



Florida Crop/Pest Management Profile: Avocado¹

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Production Facts

- The 1998-1999 average yield of avocados in Florida was 153 bushels/acre. At a price of \$17.90 per bushel, the Florida crop (920,000 bushels) was worth approximately \$16.5 million (1).
- In 2000-2001, 6,000 bearing acres in Florida produced just over one million bushels, which occurred for the first time since hurricane Andrew. At an average price of \$14.60 per bushel, the crop for this season was valued at \$15.2 million (2).
- In 1999-2000, Florida was second behind California in avocado production. Florida accounted for 9 percent of the acreage and 12 percent of the production nationally, but only accounted for 4 percent of the value, owing to the fact that Florida avocados sell for about one-third of the price garnered by California avocados (2).
- Avocado acreage declined approximately 2.5 percent from 6,447 acres in 1996 to 6,288 in 2000. The decrease was due to attrition, urbanization, and removal of undesirable varieties (3).
- Over 90 percent of avocado is grown in Miami-Dade County (3). Of the 518 farms reported in 1997, 14 percent were less than one acre, 42 percent were between 1 and 4.9 acres, 26 percent were between 5 and 14.9 acres, 8 percent were between 15 and 24.9 acres, 1 percent were between 25 and 49.9 acres, 1 percent were between 50 and 99.9 acres, and 3 percent were over 100 acres in size. Approximately two-thirds of the state's avocados were produced on the 25 acre or greater farms, while the smaller farms produced the remainder of the crop (4).
- Three races of avocado are recognized: West Indian, Guatemalan, and Mexican. These differ in blooming/maturity season, development period, fruit size, skin texture/color, oil content, and cold hardiness. West Indian and West Indian-Guatemalan hybrid cultivars predominate in Florida (5).
- Avocado may be self- or cross-pollinating, and they are separated into A and B varieties based on reproductive functionality (5).

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Production Regions

Avocado (*Persea americana*) is grown primarily in south Florida. In 1997, 93 percent of Florida's avocado farms and 98 percent of the avocado acreage were located in Miami-Dade County. The remainder of farms and associated acreage were located in Brevard, Broward, Collier, Hillsborough, Palm Beach, and other counties (4).

Production Practices

The avocado tree is classified as an evergreen and is in the Lauraceae family. It is a plant that is indigenous to tropical America and was first imported into Florida in 1833. The tree can grow to a height of 60 feet but it is generally maintained at a height of 20 feet for ease of harvest and maintenance.

The fruit vary in shape and weight ranges from a few ounces to five pounds. Oil content of Florida avocado generally ranges from three to 15 percent, and the fruit does not ripen until it is picked or falls off the tree. This phenomenon allows avocado growers to store the fruit on the trees until labor or markets are available/favorable. The Florida Avocado Administrative Committee establishes dates each season at which time certain size fruit are considered mature (5,6).

Avocado should be planted in well-drained soil, such as the well-drained rockland and sandy soils present in south Florida. The plant does not tolerate flooding or standing water, as it is predisposed to *Phytophthora* infection. Additionally, consistently wet soils lead to reduced yield and nutritional deficiencies. The soils present in south Florida generally fulfill this requirement once the fertility of the soil has been amended. Although it does not tolerate consistently wet soils, avocado trees do have a high water requirement. During dry periods, irrigation systems should be able to provide 1 inch of water per week (5).

Cultivars commonly used in Florida avocado production are "Simmonds", "Choquette", "Monroe", "Lula", "Nadir", and "Booth" varieties. "Simmonds" and "Nadir" are early-maturing varieties (late June), "Booth", "Waldin", and "Choquette" ripen in

October, and "Lula", "Taylor" and "Monroe" mature in November. Avocado is generally propagated vegetatively. Cleft and veneer grafting techniques are used during the cooler months to merge healthy seedling rootstock (typically "Lula" or "Waldin") with scions from the desired variety. Scions may also be added to mature trees in a technique referred to as top-working. Top-worked trees produce marketable fruit within two or three years while new plantings require three to four years (5,6).

