliage, flowering and woody ornamentals. In 1995, 57 percent of Florida's ornamental nurseries utilized metalaxyl in their disease management programs (6). In 1998, metalaxyl was replaced by the chemical isomer mefenoxam (Subdue Maxx), which has a REI of 0.

Copper-based (Kocide) - (REI of 48 hours). Kocide is an inorganic fungicide used to control *Alternaria* diseases, anthracnose, bacterial leaf spots, *Botrytis*, *Entomosporium*, and *Volutella*. It was used by 51 percent of ornamental nurseries in the state in 1995 (6).

Mancozeb (Dithane/Fore/Protect) - (REI of 24 hours). Mancozeb is a broad-spectrum ethylene(bis) dithiocarbamate (EBDC) fungicide used as a foliar spray in the control of anthracnose, fungal leaf spots, downy mildew, rust and *Botrytis* diseases. Mancozeb was used by 45 percent of Florida nurseries in 1995 (6).

Chlorothalonil Bravo/Daconil/ Exotherm/ Echo/ Thalonil) - (REI of 48 hours). Chlorothalonil is a broad-spectrum nitrile compound used as a foliar spray in the control of fungal leaf spots, powdery mildew, rust and *Botrytis* diseases. It was used by 42 percent of the state's ornamental plant nurseries in 1995 (6).

Fosetyl Aluminum (Aliette) - (REI of 12 hours). Fosetyl aluminum is a systemic organic phosphate fungicide used as a foliar spray or a soil drench to control downy mildew and fire blight, as well as diseases caused by *Phytophthora*, *Pythium*, and *Xanthomonas*. In 1995, 37 percent of ornamental nurseries in Florida reported using it (6).

Etridiazole + Thiophanate Methyl (Banrot) - (REI of 12 hours). Etridiazole plus thiophanate methyl is applied to the soil mix at seeding or transplanting or as a drench on bedding, foliage and container plants. As part of a management program of the diseases caused by the pathogens *Fusarium*, *Phythophthora*, *Pythium*, *Rhizoctonia*, and *Thielaviopsis*, it was used by 37 percent of ornamental nurseries in 1995 (6).

Iprodione (Chipco 26019) - (REI of 12 hours). Iprodione is a dicarboximide contact fungicide applied as a soil drench or foliar spray to control diseases caused by *Alternaria*, *Bipolaris*, *Botrytis*, *Drecholera*, *Exserohilum*, *Fusarium*, *Monilinia* and *Rhizoctonia*. Thirty-six percent of Florida nurseries reported using it in 1995 (6).

Thiophanate Methyl (Cleary 3336/Fungo/Sys Tec 1998) - (REI of 12 hours). Thiophanate methyl is a systemic fungicide used as a foliar spray or soil drench after transplanting for the control of bulb rots, scab, and diseases caused by *Botrytis*, *Fusarium*, *Penicillium*, *Rhizoctonia*, *Sclerotinia* and *Thielaviopsis*. It was used by 34 percent of ornamental nurseries in 1995 (6).

Mancozeb + Thiophanate Methyl (Zyban, Duosan) - (REI of 24 hours). Mancozeb plus thiophanate methyl is a broad-spectrum, systemic protectant fungicide applied as a foliar spray to control anthracnose, black spot, downy mildew, flower blight, powdery mildew, scab and rust. It was used by 17 percent of ornamental nurseries in 1995 (6).

Ethazole (Terrazole, Truban) - (REI of 12 hours). Ethazole, used as a soil drench on bedding, container and foliage ornamentals, controls diseases caused by *Phythophthora* and *Pythium*. Fourteen percent of ornamental nurseries in Florida applied it in 1995 (6).

Propiconazole (Banner) - (REI of 24 hours). Propiconazole is a systemic fungicide applied as a

foliar spray to bedding, flowers and woody ornamentals to control powdery mildew, rust, scab, anthracnose and *Entomosporium* diseases. It was used by 11 percent of ornamental nurseries in the state in 1995 (6).

PCNB (Terraclor) - (REI of 12 hours). PCNB is an organochlorine fungicide applied as a soil drench at seeding or transplanting or broadcast and mixed into soil before planting. Used on bedding, foliage, flowering and woody ornamentals, it controls diseases caused by the pathogens *Botrytis*, *Rhizoctonia*, *Sclerotinia*, *Stromatinia*, *Ovulinia*, *Pellicularia* and *Sclerotiium*. Ten percent of Florida ornamental nurseries applied PCNB in 1995 (6).

Use of Chemicals in IPM Programs

In 1995, 65 percent of ornamental nursery firms reported applying control measures upon detecting diseases, and 57 percent followed a preventative schedule of treatment, with some reporting both practices (6).

Cultural Control

Many diseases on ornamental plants can be managed by keeping foliage dry, using clean cuttings and following strict sanitation practices. Minimizing plant stress by providing adequate but not excessive water and nutrients, as well as managing insect and nematode pests to reduce feeding damage that provides entrance to pathogens are also important cultural practices (67,76).

Ornamental nursery growers reported using several cultural practices to manage plant diseases in 1995. Disease control tactics employed include removing infected plant material (83 percent of nurseries), inspecting incoming plant stock (74 percent of nurseries), providing air circulation by elevating or spacing plants (72 percent of nurseries), managing irrigation (69 percent of nurseries), disinfesting benches and cloth ground covers (55 percent of nurseries), using soil sterilization or solarization (49 percent of nurseries), ventilating greenhouses (47 percent of nurseries), maintaining disease activity records (35 percent of nurseries), and using screening or barriers to exclude pests (21 percent of nurseries) (6). For most Florida nursery growers, disease prevention is the most important factor in deciding at what time of the day to irrigate (15).

Biological Control

Research on biological control of plant pathogens in Florida has demonstrated the potential of several indigenous organisms to manage soil-borne plant pathogens. The bacteria *Bacillus*, *Pseudomonas* and *Streptomyces* and the fungi *Gliocladium* and *Trichoderma* have been shown to reduce a variety of fungal pathogens when used as seed treatments or incorporated into transplant media. Commercial formulations of fungal antagonists and biofungicides are increasingly available. Currently, there are a few biological control agents available to manage plant pathogens on ornamentals, including such products as AQ-10 (containing isolate M-10 of *Ampelomyces quisqualis*, used in the mangement of powdery mildew), Bio-Trek and Root Shield (containing the fungal antagonist *Trichoderma harzianum* Rifai strain KRL-AG2 (T-22), used in the management of *Pythium* spp., *Rhizoctonia solani* and *Fusarium* spp.), SoilGard (containing the common soil-borne fungus *Gliocladium virens*, used in the management of damping-off and root rot pathogens, especially *Rhizoctonia solani* and *Pythium* spp.), and Mycostop (containing a live formulated strain of the bacterium *Streptomyces griseoviridis*, used to manage *Pythium*, *Rhizoctonia*, *Phythophthora*, *Botrytis* and *Fusarium* diseases) (76-78).

