Florida Crop/Pest Management Profile: Squash[1]

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Production Facts

- Florida is ranked second nationally in the production of fresh market squash (2).
- Florida squash growers produce primarily summer squashes (Cucurbita pepo), such as crookneck squash, straightneck squash, scallop squash, and zucchini squash. Growers also produce some winter squashes (4), such as acorn (C. pepo), butternut squash (C. moschata), and spaghetti squash (C. pepo). There is some commercial production of calabaza or Cuban squash (Cucurbita moschata) in South Florida, and Floridians produce a variety of tropical squashes and related cucurbits [such as pumpkin (Cucurbita spp.), chayote (Sechium edule), banana squash (Cucurbita maxima), and gourds (Lagenaria spp. and Luffa spp.)] in home gardens, but this profile includes only summer and winter squashes (12,13,14,15,16).
- Cash receipts for squash produced in Florida in 1999-2000, which totaled $45.9 million, accounted for approximately 20 percent of the total U.S. cash receipts for squash production (2,8).
- Of Florida's vegetable crops, squash is ranked 6th in terms of harvested acres and 7th in terms of total value (4).
- During the 1999-2000 crop year, Florida squash growers planted 12,100 acres and harvested 11,800 acres, producing a total of 3.45 million bushels (145 million pounds). Average yield was 293 bushels per acre (12,310 pounds per acre) and total value of the crop was $45.9 million. During the previous year, 13,000 acres of squash were planted and 3.53 million bushels (148 million pounds), with a total value of $53.8 million, were produced on 12,600 harvested acres, yielding 280 bushels per acre (7).
- In 1997, there were 293 squash producing farms in Florida (6). Of those farms, 43.1 percent produced squash on less than 5 acres, as a group representing 2.0 percent of the state's total squash acreage. An additional 34.5 percent maintained between 5 and 24.9 acres of squash (representing 9.8 percent of the state's squash acreage), 6.1 percent planted between 25 and 49.9 acres (5.5 percent of acreage), 8.5 percent planted between 50 and 99.9 acres (15.4 percent of acreage), and 7.8 percent planted greater than 100 acres (67.3 percent of acreage).
- Nearly the entire squash crop in Florida is produced for the fresh market (9). Although summer production is mainly for local markets, squash is one of the few crops in the state that is shipped every month of the year (17). Fall shipments to markets outside Florida peak in November or December and spring shipments peak in April or May (4).

1. This document is CIR1265, one of a series of the Agronomy, UF/IFAS Extension. Original publication date June 2001. Revised August 2004. Reviewed August 2014. Visit the EDIS website at http://edis.ifas.ufl.edu.

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- The average price paid to Florida's squash growers during the 1999-2000 season was $13.29 per bushel, down from the 1998-99 seasonal average of $15.25 per bushel (7).
- The total estimated cost for the production of summer squash in the Dade County area in 1999-2000 was $4,093 per acre. Harvest and marketing costs represented $1,950 of that, with pre-harvest costs totaling $2,143 per acre. Operating costs totaled $1,223 per acre, $208 of which was for fungicides and $158 of which was for insecticides (3).

Production Regions

Squash is produced throughout the state of Florida. Southeast Florida (Miami-Dade County) is the principal squash-producing region in the state as well as a national leader in squash production (2). In 1997, 13 percent of Florida's squash farms and 59 percent of the squash acreage was located in Miami-Dade County. Other important squash producing regions include southwest Florida, west-central Florida, and north Florida. Southwest Florida (Lee, Hendry and Collier counties) accounted for 4.7 percent of the state's squash producing farms and 13.5 percent of total squash acreage in 1997. Thirty percent of the state's squash-producing farms and 11.6 percent of total squash acreage was located in west-central Florida (Hillsborough, Hardee, and Manatee counties) in 1997. North Florida (Alachua, Columbia, and Gilchrist counties) accounted for 11.6 percent of squash-producing farms and 4.4 percent of total squash acreage (6).

Production Practices

Squashes are warm season plants that are somewhat adapted to cool conditions. They tolerate monthly mean temperatures from 18 to 27°C (64 to 80°F), but grow best when temperatures are between 75 and 85°F (24 and 29°C) during the day and between 60 and 70°F (16 and 21°C) at night. Temperatures below 40°F (4.4°C) for several days can severely injure the plant, and temperatures above 85°F (29°C) will result in blossom drop and the production of small fruit (18,20).

Squash grows best in a fertile, well-drained soil with a pH between 6.5 and 7.5 (18). In the Homestead area (Miami-Dade County), where the majority of the state's squash production occurs, soils are principally marl rock. Squash production in the rest of the state is mainly on deep, sandy soils (20).