Avocado trees are planted from 15 to 25 feet apart within rows and from 25 to 30 feet between rows. Consequently, an eight- to twelve-year-old grove would have about 75 trees per acre. The trees reach full-bearing potential by the seventh year. The useful life of an avocado tree is approximately 40 years, although 75-year-old trees have been reported. During the life of a grove, healthy trees are pruned and diseased and undesirable trees are removed and replaced with "resets" or mature trees that have been moved and replanted (5,6).

Less than one percent of the self- or cross-pollinating flowers on an avocado tree set fruit. A varieties such as "Waldin", "Lula", and "Taylor" fruit well in solid plantings, while B varieties such as "Booth" do not, and should be interspersed with A varieties to facilitate adequate pollination. Some varieties bear many fruit, a portion of which abscise, while others bear fewer fruit that are retained until maturity. Often, a tree will bear well only every other year. The greatest production in Florida is from August through December (5).

Avocado trees are generally picked twice a season. Larger fruit are picked first, leaving the smaller fruit to enlarge. Picking is quite labor intensive, and laborers often wear cotton gloves and use canvas picking bags to minimize damage of the soft fruit. The picker must be able to selectively choose only desirable avocados and pick them without injuring the fruit. The fruit is packed into various size boxes in the packinghouse, some of which may be marketed under the growers name and a portion which is pooled and sold by the smaller growers. It is important to note that off-farm activity was high among Florida avocado growers (63 percent worked off-farm at least one day and 40 percent worked off-farm 200 days or more a year in

1987). This same grower group cultivated other tropical crops, as avocado only comprised 18 percent of total sales (6).

Insect/Mite Management

Insect/Mite Pests

The principal pests on avocado in Florida are mites (avocado red mite, avocado brown mite, avocado bud mite), avocado lace bug, mirids, scale (dictyospermum scale, Florida red scale, Florida wax scale, lantania scale, pyriform scale), avocado tree girdler, redbanded thrips, and fire ants. Minor and occasional pests include aphids, mealybugs, avocado leafroller, avocado looper, banded cucumber beetle, caterpillars, grasshoppers, and slugs/snails (7).

MITES (*Oligonychus yothersi*, *Oligonychus punicae*, *Tegolophus perseiflorae*) Spider mites of the genus *Oligonychus* commonly infest avocados in Florida. Feeding is first confined to the upper leaf surface, along the midrib, and then along secondary veins. The areas along the veins become reddish-brown. Damage by the spider mites is regularly observed from October through February, causing a reduction in photosynthesis of up to 30 percent. Infested leaves often abscise prematurely. Control measures are often started when mite pressures reach six or more mites per leaf. For spider mites in general, life cycles may range from five to 20 days and life span may be as long as one month. The female lays several hundred eggs over a lifetime, and they are capable of overwintering within the grove (7).

Avocado bud mite (*T. perseiflorae*) populations start to increase from March to May. These mites are found on buds and on developing fruit. The feeding causes necrotic spots and irregular openings in apical leaves and may cause fruit deformation and discoloration (7).

AVOCADO LACE BUG (*Pseudacysta perseae*) The avocado lace bug was historically regarded as having a limited distribution throughout the peninsula, causing little economic damage. However, the number of complaints regarding leaf

damage by this insect has increased recently. These small (2 mm) insects are black with pale yellow legs and antennae. The shape is classically "bug-like" (i.e., belonging to the family Hemiptera). This species is the only one described for the genus *Pseudacysta*, so identification to genus is imperative to get to the specific level. The avocado serves as a host to the bug, as do red bay and camphor in the rest of the Deep South (8).