Nematode Management

Nematode Pests

Many states and foreign countries have instituted quarantine laws restricting the importation of plants infested with several nematodes commonly found in Florida ornamental nurseries. Due to these regulations, effective management of plant parasitic nematode populations has been vital to Florida's ornamental nursery industry (79). The most common plant parasitic nematodes in Florida nurseries include root-knot (*Meloidogyne* spp.), lesion (*Pratylenchus* spp.), foliar (*Aphelenchoides* spp.) and stunt (*Tylenchorhynchus* spp.) nematodes. Quarantine restrictions have been imposed for both burrowing (*Radopholus* spp.) and reniform (*Rotylenchulus* spp.)

nematodes (80).

Typical below-ground symptoms of nematode attack include knots or galls on roots, lesions on roots, excessive branching of roots, injury to root tips, and stunted root systems. In addition, damage to roots from nematodes may contribute to greater problems with root rots from bacteria and fungi. Typical above-ground symptoms of nematode infestation include yellowing of leaves, slow decline in plant growth, and loss of foliage (80).

Root-knot Nematodes (*Meloidogyne* spp.). Many ornamental plants are affected by root-knot nematodes, whose damage can leave the plant stressed and more susceptible to other pests. Characteristic symptoms of root-knot attack are swollen galls on the roots. Size and shape of the galls will vary in different plant species, since plants react distinctly to the nematodes. Extended root-knot attack may leave the plant stunted, chlorotic and weak. Root-knot nematodes are occasionally a quarantine problem, but only when they are found in large numbers, as opposed to quarantine restrictions against the mere presence of certain other nematodes. Native populations of root-knot nematodes occur throughout the state, so this pest is more difficult to control on ornamental plants growing directly in field soil (81,82).

Root-knot nematodes enter the root tissue as second-stage juveniles (larvae). Within the root, they feed and migrate into the cortical and vascular tissue. They then become sedentary, feeding on the plant cells around them and causing them to become abnormally large, providing sufficient food reservoirs for the nematode until it matures. The enlarged plant cells form the characteristic galls produced by root-knot nematode attack. On preferred hosts, root-knot nematodes continue to feed and reproduce until limited by lack of food. Completion of the life cycle takes about 25 to 30 days under favorable conditions (83).

Lesion Nematodes (*Pratylenchus* spp.). Lesion nematodes can potentially cause severe damage because of their habit of moving throughout plant roots from within, destroying extensive amounts of tissue as they feed and move on. Lesion nematodes, which possibly can be damaging in ferns, are the subject of quarantine regulations in several states (80). *Pratylenchus penetrans* inhibits frond production of leatherleaf fern and can infect both roots and rhizomes. The nematode can be spread in infected rhizomes during propagation (84).

Foliar Nematodes (*Aphelenchoides* spp.). Foliar nematodes, which live inside and damage leaves, buds, and other above-ground plant parts, occasionally become a problem on nursery crops in Florida. These nematodes have a wide host range, attacking such plants as azaleas, mums, bird's-nest and several other species of fern, chrysanthemum, begonias, dahlias, strawberries, many lilies and African violets. Although there are over 120 species of foliar nematodes, only a few species may seriously damage ornamentals in Florida, including the rice white tip nematode, *A. besseyi* (which infects many grasses, vegetable and agronomic crops in addition to ornamentals), the strawberry nematode, *A. fragariae* (which can be found on ferns and plants in the families Liliaceae, Primulaceae and Ranunculaceae), and the chrysanthemum leaf nematode, *A. ritzemabosi* (which infests over 200 plants species, many of which are in the family Compositae) (85-87).

Foliar nematodes are able to reproduce much more rapidly than most plant parasitic nematodes. The time to complete the life cycle, which varies by temperature and nematode species, may be as short as 10 to 14 days (87). In addition to occasionally causing severe defoliation, these nematodes damage ornamental plants by producing dried out and dead tissue that while not a serious threat to the plant's health, can reduce the salability of ornamentals. When foliar nematodes feed within buds, leaf growth can be reduced or distorted. When feeding in the center of young leaves, foliar nematodes are unable to move through the tissue around major leaf veins, producing blotches that later turn dark. Lesions bounded by the major leaf veins are therefore a characteristic symptom of foliar nematodes. However, there are some bacterial diseases that are also confined by leaf veins, so presence of the nematodes must be confirmed. When infected leaf tissue is left floating on clean tap water, the nematodes will emerge within a few minutes to a day

and are best observed with a low power microscope (85-87).

Since foliar nematodes cannot pass easily through tough leaf tissue, they abandon the interior of the leaf to move across the outer leaf surface when it is wet. Re-distribution of this pest is therefore dependent on surface moisture present on leaves and stems. Foliar nematodes are most easily spread when foliage of one plant is touching that of another. They may also be distributed within a nursery in mist propogation chambers or in infested leaves, which drop from the plant. Dried leaves below infected plants may contain thousands of living foliar nematodes. Additionally, foliar nematodes can be introduced from native vegetation around the nursery when container plants are grown near weeds (85-87).

Burrowing Nematodes (*Radopholus* spp.). Burrowing nematodes are among the most serious for the ornamental nursery industry and are the subject of many states and other nations' quarantine regulations. The citrus burrowing nematode (*Radopholus citrophilus*) can be particularly damaging to many ornamental plants. Burrowing nematodes are similar to lesion nematodes in their feeding habits, entering the root and migrating within it. They are most often found in the tender tissue of the root cortex (80).

When oxamyl was widely used for mite control, it also kept nematode populations low, but now that it is no longer available, burrowing nematodes are a more serious problem. Plants grown in field soil cannot be certified to be free of burrowing and other nematodes, and the inability to effectively manage burrowing, reniform, and to some extent root-knot and lesion nematodes has limited sales of Florida ornamentals in states and countries with quarantines (82).

Reniform Nematodes (*Rotylenchulus* spp.). Reniform nematodes are the other major nematode pest of ornamentals in Florida from a quarantine perspective. While burrowing nematodes have historically been a quarantine problem, reniform nematodes have only more recently become an obstacle to the wider marketing of Florida ornamentals. Although most ornamental palms commonly grown in south Florida are not hosts to reniform nematodes, they are restricted from markets in California and Arizona when they are grown in reniform-infested soils (82,88).

Reniform nematodes feed within the plant root. Like the root-knot nematode, they settle on a feeding site once within the root and inject growth regulating substances that alter the root tissue, redirecting energy and nutrients toward the feeding site. Damage to the plant therefore comes about through disruption of the vascular system. Both juveniles and adults are able to survive in soil and plant tissue for 25-27 months in the absence of a food source. Elimination of reniform nematodes from infested sites is complicated by its long survival (80,88).

Chemical Control

Many ornamentals growers now utilize sterilized growing media, and soil fumigants are rarely applied, except where in-ground production is utilized. Four percent of nursery firms used soil fumigants during 1995, with 1 percent of nurseries using methyl bromide/chloropicrin, which is now being distributed within a quota system (6). The fumigant 1,3-D (Telone) is also used by some growers. Metam sodium (Vapam) and dazomet (Basamid), the only two other fumigant nematicides available, are not very effective and require a long period from application to planting (82).