Squash cultivars were originally all vining in habit, but present cultivars have either vining or spreading growth habits, and the newest cultivars have a dwarf or bush growth habit for ease of cultivation in beds (18). Squash in Florida is largely direct seeded/transplanted, although some of South Florida squash (10 percent) is grown using plastic mulch (20,53). Growers who plant squash as part of a double-cropping system will plant it on the mulched bed following a high-value crop like tomato, pepper, or eggplant. In that case, the bed has been previously fumigated with methyl bromide, the effect of which generally carries over to the squash crop. When squash is the first crop of the season, it may be directly planted without mulch, planted on newly laid plastic-mulched beds, or planted on old plastic which has been over-summered (9).

Squash is planted in Florida between August 15 and April 1. Growers in South Florida, where frost is not a danger, plant anytime from August to March, while in North and Central Florida, fall planting occurs in August and September. Squash growers plant the spring crop between February and April in North Florida, once most frost danger has passed, and between January and April in Central Florida (2,19). Bush varieties, which require 40 to 65 days from seed to maturity, are planted at a depth of 1.0 to 1.5 inches (2.5 to 3.8 cm) and a spacing of 36 to 48 inches (91 to 122 cm) between rows and 12 to 24 inches (30 to 61 cm) between plants. When planted in beds under mulch, squash is grown in two rows per bed with 12 to 18 inches (30 to 46 cm) between rows. Plant population under closest spacing is 14,520 plants per acre. Vining varieties, which require 85 to 120 days from seed to maturity, are planted at a depth of 1.5 to 2.0 inches (3.8 to 5 cm) and a spacing of 60 to 108 inches (152 to 274 cm) between rows and 36 to 60 inches (91 to 152 cm) between plants. Plant population of vining varieties under closest spacing is 2,904 plants per acre (19).

Squash requires approximately one inch (2.5 cm) of water weekly, either from rain or irrigation (18). Nationally, 75 percent of squash-producing farms are irrigated, and 94.5 percent of squash acreage is irrigated in Florida (6).

Squashes are annual plants, with male and female flowers on the same plant. For the female flowers to produce fruit, pollen from the male flower must be transferred to the female flower by insects. Growers pay to have bee colonies left in their squash fields during the flowering period, which usually lasts one month but may continue up to six weeks. Some growers plant successively over a period of four to five weeks, which prolongs the overall flowering period for their fields. Generally, satisfactory pollination occurs when one strong hive is present for every two acres of squash. Flowers of squash and other cucurbits open just after sunrise and close in the late afternoon or early evening. Therefore, pesticide applications to the squash crop during flowering must be made before sunrise or after dark to avoid negatively affecting bee activity (11,18,19).

Growers in Florida harvest squash from September 1 to July 1, with the most active time of harvest occurring from mid-November to mid-May (2). Winter squashes are harvested once, when mature, often after the plant is dead. Summer squash, which must be harvested when immature, is picked by hand in multiple harvests (usually from 4 to 10), approximately every two to three days. New female flowers are produced and fruit set in response to squash removal. The plant ceases to produce new fruit when some have matured and produced seed (usually three to four weeks). Maximum quality is obtained from summer squash that have tender skin and only partially developed seeds. Harvesting of smaller fruit is therefore necessary for quality, and the maximum recommended length of zucchini and yellow straightneck squashes is about 6 inches (15 cm). The skin and seeds become tough if the squash grows beyond that size, and large squash may be reduced in value or rejected in the market (17,18).

With respect to labor activities associated with the crop, most are non-worker related. Seeds and fertilizer are mechanically planted/applied, scouts access the fields at appropriate times, and applications are done either aerially or by ground equipment. Workers have contact with the squash crop only at harvest. Since squash is planted in staggered stages for an approximate ten-month production window, these workers are largely harvesting continuously at a rate relative to market activity. Many wear gloves to protect their hands and the fruit (53).

Squash is easily damaged during the harvest process, and any punctures or abrasions leave it more susceptible to post-harvest decay. Pickers usually place the squash in plastic buckets, which are less likely to damage the product and can be disinfected to minimize the spread of post-harvest diseases and food-borne illness pathogens. Bacterial soft rot can also be minimized by removing part of the stem with the fruit when picking. Obvious culled fruits are left in the field during the harvest and remaining culls are removed on the packing line (11,17).

In Florida, summer squash is washed and packed directly in the field or in packing houses. When field packed, immediately after harvesting the squash is washed in a vat of water, to which a soap or bleach solution has been added. The vats are held on large wagons brought into the field for the harvesting process. After the squash is washed, packers on the wagons grade it during the packing process. Florida squash is packed in 24-pound cartons or 20- and 28-pound crates/fiberboard boxes and shipped immediately (9,17,20).

Summer squash is highly perishable, and under ideal conditions [42 to 50°F (5.5 to 10°C) and 90 to 95 percent relative humidity], maximum storage life is two weeks. Storage time is maximized by removing field heat after harvest by cooling squash to 42°F (5.5°C) with hydrocooling or forced-air cooling. At temperatures below 40°F (4.4°C), chilling injury occurs. Squash is also susceptible to water loss, which can be minimized by storage under conditions of high relative humidity or by waxing (17).