The avocado lace bug inhabits the undersurface of leaves and feeds by penetrating the tissue and removing plant sap with its piercing-sucking mouthparts. The bug lives in colonies, depositing eggs upright in irregular clusters in the same area it inhabits and the life-cycle is about three weeks. When a colony is present, dark, sticky secretions cover the leaf surface. The bug is often found during dry months (November through February). It is believed that the feeding wounds produced by the bug serve as entry points for anthracnose-causing fungi, which produce large necrotic blotches on avocado leaves. Field surveys have shown that certain avocado varieties ("Loretta" and "Booth 8") suffered as much as 28 percent damage to the leaves, while "Simmonds" trees suffered complete loss of fruit set and premature defoliation when 100 percent of the leaves were infested. The most important predators of the lace bug are two egg parasitoids, the green lacewing, and a predacious mirid (8,9).

MIRIDS (*Dagbertus fasciatus*, *Dagbertus olivaceous*, *Rhinacloa* sp.) These small sucking insects are prevalent during the flowering months of January through April. The flower and early fruit feeding by the insects may cause the fruit to drop, and wounds serve as entry points for decay organisms. The insects are small (3 mm) and vary in color from green to brown. In addition to feeding, the insects lay eggs on opening buds, leaves, flowers, and small fruit (7).

SCALE (*Chrysomphalus dictyospermi*, *Chrysomphalus aonidum*, *Ceroplastes floridensis*, *Hemiberlesia lataniae*, *Protopulvinaria pyriformis*) Soft and armored scales are plant-feeding insects which are often controlled by natural and released parasites, predators, and pathogens. In cases when the natural balance of predation has been disrupted, scale populations may increase to levels requiring

treatment. Since scale insects are relatively immobile and at least one month is required for the egg to reach the adult stage, an infestation builds up slowly (in comparison to mites or aphids) and may be hard to spot. It is also important to verify that the scale insects attached to the plant are alive, as mummies accumulate on the plant over time. Economic thresholds for scale have not been determined. Most effective control is obtained when the scales are in nymphal stages, as egg and adult stages are recalcitrant to insecticide applications (10).

AVOCADO TREE GIRDLER (*Heilipus squamosus*) This weevil is one of the most potentially damaging pests of avocado. The adult weevil is about 1.2 cm in length, predominantly black in color with irregular white areas and spots on the wing covers. Eggs are deposited in the inner bark, near ground level. The larvae burrow in the inner bark or in the wood of small trees as they feed. Reddish-brown frass extruding from burrowing holes is a sign of infestation. Young trees two to four years old may be girdled so completely that they die. Adults weevils feed on buds, twigs, blossoms, and young fruit after they have emerged (32).

REDBANDED THRIPS (*Selenothrips rubrocinctus*) The redbanded thrips is ubiquitous in its distribution throughout Florida, but it is generally found in damaging numbers from Orlando to Key West. Female redbanded thrips are slightly greater than 1 mm in length, and have a dark brown to black body underlain by red pigment, chiefly in the first three abdominal segments. The larvae is light yellow to orange, with the first three and last segments of the abdomen bright red. The life cycle of this thrips is about three weeks in Florida, and several generations are possible each year. In addition to attacking avocado and mango, this thrips also attacks sweetgum trees. Redbanded thrips prefer young foliage, which may lead to leaf drop, at times totally denuding trees. The frass and associated sooty mold from thrips feeding gives rise to fruit which is out-of-grade (11).

RED IMPORTED FIRE ANT (*Solenopsis invicta*) This ant is well known by most everyone living in the southern United States. Introduced near

Mobile, AL, around WWII, this ant has spread throughout all the states which do not have freezing winters. The colonies can be either single-queen or multiple queen, and can number up to a quarter million individuals. These ants take advantage of any food items available, which in this case includes avocado fruit, as fire ants are especially attracted to oily compounds. The ants may also protect aphid colonies from predators. The venom of the ant is highly irritating to mammalian skin, making picking activities hazardous when colonies are actively foraging on trees (12).