There are very few non-fumigant nematicides available, particularly for ornamentals production. Oxamyl (Vydate) and fenamiphos (Nemacur) are among the few pesticides proven effective against nematodes, which are still available for nursery crops (85). However, oxamyl is no longer manufactured and will be unavailable when existing supplies are depleted. Fenamiphos can be used only in field production, and actual use is low because of the cost involved and the nematicide's toxicity. Fenamiphos is the only existing nematicide available for post-planting application to most ornamental plants in Florida. Ethoprop (Mocap) is labeled for preplant application for nematode control but under very limited use (82). Nine and 2 percent of nursery growers reported using oxamyl and fenamiphos, respectively, during 1995 (6). In a separate survey, leatherleaf fern growers have reported applying nematicides an average of 2.1 times per year (18).

Often, pesticides used to control insects and mites have been thought to simultaneously keep foliar nematode populations under control. However, with the shift toward biological control systems and more specific pesticides, foliar nematode outbreaks are becoming more frequent. In addition, since neither oxamyl nor aldicarb is now available to ornamentals growers, there is currently no chemical control for foliar nematodes on ornamental plants. With no chemical or biological control alternatives, prevention through appropriate cultural practices is the only option for foliar nematode management (82,85).

Chemical Alternatives

Many newer products have been marketed, but efficacy tends to be low and the university system has been unable to run efficacy trials for all new products. Several plant-based nematicides have been developed, but extremely high amounts of material must be applied in order to acheive desired results. At rates of at least one ton per acre, botanicals offer some suppression of root-knot nematodes, but they do not provide complete control, and the high rates required make their use costly. For example, Neotrol contains ground-up sesame, which is used as a soil amendment to reduce nematode populations, particularly root-knot nematode. In efficacy trials with turf in Florida, Neotrol had no effect on root-knot, lance, stubby root, or ring nematodes at application rates of up to 100 grams per square meter (approximately 2 pounds per 100 square feet) (82).

There is a great need in the ornamentals industry in Florida for effective nematicides for production needs and, more importantly, for quarantine requirements. Land in south Florida that is well suited to ornamentals production, particularly palm trees, could be used to grow plants with a strong market in California. However, the presence of reniform nematodes in Florida soils, which are under quarantine in California, coupled with the inability to completely eliminate them from ornamentals production, prohibits the use of field soils to expand ornamentals production in Florida (82).

The chemical nematicides that remain available for ornamentals are older products with similar modes of action. There are currently no alternative nematicides in the research process that are not organophosphates, carbamates, avermectins, or "non-traditional" nematicides. Efficacy data are generally lacking for the last group, and the avermectins have not maintained activity in the soil so as to successfully manage nematode populations (82).

Use of Chemicals in IPM Programs

Seventeen percent of ornamental nurseries reported that they apply nematode control measures after detecting the presence of nematodes, while 11 percent apply controls according to a preventative schedule (6).

Cultural Control

As a result of the quarantine restrictions imposed on imports by other states, the Florida Department of Agriculture and Consumer Services, Division of Plant Industry launched an educational program over 2 decades ago. The program was aimed at instructing commercial ornamentals growers in preventative sanitation measures to achieve the nematode-free production and sale of ornamental plants throughout the state (79).

Most nematode pests are thought to enter nurseries in untreated soil or planting media. Many arrive in infested plant tissue, and some disperse through water. Movement on vehicles, humans and animals, as well as on wind and in fertilizer or packing materials are other means of nematode dispersal throughout a nursery operation. The most important factor in minimizing entry and spread of nematodes is ensuring the use of nematode-free seeds, cuttings and other propagative stock, in addition to nematode-free planting media. Furthermore, plants should be grown in pots, flats and other containers that have been appropriately sterilized and remain out of contact with soil during the entire production phase. Finally, thorough washing of tools and workers hands can reduce nematode spread (79). In addition to using nematode-free propagating material and other sanitation measures, spread of foliar nematodes within a nursery production system can be prevented by minimizing foliar wetting, cleaning fallen leaves, and isolating infected plants (85).

Due to the extremely limited availability of chemical nematicides for ornamentals, Florida growers continue to rely principally on sanitation and clean culture, separation of infected plants, and the use of resistant and tolerant plant varieties for nematode management. However, these practices, while effective, cannot ensure nematode-free plants. In addition, being preventive in nature, these cultural practices are also unable to manage nematodes in the event of contamination (82).

Twenty-five percent of nursery firms reported disinfecting benches and cloth ground covers during 1995, a practice useful in reducing spread of both foliar and root-feeding nematodes. Forty-nine percent reported practicing sterilization or soil solarization during 1995 (6). Most of these were probably practicing sterilization of potting media, since it is a much more common practice than soil solarization, which is generally not feasible under Florida conditions. While solarization has been practiced on a commercial scale in drier climates, Florida's rainy summers reduce its effectiveness, since it requires exposure of the field for 6 to 8 weeks during the hottest months. Solarization also tends to give only partial control in the top 6 to 8 inches (15 to 20 cm) of soil and involves high costs and labor demand (82). However, soil solarization of greenhouse soils and potting mixes can be accomplished more rapidly. Work is also in progress to find ways of speeding up the process by increasing soil temperature and depth of heating, for example by using soil amendments and solar heated water in conjunction with solarization (89).

Heat treatment in the field with steam pans is being developed and is already in use by some growers, particularly for cut flower production. For example, a 70-acre chrysanthemum nursery in Alvah, Florida has used several small steam machines in the field. Each machine is able to disinfest a quarter acre of planting bed per workshift, and the steam machines have provided equal or better results, in terms of both economics and pest control, than fumigation with methyl bromide. However, the cost makes the use of field steam unrealistic for the production of many other types of ornamentals. As with solarization, steam treatment is more feasible with greenhouse and potting soils than with field soils (82,89).

Biological Control

Several biologically-based products are commercially available and have been tested for reducing nematode populations in Florida. For example, the root-colonizing antagonists *Strepomyces lydicus (*Actinovate Plus) and *Burkholderia* (=*Pseudomonas*) *cepacia* (Deny) are thought to colonize root surfaces and nearby soil and protect the roots from nematode attack. However, field trials on turf in Florida have shown them to have no significant effect on nematode populations, and there have been concerns about human pathogenesis from either the pathogen or contamination of the culture. Another microbial product, Prospernema, which contains spores of nematode-trapping fungi, has also failed to reduce nematode populations. Finally, Ditera is a fermentation product from a culture of several isolates of the fungus *Myrothecium verrucaria*. The fungus has been identified as producing toxic metabolites harmful to nematodes, but trials on ornamentals, turf and vegetables have all failed to produce expected results under Florida conditions (82).