The thick rind on winter squashes allows for storage of up to six months. After harvest, winter squashes are cured to heal any damage to the rind. Curing involves storage for 10 days at a temperature from 27 to 30°C (80 to 86°F) and 80 percent relative humidity (18). Both winter and summer squashes are shipped by refrigerated trucks to wholesale markets or retail stores (20).

Insect/Mite Management

Insect/Mite Pests

The principal pests on squash in Florida are the silverleaf whitefly, pickleworm, melonworm, squash bug, leafminers, and aphids. Minor and occasional pests include melon thrips, stink bugs, squash vine borer, southern armyworm, banded cucumber beetle, and two-spotted spider mite. Insects and mites that may occasionally be seen on squash but are not economically damaging include garden fleahoppers, fruit flies, spotted cucumber beetle, striped cucumber beetle, potato leafhopper, broad mite, leaffooted bug, western flower thrips, sweetpotato whitefly, greenhouse whitefly, cutworms, ants, cabbage looper, field crickets, other armyworms (fall armyworm, beet armyworm, yellow-striped armyworm), flea beetles, grasshoppers, lygus bugs, saltmarsh caterpillar, squash beetle, tobacco budworm, and wireworms (9,11,22,23,42). In general, insect pest populations tend to be greater on fall-planted than on spring-planted squash in Florida (50).

Silverleaf Whitefly (*Bemisia argentifolii*). The silverleaf whitefly, previously known as strain B of the sweetpotato whitefly (Bemisia tabaci), causes the silverleaf disorder of squash. The whitefly was a minor pest before 1987, when outbreaks were first observed in a poinsettia greenhouse and later in tomato and squash fields in Palm Beach County. Since then, the silverleaf whitefly has caused economic damage to a number of vegetable crops throughout the state, especially tomato and squash. All types of squash are susceptible to the silverleaf disorder, but it has not been seen on other cucurbits such as muskmelon, cucumber, or watermelon (44,45).

Silverleaf signs on squash leaves occur only on the upper surface, beginning as a lightening of the leaf veins. Veins begin to appear silver, and under severe infestations, the entire upper leaf surface eventually turns silver. In such severe cases, all leaves on a plant may be affected, and the plant may be stunted, reducing fruit production. Silverleaf signs have been observed on plants as young as those with only three true leaves, to plants already producing fruit. Severe leaf silvering affects fruit quality, making yellow summer squash paler in color, zucchini squash light- to yellowish-green, acorn squash a mottled green or yellow, and golden acorn squash white. During the initial outbreaks of silverleaf in South Florida, greatest damage occurred in acorn squash. Reduced fruit quality and in some cases complete yield loss have caused severe economic damage to squash growers in the state (44,45,46,47).

Researchers first recognized the relationship between silverleaf symptoms on squash and feeding by whitefly nymphs (an immature stage) of the silverleaf whitefly in 1990. Tests on affected plants eliminated viruses as the cause of silvering and suggested that feeding by nymphs on the squash plant causes inhibition of plant hormones that results in silvering. The plant's physiological response to whitefly feeding can be intensified by stress factors, such as low soil moisture or high light intensity. Damage is produced by nymphs and not by adults. Feeding by nymphs on lower leaves induces the disorder systemically on young, developing leaves. When whitefly nymphs are removed from plants with silverleaf either physically or insecticidally, new growth does not show silverleaf symptoms; however, affected leaves remain silvered (46,47,52).

Whiteflies generally present a greater problem during the fall squash crop, particularly in North Florida, since whitefly populations peak there during the fall (20,51). In West-central Florida, sticky trap catches of adult silverleaf whiteflies have been greatest in the early summer and late fall. Research in Southwest Florida has shown that whitefly populations build up on crops, commonly peaking at harvest as the whitefly migrates from crop to crop throughout the year. With a host range of over 500 species of plants, the silverleaf whitefly has been observed to reproduce on at least 15 crops and 20 weed species in Florida. However, weeds generally support only low populations of whiteflies during fallow periods, apparently due to attack by natural enemies (48,49).

Female whiteflies lay stalked, cigar-shaped eggs deposited singly on the undersides of leaves. The nymphs go through four instars. The first instar or "crawler" has well-developed legs and is the only mobile immature life stage. After finding a suitable feeding site on the lower surface of a leaf, the crawlers insert their mouthparts, begin feeding, and usually do not move again. The subsequent instars are flattened, oval scales and the final resting, or pupal stage is more convex and elliptical with large, conspicuous red eyes (47). Development time from egg to adult is about three weeks at 80°F (27°C).