Chemical Control

A schedule of yearly maintenance has been published for Florida avocados (7). During December through February, prune/survey for avocado tree girdler and lace bug and manage avocado red mites. From January through March, manage bloom infesting insects. From May through July, prune wood from girdler attack and spray for scale, mealybug, or other major infestations. From August through September, manage thrips and fruit-scarring caterpillars.

In 1999-2000, 71 percent of responding avocado growers surveyed reported insecticide use. Those survey respondents that provided insect damage estimates indicated that from 10 to 90 percent of the avocado crop would be lost to insect damage (n=13, mean of 60 percent). Statistical data for 1999 documented insecticide use on 90 percent of the acreage (13). Insecticides and miticides registered for use on Florida avocado include azadirachtin (Azatin®, Margosan®), *Bacillus thuringiensis* (Cutlass®, Condor®, Javelin®), malathion (Atrapa®), methomyl (Lannate®), fenoxycarb (Logic® - for ants only on non-bearing trees), insecticidal oil (Volck®, Sun Spray®), permethrin (Ambush®, Pounce®), insecticidal soap (Safer®), pyrethrin plus rotenone (Pyrellin®), pyrethrin (Pyronyl®, Diatect®), metaldehyde (for slugs and snails) and sulfur.

PERMETHRIN (Ambush®/Pounce®) Permethrin is a pyrethroid insecticide that acts as a neurotoxicant. The compound is used to manage all avocado insects other than mites and armored scale

insects. The median price of permethrin is \$56.32 per pound of active ingredient and the approximate cost per application is \$11.26 per acre (7,14). The pre-harvest interval (PHI) for permethrin is 7 days, and the restricted-entry interval (REI) is 12 hours. No more than 1.2 pounds of active ingredient per acre per season may be applied (15,16).

In 1999-2000, 52 percent of surveyed avocado growers in Florida applied permethrin either one (46 percent), two (18 percent), three (18 percent), four (9 percent) or five (9 percent) times for an average use of 2.2 times per season. In 1999, a total of 800 pounds of active ingredient were used an average of 1.9 times on 46 percent of the avocado acreage in Florida (13).

FENOXYCARB (Logic®) Fenoxycarb is a carbamate compound used as an insect growth regulator, which causes death in the last pupal stage (17). The bait product is used to control ants (particularly the imported red fire ant). The price of fenoxycarb is \$715 per pound of active ingredient and the approximate cost per application is \$14.30 per acre (18). In 1999-2000, 17 percent of surveyed avocado growers in Florida applied fenoxycarb to their acreage once or twice per season to non-bearing avocado groves.

CROP OILS (Volck®, Sunspray®) Crop oils work by smothering immobile insects such as scales, aphids, and mites. The oils are usually made up as 1.5 to 3 percent solutions which are applied thoroughly to each tree. Price varies greatly based on amount and formulation used. In 1999-2000, 17 percent of surveyed avocado growers in Florida applied oil to their acreage once, twice, or three times per season.

INSECTICIDAL SOAPS (Safer®) As with crop oils, soaps work by asphyxiating non-winged insects. Again, prices vary widely, and solutions (e.g. 2 percent) are applied thoroughly to trees. In 1999-2000, 11 percent of surveyed avocado growers in Florida applied soaps to their trees four or six times per season.

MALATHION (Atrapa®) Malathion is an organophosphorous compound which causes death by interfering with proper nerve transmission.

Malathion is used to control greenhouse whitefly, brown and lantania scale, and caterpillars (7). The median price of malathion is \$5.44 per pound of active ingredient and the approximate cost per application is \$25.50 per acre (7,14). The PHI is 7 days and the REI is 12 hours (19). In 1999-2000, 11 percent of surveyed avocado growers in Florida applied malathion to their acreage once or twice per season.

BACILLUS THURINGIENSIS (Javelin®)

The biopesticide *Bacillus thuringiensis* (*B.t.*) is used to manage lepidopteran larvae. The median price of *B.t.* is \$140.16 per pound of active ingredient and the approximate cost per application is \$13.18 per acre (14,20). *B.t.* may be applied up to the day of harvest (PHI= 0 day), and the REI is 4 hours (20,21). In 1999-2000, 10 percent of surveyed avocado growers in Florida applied *B.t.* to their acreage once or twice per season.