The most promising biological control agent for nematodes is the bacterium *Pasteuria penetrans*, which would be a feasible biological control agent for specific nematodes if it could be mass-produced. Growing the bacteria involves infecting nematodes with spores, growing them in a host plant, and then grinding the roots of the host plant as the source of spores. This process does not permit large-volume production, which is a limiting factor in the commercial development of the bacteria. Also, each bacterial isolate attacks only some species and races of nematodes but not others, so growers would have to know which nematode they have and match it with the appropriate isolate of *Pasteuria*. Therefore, although there are many promising candidates, and research is underway on biological control agents that may prove useful in the management of nematode pests, at present no commercially available biological control agent can provide an acceptable level of control on ornamentals in Florida (82).

Weed Management

Weed Pests

In addition to competing for water, light, space and nutrients, weeds can be detrimental to the growth of ornamental plants by harboring populations of insects and mites that can then move onto ornamental crops. Weed management is therefore important both at the direct production site (within containers or in field sites) as well as in surrounding areas (in aisles and around greenhouse and nursery entrances). Some of the weeds encountered in ornamental plant production in Florida include bittercress (*Cardamine* sp.), carpetweed (*Mollugo verticillata*), chamberbitter or leafflower (*Phyllanthus urinaria*), common chickweed (*Stellaria media*), mouseear chickweed (*Cerastium vulgatum*), large crabgrass (*Digitaria sanguinalis*), smooth crabgrass (*Digitaria ischaemum*), hairy crabweed (*Fatoua villosa*), cudweed (*Gnaphalium* spp.), dogfennel (*Eupatorium capillifolium*), dollarweed or pennywort (*Hydrocotyle* spp.), Florida betony (*Stachys floridiana*), eclipta (*Eclipta alba*), Florida pusley (*Richardia scabra*), goosegrass (*Eleusine indica*), common lambsquarters (*Chenopodium alba*), long-stalked phyllanthus (*Phyllanthus tenellus*), mayweed (*Anthemis cotula*), yellow nutsedge (*Cyperus esculentus*), pigweed (*Amaranthus* spp.), redroot purslane (*Portulaca oleacea*), annual ryegrass (*Lolium multiflorum*), shepherds-purse (*Capsella bursa-pastoris*), prostrate spurge (*Chamaesyce humistrata*), spotted spurge (*Chamaesyce maculata*), torpedograss (*Panicum repens*), common vetch (*Vicia sativa*), and yellow woodsorrel (*Oxalis stricta*). The predominant weed species in Florida ornamentals change according to the season, but some common weeds are given below (57).

Common Chickweed (*Stellaria media*). Common chickweed is a broadleaf winter annual that flowers throughout the growing season and spreads by seed or by rooting of stems at the node. Often spreading to form extensive mats, it prefers moist, cool and shady conditions (58).

Florida Pusley (*Richardia scabra*). An annual plant, Florida pusley is found from the central part of the state northward. It blooms in any month that does not have frost, and it is often mixed with Brazil pusley (59).

Spotted Spurge (*Chamaesyce maculata*). Spotted spurge is a low growing summer annual that is native to the southeastern U.S. It reproduces by seed and forms widely spreading mats (58).

Woodsorrel (*Oxalis* spp.). Woodsorrels, which can be either annual or perennial, range from 0.1 to 0.5 meters tall. These herbaceous or bushy weeds are found throughout the state (59).

Chemical Control

In a survey of 1989 herbicide use by growers of woody ornamentals throughout the state, 56 percent of nursery firms used pre-emergent herbicides, while 71 percent used post-emergent herbicides and 49 percent used both types. Palm growers primarily used post-emergent herbicides, which was expected given the limited number of pre-emergent herbicides available for use on palms at the time. Since that survey was completed, several pre-emergent herbicides have been labeled for a variety of palm species (60).

The 1989 survey found weed management practices to be relatively homogeneous throughout Florida, despite differences in product line. The herbicides most commonly used by woody ornamentals nurseries in 1989 were glyphosate (Roundup) a post-emergent herbicide, and oxadiazon (Ronstar), oryzalin (Surflan), and oxyfluorfen + pendimethalin (Ornamental Herbicide 2), all pre-emergent herbicides. Those same four herbicides remained the most commonly used herbicides in Florida's ornamentals production in 1995, as revealed by the survey of all types of ornamental nurseries that year (6,60).

Other pre-emergent herbicides used by 8 to 11 percent of nurseries in 1995 are isoxaben + trifluralin (Snapshot TG), oxyfluorfen + oryzalin (Rout), prodiamine (Factor), isoxaben + oryzalin (Snapshot DF), and pendimethalin (Pendulum/Turf and Ornamental Weedgrass Control). Pre-emergent herbicides used by less than 5 percent of nurseries that year include metolachlor (Pennant), isoxaben (Gallery), napropamide (Devrinol), diuron

(Karmex), oxyflourfen (Goal), trifluralin (Treflan), bromacil (Krovar), princep (Simazine), 2,4-D (2,4-D), and benefin + oryzalin (XL). Post-emergent herbicides used by less than 10 percent of nurseries in 1995 include paraquat (Gramoxone), diquat (Diquat/Reward), potassium salts of fatty acids (Sharpshooter), sethoxydim (Vantage), pelargonic acid (Scythe), and glufosinate-ammonium (Finale), in decreasing order of use (6).

In 1995, nursery firms overall used an average of 2.1 different herbicides. There was some variation among plant types, with an average of 1.6 herbicides being used for floriculture (cut flowers and flowering potted plants), 1.7 for foliage, 1.8 for liners, 2.4 for woody ornamentals, 2.7 for bedding plants, and 2.9 for trees. In a separate survey, leatherleaf fern growers have reported applying herbicides an average of 2.8 times per year (6,18).

Fifteen percent of nurseries statewide reported no herbicide use in 1989, while 12 percent reported no herbicide use in 1995. In 1989, growers who did not use herbicides most commonly (35 percent) gave the reason that herbicides were too expensive relative to labor. Twenty-seven percent felt that they had no reason to use herbicides, and only 7 percent expressed environmental concerns as a reason for not using herbicides (6,60).

Oxadiazon (Ronstar). Oxadiazon is a pre-emergent herbicide used by 25 percent of nurseries in Florida in 1995. It is effective on most nursery weeds, but not on spurges and common chickweed (6,57).

Oryzalin (Surflan) - (REI of 12 hours). Oryzalin is a selective, pre-emergent herbicide used for the control of most annual grasses, including crabgrasses, foxtails, goosegrass, lovegrass and many broadleaf weeds, including bittercress, common chickweed, prostrate spurge, yellow woodsorrel, Florida pusley, and pigweeds. Fifteen percent of Florida nursery growers applied oryzalin in 1995 (6,57,61).

Oxyfluorfen + Pendimethalin (Ornamental Herbicide 2). Oxyfluorfen plus pendimethalin is a pre-emergent herbicide used in the control of a wide variety of nursery weeds, particularly spurges. It was used by 13 percent of ornamental nurseries in Florida in 1995 (6,57).

Isoxaben + Trifluralin (Snapshot TG) - (REI of 12 hours). Isoxaben plus trifluralin is a pre-emergent herbicide that controls many grasses and broadleaf weeds, including common chickweed, spurges, woodsorrel and annual grasses. Eleven percent of ornamental nurseries used this product in 1995 (6,57).

Oxyfluorfen + Oryzalin (Rout). Oxyfluorfen plus oryzalin is a broad-spectrum, pre-emergent herbicide used in the control of many weeds found in nurseries, including spurges. It was used by 9 percent of Florida nurseries in 1995 (6,57).

Prodiamine (Factor) - (REI of 12 hours). Prodiamine is a broad-specturm, pre-emergent herbicide used to control a range of weeds, including spurges. Eight percent of all surveyed ornamental nurseries reported using prodiamine in 1995. Prodiamine is the predominant pre-emergent herbicide used in the cut foliage industry (6,57,62).

Pendimethalin (Pendulum/Turf and Ornamental Weedgrass Control) - (REI of 12 hours). Pendimethalin is a pre-emergent herbicide used in the control of some annual grasses, including crabgrass, foxtail and goosegrass, as well as some broadleaf weeds, including prostrate spurge, common chickweed and woodsorrel. Pendimethalin was used by 8 percent of the state's ornamental nurseries in 1995 (6,57).

Glyphosate (Roundup) - (REI of 12 hours). Glyphosate is a post-emergent, nonselective herbicide that kills grasses, broadleaf weeds and sedges. Used for eliminating weeds around container beds and in field nurseries, it was applied by 82 percent of nurseries in their weed management programs in 1995. Glyphosate is a systemic herbicide that requires between 3 and 10 days to kill most weeds, often requiring a second application for weeds like nutsedge and bermudagrass that have underground storage organs (6,57).

Paraquat (Gramoxone) - (REI of 12 hours). Paraquat is a post-emergent, quaternary nitrogen herbicide used for broadleaf weed control. It was

applied by 8 percent of ornamental nurseries in the state in 1995 (6).

Diquat (Diquat/Reward) - (REI of 12 hours). Diquat is a post-emergent, quick-acting herbicide applied as a directed spray to kill most young annual weeds. It has no residual activity in the soil, and perennial weeds are likely to regrow. Diquat was used by 6 percent of Florida ornamental nursery growers in 1995 (6,57).

Use of Chemicals in IPM Programs

Sixty-six percent of ornamental nurseries in Florida surveyed in 1995 used weed control after weeds were detected, while 43 percent utilized preventative weed management practices (6).

Cultural Control

Weed management in ornamentals production is most effectively achieved by preventative practices. Proper nursery sanitation is especially important, particularly in container production. Removal of established weeds in containers is limited mainly to hand weeding, so prevention is very important. Seeds are the principal source of weeds, and since most weed seeds move only a short distance, eliminating seed-bearing weeds around the production area can greatly reduce the entrance of weeds to the nursery. Since irrigation water can distribute weed seeds, irrigation system filters can remove weed seeds before they arrive at containers. Following adequate sanitation measures during propagation and ensuring that planting media is free of weed seeds are also important cultural control measures (57).

Another essential part of weed management is to guarantee the production of a healthy crop that is able to outcompete weeds. Monitoring soil fertility, pH levels, shade levels, plant spacing and pest populations can aid in preventing damaging levels of weeds, as can the use of mulches or ground covers (63). Mulches are particularly helpful in suppressing the growth of annual weeds. Both organic mulches, such as pine straw, wood chips, straw and leaves, and synthetic mulches such as landscape fabrics, are used in the production of ornamentals in Florida (64).

Woody ornamentals growers surveyed in 1989 reported using mowing (46 percent of growers), hand weeding (19 percent of growers), and mulches (excluding the use of plastic mulch on container beds) (14 percent of growers). The relatively low usage of mulches was probably related to the relatively low percentage of field-grown plants relative to container-grown plants. Of the growers claiming not to use herbicides in 1989, 72 percent relied exclusively on handweeding for weed control and 78 percent had less than one acre of woody ornamentals (60).

Of the ornamental nursery growers surveyed about their 1995 production practices, 60 percent said that they utilized cultivation and hand weeding. Forty-nine percent used soil sterilization or solarization, 26 percent adjusted fertilization rates, and 16 percent applied mulches (6).

Key Contacts

- **Florida Nurserymen and Growers Association**, 1533 Park Center Drive, Orlando, FL 32835-5705, (407) 295-7994
- **Florida Fern Growers Association**, 111 East Hagerstrom Road, Pierson, FL 32180-2533, (904) 749-0808
- **Pat Cockrell**, Florida Farm Bureau, Box 147030, Gainesville, FL 32614, (352) 378-8100 ext. 1545
- • **O. Norman Nesheim,** Pesticide Information Office, University of Florida, P.O. Box 110710, Gainesville, FL 32611-0710; (352) 392-4721; email: onn@mail.ifas.ufl.edu

Aknowledgements

The following individuals served as reviewers and/or provided information used in this profile:

- **Robert Dunn**, Professor of Nematology, University of Florida, Gainesville.
- **Richard Henley**, Professor of Environmental Horticulture, University of Florida, Central Florida REC-Apopka.

- **Russell Mizell**, Assistant Center Director and Professor of Entomology, University of Florida, North Florida REC-Monticello.
- **Jeff Norcini**, Assoc. Professor of Environmental Horticulture, University of Florida, North Florida REC-Monticello.
- **David Norman**, Asst. Professor of Plant Pathology, University of Florida, Central Florida REC-Apopka.
- **Lance Osborne**, Professor of Entomology, University of Florida, Central Florida REC-Apopka.
- **James Price**, Assoc. Professor of Entomology, University of Florida, Gulf Coast REC-Bradenton.
- **Gary Simone**, Professor of Plant Pathology, University of Florida, Gainesville.
- **Robert Stamps**, Professor of Environmental Horticulture and Extension Cut Foliage Specialist, University of Florida, Central Florida Research and Education Center, Apopka, FL.

Support for Florida's Crop/Pest Management Profile project and this publication was provided through a grant from the U. S. Environmental Protection Agency Region IV as a part of their Agriculture Initiative Program and by the Pesticide Impact Assesment Program (PIAP) of the U. S. Department of Agriculture. Dr. O. Norman Nesheim, Professor and Pesticide Informatio Cooordinator at the University of Florida, is the state liaison representative for PIAP.

References

1. Florida Department of Agriculture & Consumer Services. (1998 October 14). 1997 Florida Agricultural Facts. Florida Department of Agriculture & Consumer Services, Tallahassee, FL. Available: http://www.fl-ag.com/agfacts/

2. U.S. Dept. of Agriculture, NASS. (1998 April). Floriculture Crops, 1997 Summary. National Agricultural Statistics Service. Available: http://usda.mannlib.cornell.edu/

3. U.S. Dept. of Agriculture, NASS. (1998). 1997 Census of Agriculture Volume 1: National, State and County Tables. National Agricultural Statistics Service. Available: http://www.nass.usda.gov/census/census97/volume1/vol1pubs.htm

4. Hodges, A.W. and Haydu, J.J. (1996). The Changing Structure of Florida's Ornamental Plant Nursery Industry, 1989 to 1994. Food and Resource Economics Department ER-96-1. Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida. Available: http://edis.ifas.ufl.edu/scripts/htmlgen.exe?DOCUMENT-FE013

5. Hodges, A.W. and Haydu, J.J. (1999 March). Economic Impact of Florida's Environmental Horticulture Industry, 1997. Economic Information Report EIR 99-1. Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida, Gainesville, FL.