AZADIRACHTIN (Azatin®) Azadirachtin is a natural compound derived from the neem tree (*Azadirachta indica*) that has insect growth regulator as well as deterrent activity (17). The compound is used to manage whiteflies, aphids, some scale insects, and caterpillars. The price of azadirachtin is \$2,119.25 per pound of active ingredient and the approximate cost per application is \$93.25 per acre (18,20). The PHI for azadirachtin is 0 day and the REI is 4 hours (20). In 1999-2000, 6 percent of avocado growers in Florida applied azadirachtin to their acreage twice per season.

Alternative Chemicals

Several new "reduced impact" chemicals have been registered for use in avocados. Messenger® (harpin protein), and Organigard® (*Beauveria bassiana*) are two products which are just now being assessed for insect management. Additionally, new strains of *B.t.* are reaching the market which are reportedly more toxic to a greater range of lepidopteran larvae.

Cultural Control

Based on survey results of all tropical fruit growing respondents, 44 percent reported keeping records of pest problems, 50 percent adjusted applications (timing or rate) to protect beneficial insects and mites, and 52 percent alternated pesticides to reduce resistance. Sixty-two percent reported selecting the pesticide that is least toxic to beneficial insects and mites and 63 percent spot sprayed only infested plants or areas. Seventy percent reported selecting pesticides that are least toxic to the environment to make this the dominant form of cultural pest control.

Biological Control

Seven percent of the responding tropical fruit growers reported release of predatory wasps for control of lepidopteran pests. Additionally, 30 percent reported the use of biological-derived pesticides like B.t.

Weed Management

Weed Pests

Weeds can reduce avocado yields by competing primarily for water and nutrients. Although individual weed species may vary from region to region within the state, predominant weed species in groves are grasses, sedges, and pigweeds (22). However, species composition is relatively unimportant as the trend has been toward use of non-selective, post-emergent herbicides.

Chemical Control

There are about a half-dozen herbicides labeled for use on bearing avocado (simazine, glyphosate, norflurazon, oxyfluorfen, paraquat, napropamide, and pelargonic acid). Fluazifop-p-butyl, trifluralin, sethoxydim, isoxaben, benefin, sulfosate, diquat, and oryzalin can be used on non-bearing avocado trees. All of these herbicides are used to control weeds

between trees. In 1999-2000, 95 percent of avocado growers surveyed reported herbicide use and statistical data for 1999 documented herbicide use on 49 percent of bearing acreage (23). Non-selective herbicides labeled for use in avocado include glyphosate (Roundup®), paraquat (Gramoxone®), pelargonic acid (Scythe®), norflurazon (Solicam®), sulfosate (Touchdown®), and diquat (Reglone®). All of these are post-emergence herbicides except norflurazon, which is a pre-emergence compound. Selective herbicides labeled for avocado in Florida include simazine (Princep®), fluazifop-p-butyl (Fusilade® 2000), oxyfluorfen (Goal®), trifluralin, sethoxydim (Poast®), napropamide (Devrinol®), oryzalin/benfin (XL®), and isoxaben (Gallery®). All of these are pre-emergence compounds except fluazifop-p-butyl and sethoxydim, which are post-emergence herbicides (24).

GLYPHOSATE (Roundup®) Glyphosate is a phosphorylated amino acid herbicide used for total vegetation control (24). Glyphosate is applied as a directed spray so that avocado foliage is not injured. The median price of glyphosate is \$10.95 per pound of active ingredient and the approximate cost per application is \$15.06 per acre (14). The REI for glyphosate is 12 hours (25).

In 1999-2000, 95 percent of surveyed avocado growers in Florida applied glyphosate either one (5 percent), two (5 percent), four (45 percent), five (20 percent), six (15 percent), seven (5 percent), or eight (5 percent) times for an average use of 3.9 times per season. In 1999, a total of 10,000 pounds of active ingredient were used an average of 4.2 times on 49 percent of the avocado acreage in Florida (23).

SIMAZINE (Princep®) Simazine is a triazine herbicide used in the management of certain grass and broadleaf weeds (24). It is generally applied to the soil once a year. The median price of simazine is \$4.16 per pound of active ingredient and the approximate cost per application is \$16.64 per acre (14). The REI for simazine is 12 hours (16). Based on survey results, 6 percent of avocado growers in Florida applied simazine to their acreage once per season.

PARAQUAT (Gramoxone®) Paraquat is a bipyridinium herbicide used for total vegetation

control (24). Paraquat is applied in a directed manner to avoid avocado foliage injury. The median price of paraquat is \$12.07 per pound of active ingredient and the approximate cost per application is \$11.31 per acre (14). The REI for paraquat is 12 hours when used as a post-directed spray (16). Based on survey results, 10 percent of avocado growers in Florida applied paraquat once per season.

Disease Management

Disease Pathogens

The principal diseases affecting avocado production in Florida include fungi, viroids, and algae. Depending on weather, *Phytophthora* root rot (*P. cinnamomi*) and seedling blight (*P. palmivora*, *P. parasitica*) may be particular concerns. Scab (*Sphaceloma perseae*), spot (*Cercospora purpurea*), anthracnose (*Colletotrichum gloeosporioides*), and wilt (*Verticillium albo-atrum*) are other fungal diseases which affect avocado production. Algal spot (*Cephaleuros virescens*) may become prevalent in late summer through late winter and there is also a sun blotch disease caused by a viroid, which may be latent for some time in the rootstock (26,27). Other diseases that intermittently affect avocado production are powdery mildew and stem-end rots.

AVOCADO ROOT ROT AND SEEDLING BLIGHT (caused by *Phytophthora* spp.) Signs of avocado root rot include small-leaf production and chlorosis on the leaves, which are prone to wilting. Leaf abscission is common and new growth is absent. Roots become blackened and brittle and the affected trees will often set a heavy crop of small fruit (27).

Irregular reddish-brown necrotic areas appear on new leaves in the case of seedling blight. The areas expand rapidly along the larger veins. Lesions on young leaves are dark in color and cause the leaves to twist and curl. Stem lesions are elongate, sunken, and dark in color as well (27).

SCAB (caused by *Sphaceloma perseae*) Scab is a pathogen of young leaves, with leaf resistance increasing greatly after one month of age.

Colonization is favored by cool, wet conditions. Signs of scab on leaves are small spots on the blade which turn from dark purple/brown to gray, often leaving a star-shaped shot-hole. Leaves may become distorted and twisted if the infestation is heavy. Lesions on petioles and twigs may be confused with scale insects upon first inspection. The avocado fruit become resistant to scab at about half size and it is prominent on fruit of susceptible varieties such as "Lula". On fruit, the spots are first oval, slightly raised, and purplish/brown. The spots form patches as they merge, and the centers of the spots may become sunken. A large portion of the fruit may become rough. Although the organism does not directly injure the fruit, entry points are created which fruit-rot organisms may colonize (26,27).

ANTHRACNOSE (caused by *Colletotrichum gloeosporioides*) Anthracnose appears to infect only the fruit portion of the avocado plant. It is a "weak" pathogen, requiring entry portals created by *Sphaceloma perseae* and *Cercospora purpurea*. Once the fruit is infected, however, the fungus rapidly degrades maturing fruit quality. Lesions become black and sunken, and a large portion of the fruit can also be overcome with the black decay. Pink spore masses may be observed as the fruit cracks (26,27).