6. Hodges, A.W., Aerts, M.J. and Neal, C.A. (1998 August). Pest Management Practices and Chemical Use in Florida's Ornamental Plant Nursery Industry. Food and Resource Economics Department Circular 1203. Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida. Available: http://edis.ifas.ufl.edu/scripts/htmlgen.exe?DOCUMENT_AA242

7. Florida Agricultural Statistics Service. (1998 May). Foliage, Floriculture and Cut Greens. Florida Agricultural Statistics Service, Orlando, FL. Available: http://www.nass.usda.gov/fl/misc/f&fcg98.htm

8. Hodges, A.W., Satterthwaite, L. and Haydu, J.J. (1997 July). Business Analysis of Ornamental Plant Nurseries in Florida, 1995. Food and Resource Economics Department EI 97-3. Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of

Florida.Available: http://edis.ifas.ufl.edu/scripts/htmlgen.exe?DOCUMENT_FE014

9. Hodges, A.W., Satterthwaite, L.N. and Haydu, J.J. (1998). Analysis of Cut Foliage Businesses in Florida, 1996. Food and Resource Economics Department EIR 98-2, Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida, Gainesville, FL.

10. Meerow, A.W. (1996 June). Container Production of Palms. Environmental Horticulture Department Circular 1163. Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida. Available: http://edis.ifas.ufl.edu/scripts/htmlgen.exe?DOCUMENT_CN010

11. Stamps, R.H. (1992). Commercial leatherleaf fern culture in the United States of America. pp. 243-249. In: Fern Horticulture: Past, Present and Future Perspectives. The Proceedings of the International Symposium on the Cultivation and Propagation of Pteridophytes, London, England. Intercept Ltd., Andover, UK.

12. Thorp, R.N. (1995). Study of the Sustainable Agricultural Practices of the Commercial Wholesale Nursery Industry of Florida. Thesis, University of Florida, Gainesville, FL.

13. Personal communication with Thomas Yeager, Horticulturist, University of Florida Environmental Horticulture Department, Gainesville, FL. May 19, 1999.

14. IFAS Taskforce on Microirrigation in Florida. (1993 January). Microirrigation in Florida: Systems, Acreage and Costs. Bulletin 276. Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida. Available: http://edis.ifas.ufl.edu/scripts/htmlgen.exe?DOCUMENT_AE031

15. Swisher, M.E., Thorp, R.N. and Yeager, T.H. (1994). Florida's Ornamental Nurseries: Are They Moving Toward Sustainability? Proc. Fla. State Hort. Soc. 107:207-211.

16. Swisher, M.E., Thorp, R.N. and Yeager, T.H. (1995 April). Florida's Environmental Horticulture Nursery Industry is Adopting Sustainable Practices. Home Economics Department SS-SA-7. Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida, Gainesville, FL.

17. Stamps, R.H., Boggess, W.G. and Smajstrla, A.G. (1991). Irrigation management practices in the leatherleaf fern industry. Proc. Fla. State Hort. Soc. 104: 328-330.

18. Boggess, W.G., Purvis, A., Stamps, R.H, Motes, R. and Ferenc, S. (1991). Fernery Management for Groundwater Quality Protection: Leatherleaf Grower Survey. Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida, Gainesville, FL.

19. Stamps, R.H. (1990). Chemigation of Cut Foliage Crops. University of Florida, Institute of Food and Agricultural Sciences, CFREC-Apopka Cut Foliage Research Note RH-90-A.

20. .Felter, L. (1996 May). Certified IPM Scout Training Class, a Success. Ornamental Research News. Vol. 3, No. 5. University of Florida, Institute of Food and Agricultural Sciences, Central Florida Research and Education Center. Available: http://www.ifas.ufl.edu/~APKWEB/orn/orn3-5.htm

21. Shives, S.A. and Cashion, G.J. (1995). The role of the professional scout in ornamental IPM. Proc. Fla. State Hort. Soc. 108:38-40.

22. Osborne, L.S., Petitt, F.L., Landa, Z. and Hoelmer, K.A. (1994). Biological control of pests attacking crops grown in protected culture: The Florida experience. Pp. 327-342. In: Pest Management in the Subtropics, Biological Control - A Florida Perspective, Intercept Ltd., Hampshire, UK.

23. Short, D.E. (1997 April). Mites and Their Control on Ornamental Plants Around the Home. Entomology and Nematology Department ENY-319. Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida. Available: http://edis.ifas.ufl.edu/scripts/htmlgen.exe?DOCUMENT_MG001

24. Short, D.E. and Castner, J.L. (1997 February). Ornamental Insects Sheet. Entomology and Nematology Department SP-124. Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida. Available: http://edis.ifas.ufl.edu/scripts/htmlgen.exe?DOCUMENT_IN023

25. Mizell, R.F., III, and Short, D.E. (1992). Seasonal occurrence and management of landscape and ornamental pests in North Florida and South Georgia. Proc. Fla. State Hort. Soc. 105:204-210.

26. Short, D.E. and Castner, J.L. (1997 February). Ornamental Insects Sheet 2. Entomology and Nematology Department SP-125. Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida. Available: http://edis.ifas.ufl.edu/scripts/htmlgen.exe?DOCUMENT_IN024

27. Short, D.E. (1997 April). Aphids on Ornamental Plants Around the Home. Entomology and Nematology Department ENY-320. Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida. Available: http://edis.ifas.ufl.edu/scripts/htmlgen.exe?DOCUMENT_MG002

28. Short, D.E, Price, J. and Osborne, L. (1997 April). Silverleaf (Sweet Potato) Whitefly on Ornamental Plants. Entomology and Nematology Department SS-ENY-911. Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida. Available: http://edis.ifas.ufl.edu/scripts/htmlgen.exe?DOCUMENT_MG362

29. Short, D.E. (1997 April). Whiteflies and Their Control on Ornamental Plants Around the Home. Entomology and Nematology Department ENY-317. Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida. Available: http://edis.ifas.ufl.edu/scripts/htmlgen.exe?DOCUMENT_MG254

30. Seal, D.R., Bryan, J.H. and Bryan, H.D. (1994). Abundance and management of silverleaf whitefly, *Bemisia argentifolii* (Homoptera: Aleyrodidae), on ornamentals. Proc. Fla. State Hort. Soc. 107: 222-226.