CERCOSPORA SPOT (caused by *Cercospora purpurea*) *Cercospora* infection first appears as small, angular brown or purple spots on the leaves, with yellow halos around many of the lesions. The spots are less than 3 mm across but may overlap to form blotches of brown tissue. During rainy periods when the fungus is most likely to flourish, grayish spore masses may be seen on the surface of the spots with a hand lens. The fungus attacks fruit in a manner similar to that for leaves, except that fissures form in the spots that may lead to secondary infection (26).

ALGAL SPOT (caused by *Cephaleuros virescens*) This alga commences colonization late in the summer and progresses through the winter months. Initially hard to visualize, green, yellow-green, or rust colored leaf spots up to 5 mm in size become raised and roughly circular. As spots on the upper leaf surface age, turning whitish-gray, the lesion becomes visible on the bottom leaf surface, turning dark green or brown. Heavy infestation may

cause leaf drop. The alga eventually produces "spores" - which are rust colored. These will give rise to more algae if not controlled (26,27).

SUN BLOTCH The signs of this disease resemble sunburn. Leaves may exhibit white or pink mottling or variegation and distortion. Conspicuous, sometimes sunken, white or yellow streaking may be apparent on the bark of young twigs and stems. The fruit will develop a red streak or lesion that may be slightly sunken. Affected trees may be stunted or demonstrate willowy growth. The viroid that causes this disease may be transmitted by seed or by vegetative propagation (27).

VERTICILLIUM WILT (caused by *Verticillium albo-atrum*) This soil-borne fungus is more prevalent in trees planted in historic areas of solanaceous crop production. The fungus invades water-conducting structures in the roots, causing a persistent wilt. Brown or gray streaks may be observed in the vascular tissue, once the bark is peeled away. Leaves may die for lack of water, but remain attached for some time. Trees also may flush out with new shoots several months after collapse, apparently recovered from the infection (27).

Chemical Control

In 1999-2000, 100 percent of avocado growers surveyed reported fungicide use. Those survey respondents that provided damage estimates indicated that from 10 to 80 percent of the avocado crop would be lost to disease (n=8, mean of 35 percent). Statistical data for 1999 documented fungicide use on 97 percent of avocado acreage (23). Fungicides registered for use on avocado include mefenoxam (Ridomil Gold®), benomyl (Benlate®), fosetyl aluminum (Aliette®), copper (Kocide®/Basicop®), sulfur (Thiolux®), and folpet (for avocado scab only).

COPPER (Kocide®/Basicop®) Copper has long been used as a fungicide and can be applied in multiple forms (copper hydroxide, copper sulfate, etc.). Copper is used to manage anthracnose, scab, *Cercospora* spot, and algal spot (27). The median price of copper hydroxide is \$2.11 per pound of

active ingredient and the approximate cost per application is \$19.50 per acre (14,27). The PHI and REI for copper hydroxide are 0 day and 24 hours, respectively (19). Based on survey results, 100 percent of avocado growers in Florida applied copper either once (5 percent), twice (5 percent), three times (14 percent), four times (9 percent), five times (24 percent), six times (24 percent) or seven or more times (19 percent) per season for an average seasonal use of approximately 5 times. Statistical data documented 101,200 pounds of copper hydroxide (85 percent of the area treated an average of 6.1 times) and 2,900 pounds of copper sulfate (6 percent of the area treated an average of 5.3 times) used on Florida avocado trees in 1999 (23).

SULFUR (Thiolux®) As with copper, sulfur has long been used as a fungicide and can be applied in the form of copper sulfate or elemental sulfur. Sulfur is used to manage powdery mildew and anthracnose (as well as mites occasionally). The median price of sulfur is \$0.88 per pound of active ingredient and the approximate cost per application is \$14.78 per acre (14,27). The PHI and REI for sulfur are 0 day and 24 hours, respectively (28). Based on survey results, 33 percent of avocado growers in Florida applied sulfur either once (43 percent), twice (14 percent), three times (29 percent), or six times (14 percent) per season for an average seasonal use of 2.4 times. Statistical data documented 9,800 pounds of sulfur (20 percent of the area treated an average of 1.4 times) used on Florida avocado trees in 1999 (23).

MEFENOXAM (Ridomil Gold®) Mefenoxam is an acylalanine systemic fungicide used to manage *Phytophthora* root rot (17,27). The median price of mefenoxam is \$157.00 per pound of active ingredient and the approximate cost per application (Ridomil® Gold GR) for mature trees is \$500.73 per acre (14,16). The PHI and REI for mefenoxam are 28 days and 48 hours, respectively. The material is not to be used from November through February. Restrictions on application number and total pounds used per year exist for this product and vary based on the formulation (16). Based on survey results, 10 percent of avocado growers in Florida applied mefenoxam once or twice to the entire grove and 5 percent spot treated trees on an as-needed basis.

FOSETYL-ALUMINUM (Aliette®)

Fosetyl-aluminum (fosetyl-Al) is an aluminum ester of alkyl phosphonate used in the management of *Phytophthora* root rot (17,27). The median price of fosetyl-Al is \$13.44 per pound of active ingredient and the approximate cost per application is \$53.76 per acre (14,29). Restrictions include maximums of 4 applications per year and 16 pounds of active ingredient per acre per year. The PHI and REI for fosetyl-Al are both 12 hours (29). Based on survey results, 11 percent of avocado growers in Florida applied fosetyl-Al to their acreage once per season.

BENOMYL (Benlate®) Benomyl is a systemic, benzimidazole fungicide used to manage anthracnose, scab, *Cercospora* spot, and powdery mildew (17,27). The median price of benomyl is \$32.40 per pound of active ingredient and the approximate cost per application is \$32.40 per acre (14,30). The PHI and REI for benomyl are 30 days and 24 hours, respectively. There is a use restriction of three pounds of active ingredient per year (30). Based on survey results, 6 percent of avocado growers in Florida applied benomyl to their acreage three times per season. Benomyl production ceased in spring of 2001.

Alternative Chemicals

Few new alternative chemicals exist for use in avocados. Messenger® (harpin protein) is a product which is just now being assessed for disease management.

Post-Harvest Control

Careful handling during and after harvest, removal of infected avocados during grading, and adequate temperature maintenance can all aid in minimizing losses from post-harvest decays. In addition to the causative agent of anthracnose (*Colletotrichum gloeosporioides*), post-harvest disease organisms that can cause rotting (especially in immature fruit) include *Diplodia natalensis*, *Dothiorella* spp., and *Lasiodyplodia* spp. (27).

Nematode Management

Nematode Pests

Plant-parasitic nematodes are microscopic roundworms, found in soils, which primarily attack plant roots. General signs of nematode damage include stunting, premature wilting, leaf yellowing, root malformation, and related symptoms characteristic of nutrient deficiencies. Stunting and poor stand development tend to occur in patches throughout the field as a result of the irregular distribution of nematodes within the soil. Species of nematodes reported to be associated with affected avocado trees include *Radopholus similis*, *Pratylenchus brachyurus*, and *Rotylenchus reniformis* (31).

Chemical Control

The only "nematicides" registered for use on avocado in Florida are Messenger® (harpin protein) and Aza® (azadirachtin). These products have recently been registered and are just now being assessed for nematode management. Harpin protein activates the systemic acquired resistance of a plant, using the endogenous "immune" system of the plant to ward off nematode attack. Azadirachtin is generally accepted as an insecticide, and little data exist that gauges the efficacy of this material against nematodes.

Other Pests

In addition to insects, weeds, diseases, and nematodes, avocado fruit can be damaged by slugs/snails and rodents. There are currently two active ingredients registered for slug/snail control in Florida avocado groves. These two active ingredients are metaldehyde and a phosphoric acid/iron mixture. Five percent of the avocado growers surveyed employed a metaldehyde bait to control slugs/snails in their grove once a season. There are no rodenticides actively registered for use in Florida avocado groves.

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