31. Short, D.E. (1997 June). Scale Insects and Mealybugs on Ornamental Plants and Their Control. Entomology and Nematology Department ENY-323. Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida. Available: http://edis.ifas.ufl.edu/scripts/htmlgen.exe?DOCUMENT_MG005

32. Short, D.E. and Castner, J.L. (1997 February). Scale Insects Affecting Ornamental Plants. Entomology and Nematology Department SP-94. Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida. Available: http://edis.ifas.ufl.edu/scripts/htmlgen.exe?DOCUMENT_IN008

33. Johnson, F.A. and Castner, J.L. (1997 February). Armyworms. Entomology and Nematology Department SP-117. Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida. Available: http://edis.ifas.ufl.edu/scripts/htmlgen.exe?DOCUMENT_IN016

34. Ruppert, P.F., Habeck, D.H., Short, D.E. and Castner, J.L. (1997 February). Caterpillars of Ornamental Plants Sheet. Entomology and Nematology Department SP 152. Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida. Available:

http://edis.ifas.ufl.edu/scripts/htmlgen.exe?DOCUMENT_IN033

35. McAuslane, H. (1997 April). "Oleander Caterpillar," UF/IFAS Featured Creatures. Entomology and Nematology Department EENY-9. Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida. Available: http://www.ifas.ufl.edu/~insect/ORN/Olecpillar.htm

36. Peña, J.E., Duncan, R. and Torres, V. (1990). Dynamics and control of the banana moth on foliage plants. Proc. Fla. State Hort. Soc. 103:189-192.

37. Osborne, L.S. (1984). Insect Pests of Leatherleaf Fern. UF/IFAS Commercial Fern Grower 7(6):1-2.

38. Capps, H.W. (1965). A new *Undulambia* species on leather-leaf fern in Florida, and note on a closely related Central American species (Lepidoptera: Pyraustidae, Nymphulinae). Florida Entomologist 48(3):155-157.

39. Personal communication with Russell Mizell, Entomologist, University of Florida North Florida Research and Education Center, Monticello, FL. March 4, 1999.

40. Short, D.E. (1997 June). Thrips on Ornamental Plants. Entomology and Nematology Department ENY-333. Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida. Available: http://edis.ifas.ufl.edu/scripts/htmlgen.exe?DOCUMENT_MG327

41. Short, D.E. (June 1997). Leafminers and Their Control on Ornamental Plants Around the Home. Entomology and Nematology Department ENY-326. Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida. Available: http://edis.ifas.ufl.edu/scripts/htmlgen.exe?DOCUMENT_MG006

42. Short, D.E. (1997 June). Boring Insects of Ornamental Plants and Trees. Entomology and Nematology Department ENY-327. Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida. Available: http://edis.ifas.ufl.edu/scripts/htmlgen.exe?DOCUMENT_MG007

43. Price, J., Short, D. and Osborne, L. (1997 May). Management of Fungus Gnats in Greenhouse Ornamentals. Entomology and Nematology Department ENY-912. Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida. Available: http://edis.ifas.ufl.edu/scripts/htmlgen.exe?DOCUMENT_IG125

44. Short, D.E. (1997 April). Lacebugs on Ornamental Plants. Entomology and Nematology Department ENY-332. Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida. Available: http://edis.ifas.ufl.edu/scripts/htmlgen.exe?DOCUMENT_MG326

45. Price, J.F., Schuster, D.J. and McClain, P.M. (1990). Azadirachtin from neem tree (*Azadirachta indica* A.Juss.) seeds for management of sweetpotato whitefly [*Bemisia tabaci* (Gennadius)] on ornamentals. Proc. Fla. State Hort. Soc. 103:186-188.

46. Short, D.E.. (1998 October). Integrated Pest Management in the Commercial Ornamental Nursery. Entomology and Nematology Department ENY-336. Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida. Available: http://edis.ifas.ufl.edu/scripts/htmlgen.exe?DOCUMENT_IG144

47. Short, D.E., Osborne, L.S. and Henley, R.W. (1997 August). 1997 Insect and Related Arthropod Management Guide for Commercial Foliage Plants in Florida. Entomology and Nematology Department ENY-803. Florida Cooperative Extension Service, Institute of Food

and Agricultural Sciences, University of Florida. Available: http://edis.ifas.ufl.edu/scripts/htmlgen.exe?DOCUMENT_IG112

48. Osborne, L.S, Ehler, L.E. and Nechols, J.R. (1985 December). Biological Control of the Twospotted Spider Mite in Greenhouses. University of Florida, Institute of Food and Agricultural Sciences, CFREC-Apopka Bulletin 853. Available: http://www.ifas.ufl.edu/~APKWEB/entomol/b853a1.htm

49. Mizell, R. (1996). Woody landscape plants, tree fruit and nuts. Pp. 371-385. In: Pest Management in the Subtropics, Integrated Pest Management - A Florida Perspective, Intercept, Ltd., Andover, UK.

50. Cashion, G.J., Bixler, H. and Price, J.F. (1994). Nursery IPM Trials Using Predatory Mites. Proc. Fla. State Hort. Soc. 107: 220-222.

51. Georgis, R. and Poinar, G.O., Jr. (1994). Nematodes as bioinsecticides in turf and ornamentals. Pp. 477-489. In: Leslie, A.R. (ed.), Handbook of Integrated Pest Management for Turf and Ornamentals. Lewis Publishers, Boca Raton.

52. Osborne, L. (1996 July). Fungus gnats and you. Ornamental Research News, Vol. 3, No. 7, University of Florida, Institute of Food and Agricultural Sciences, Central Florida Research and Education Center. Available: http://www.ifas.ufl.edu:7100/~apkweb/orn/orn3-7.htm.

53. McAuslane, H.J. and Bennett, F.D. (1995). Parasitoids and predators associated with *Syntomeida epilais* (Lepidoptera: Arctiidae) on oleander. Florida Entomologist 78(3): 543-546. Available: http://www.fcla.ufl.edu/FlaEnt/fe783.htm

54. Ru, N. and Sailor, R.I. (1979). Colonization of a citrus whitefly parasite, *Prospaltella lahorensis*, in Gainesville, Florida. The Florida Entomologist 62(1):59-65.

55. De Quattro, J., Senft, D. and Wood, W. (1997 February). The Whitefly Plan: A Five-Year Update. Agricultural Research 45(2):4-12. Available: http://www.ars.usda.gov/is/AR/archive/feb97/

56. Short, D.E. and Price, J.F. (1994 April). 1994 Pest Control Guide for Commercial Flower Crops in Florida (Non-Greenhouse and Greenhouse). Entomology and Nematology Department SS-ENY-801, Extension Entomology Report #50. Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida. Available: http://hammock.ifas.ufl.edu/txt/fairs/ig/49238.html

57. Norcini, J.G. and Stamps, R.H. (1994). Container Nursery Weed Control. Environmental Horticulture Department Circular 678. Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida. Available: http://edis.ifas.ufl.edu/scripts/htmlgen.exe?DOCUMENT_CN007

58. Miller, J.F., Worsham, A.D., McCormick, L.L., Davis, D.E., Cofer, R. and Smith, J.A. (1975). Weeds of the Southern United States. Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida,

59. Hall, D.W. and Vandiver, V.V. (1991 May). Weeds of Florida. SP-37. Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida. Available: http://edis.ifas.ufl.edu/scripts/htmlgen.exe?MENU-FW:FW

60. Norcini, J.G., Zimet, D.J., McDowell, J.M. and Landrum, L.B. (1991). Herbicide use by Florida's woody ornamental industry. Proc. Fla. State Hort. Soc. 104:293-296.

61. Norcini, J.G. (1998 June). Preemergent Herbicides for Use in Ornamentals. Environmental Horticulture Department OH-94. Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of

Florida. Available: http://edis.ifas.ufl.edu/scripts/htmlgen.exe?MENU-WG:Ornamentals-and-Turf

62. Personal communication with Robert Stamps, Cut Foliage Specialist, University of Florida Central Florida Research and Education Center, Apopka. March 17, 1999.

63. Stamps, R.H. and Poole, R.T. (1986). Herbicides and Cut Foliage: II. Eucalyptus, Euonymus and Photinia. UF/IFAS, AREC-Apopka Cut Foliage Research Note RH-86-B.

64. Norcini, J.G. (1998 June). Weed Management in Ornamentals. Environmental Horticulture Department ENH-93. Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida. Available http://edis.ifas.ufl.edu/scripts/htmlgen.exe?DOCUMENT_WG057

65. Simone, G.W. (1997 September). Fungicides with Broad Clearances. Plant Pathology Department PDMG-V2-03, part of the 1998 Plant Disease Management Guide, Volume 2. Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida. Available: http://edis.ifas.ufl.edu/scripts/htmlgen.exe?DOCUMENT_PG070

66. Personal communication with David Norman, Plant Pathologist, University of Florida, Central Florida Research and Education Center, Apopka, FL. April 8, 1999.

67. Chase, A.R. (1997). Foliage Plant Diseases, Diagnosis and Control. APS Press, St. Paul, Minn. 169 pp.

68. Chase, A.R. (1992). Efficacy of thiophanate methyl fungicides for diseases of Florida ornamentals. Proc. Fla. State Hort. Soc. 105:182-186.

69. Norman, D.J. (1996 January). Cool, wet soil and *Rhizoctonia*. Ornamental Research News, Vol. 3, No. 1, Central Florida Research and Education Center Available: http://www.ifas.ufl.edu:7100/~apkweb/orn/orn3-1.htm.

70. Chase, A.R. (1990). Control of some bacterial diseases of ornamentals with Agribrom. Proc. Fla. State Hort. Soc. 103:192-193.

71. Norman, D.J. (1995 October). Rain and bacterial diseases. Ornamental Research News, Vol. 2, No. 10, University of Florida, Institute of Food and Agricultural Sciences, Central Florida Research and Education Center. Available: http://www.ifas.ufl.edu:7100/~apkweb/orn/orn2-10.htm

72. Chase, A.R. and Mulish, T.A. (1992). Fungicide Tests for Control of *Phytophthora* and *Pythium* Diseases on Ornamentals. CFREC-Apopka Research Report RH-92-9, University of Florida, Institute of Food and Agricultural Sciences. Available: http://www.ifas.ufl.edu/~APKWEB/cfrec/rh-92-9.htm

73. Chase, A.R. and Broschat, T.K. (eds.). (1991). Diseases and Disorders of Ornamental Palms, APS Press, St. Paul, MN.

74. Leahze, R., Schubert, T., Strandberg, J., Stamps, B., and Norman, D. (1995). Anthracnose of Leatherleaf Fern. Plant Pathology Circular No. 372, Florida Department of Agriculture and Consumer Services, Division of Plant Industry. Available: http://www.ifas.ufl.edu/~APKWEB/cutfol/ppc372.htm

75. Norman, D.J. (1996). Diseases of English Ivy. CFREC-Apopka Research Report RH-96-4. University of Florida, Institute of Food and Agricultural Sciences. Available: http://www.ifas.ufl.edu/~APKWEB/cfrec/rh-96-4.htm

76. McGovern, R.J. (1997 April). Integrated Disease Management in Annual Ornamentals. University of Florida GCREC Extension Report BRA-1997-1

77. Simone, G.W. (1997). Fungicide Re-entry Intervals and Protective Clothing Requirements Under the Worker Protection Standard of 1994. Plant Pathology Department PP/PPP 49. Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida.

78. McGovern, R.J. (1996). Enhanced survival of *Impatiens* in a *Rhizoctonia solani*-infested medium by biological controls and fungicides. Proc. Fla. State Hort. Soc. 109:21-23.

79. Esser, R.P. (1996). Sanitation Practices to Control Plant Parasitic Nematodes in Florida Plant Nurseries. Contribution No. 467, Bureau of Entomology, Nematology and Plant Pathology - Nematology Section, Florida Dept. of Agriculture and Consumer Services, Division of Plant Industry.

80. Dunn, R.A. (1999 January). Nematode Management for Nursery Crops (Ornamentals and Planting Stock of Fruits and Nuts). Entomology and Nematology Dept. RF-NG011. Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida. Available in March 1997 version: http://edis.ifas.ufl.edu/scripts/htmlgen.exe?DOCUMENT_NG011

81. Dunn, R.A. (1997 February). Root-knot Nematodes as Pests of Ornamental Plants. Entomology and Nematology Dept. SP 222. Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida. Available: http://edis.ifas.ufl.edu/scripts/htmlgen.exe?DOCUMENT_IN037

82. Personal communication with Robert Dunn, Nematologist, University of Florida Department of Entomology and Nematology, Gainesville, FL. April 30, 1999.

83. Stokes, D.E. (1977 January). Effects of root-knot nematodes on ornamental plants. Nematology Circular No. 24. Fla. Dept. of Agric. & Consumer Serv., Division of Plant Industry, Gainesville, Florida.

84. O'Bannon, J.H., Esser, R.P., Lehman, P.S. and Milatos, C. (1988 September). The root-lesion nematode, *Pratylenchus penetrans* and other nematodes associated with leatherleaf fern. Nematology Circular No. 157. Fla. Dept. of Agric. & Consumer Serv., Division of Plant Industry, Gainesville, Florida.

85. Dunn, R.A. (1995 October 10). Foliar Nematodes in Nursery Crops. University of Florida Pest Alert. Available: http://extlab1.entnem.ufl.edu/pestalert/rad-1011.htm

86. Dunn, R.A. (1997 February). Foliar Nematodes as Pests of Ornamental Plants. Entomology and Nematology Department SP 221. Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida. Available: http://edis.ifas.ufl.edu/scripts/htmlgen.exe?DOCUMENT_IN036

87. Dunn, R.A. (1996 March/April). A "New" Old Pest: Foliar Nematodes. Ornamental Outlook. pp. 19-20.

88. .Inserra, R.N. and Dunn, R.A. (1992 May-June). Effect of *Rotylenchulus reniformis* survival on nematode management in ornamental nurseries of southern Florida. Nematology Circular No. 199. Fla. Dept. of Agric. & Consumer Serv., Division of Plant Industry, Gainesville, Florida.

89. Grossman, J. and Liebman, J. (1995 July). Alternatives to methyl bromide - steam and solarization in nursery crops. The IPM Practitioner 17(7):1-12.