Pickleworm (*Diaphania nitidalis*). Pickleworm is a tropical moth that is capable of overwintering in South Florida during normal conditions and may overwinter as far north as Orlando when winters are mild. However, pickleworm is highly dispersive, infesting much of the Southeast each summer. The moths commence flying between three and five hours after sundown, with peak activity around midnight.

Pickleworm can complete a life cycle in approximately 30 days, and up to four generations per season have been documented in Georgia. The wingspan is about 3 cm, with the central portion of the front and hind wings a transparent yellow, bordered by dark brown. The adult moths are generally not found in the field during the day, instead residing in woods or weedy areas. Female moths lay 300 to 400 eggs (0.8 mm in length) in clusters at points of active plant growth. The eggs are initially white but turn yellow after 24 hours and hatch in four days.

The larvae go through five instars with a development time of two weeks and may reach a length of 2.5 cm in the fifth instar. The first four instars are white-colored with black or gray spots. The spots are lost at the final instar, with color dictated by diet. Pupation often occurs in a leaf fold, and no cocoon is apparent.

Summer squash is a favored food source for the pickleworm. Young larvae preferentially feed on the blossoms, and may stay within this structure throughout the larval stage. However, larvae do burrow and feed on squash fruit and the apical portions of vines when blossoms and fruit are gone. The burrowing and associated frass make the fruit unmarketable (55).

Melonworm (*Diaphania hyalinata*). Melonworm is another tropical moth that is capable of overwintering in South Florida, and it also infests much of the Southeast each summer. Melonworm can complete a life cycle in approximately 30 days, and up to three generations per season have been documented. The wingspan is about 2.5 cm, pearly white centrally and slightly iridescent, with a broad band of dark brown around the perimeter. Unlike the pickleworm, melonworm moths are found in the field during the day, and will fly short distances when disturbed. Female moths lay eggs (0.7 mm in length) in clusters of two to six. The eggs are initially white or greenish, but turn yellow shortly after laying, and hatch in three or four days.

The larvae go through five instars with a development time of two weeks and may reach a length of 1.6 cm in the fifth instar. The first instar is colorless, but by the second instar, the larvae assume a pale yellow-green color and construct a loose silken structure under leaves which serves to shelter them during the daylight hours. At the fifth instar, two lateral white stripes appear which run the length of the larvae. These stripes disappear just prior to pupation, when the larva spins a loose cocoon on the host plant, often folding a leaf over for added shelter.

Melonworm feeding is restricted to cucurbits. The preferred genus is Cucurbita (squash and pumpkin) but Cucumis species (cantaloupe and cucumber) are also attacked. The larvae preferentially feed upon foliage of favored plants, often the young leaves of vegetative buds, leaving the veins and creating a lace-like appearance. A study in Florida addressing melonworm damage in summer squash ascribed 23 percent loss to indirect damage (foliage feeding) and 10 percent loss to direct damage (blemished squash) (56).

Squash Bug (*Anasa tristis*). Squash bugs are small, brownish-black insects with a shield-shaped back. The squash bug causes severe damage to cucurbits because it secrets highly toxic saliva into the plant. The foliage is the primary site of feeding but the fruit is also fed upon. The foliage wilts, becomes blackened, and dies following feeding. This malady is sometimes called "anasa wilt." Often an entire plant or section of plant perishes while nearby plants remain healthy. The amount of damage occurring on a plant is directly proportional to the density of squash bugs (20).

Aphids (*Myzus persicae, Aphis gossypii, Aphis craccivora*, others). Aphids common in vegetable production areas vary in color and size (1-2 mm), but have in common the ability to reproduce rapidly (one generation per week under optimum conditions). In Florida, sexual reproduction is not required for population increases as the female aphid reproduces asexually. The young are flightless, except under stress conditions, when winged forms are produced. Non-winged aphids are tear-drop shaped with projections (cornicles) on the dorso-posterior of the body.

Aphid feeding in the phloem causes direct plant damage. The saliva injected during feeding may cause the foliage to become twisted, curled, or cupped downward. A large aphid infestation may cause plants to gradually wilt, turn yellow or brown, and die. Indirect damage also occurs through the excretion of excess sugar as honeydew, which accumulates on the upper surfaces of leaves and supports the growth of sooty mold.

In addition to the damage caused by feeding, aphids can transmit viruses. Several viruses common to cucurbit plants are cucumber mosaic virus, watermelon mosaic virus 2, and zucchini yellow mosaic virus. The three aphids named are capable of growth and reproduction on cucurbit plants, but other species may serve as virus transmitters in crops such as squash. This process may only take seconds, as the aphid probes the plant to determine suitability. Consequently, insecticides may have little effect on virus transmission.

Aphids in Florida are naturally controlled by parasitic wasps, ladybird beetle larvae, and syrphid fly larvae. However, if non-selective insecticides are used, these natural enemies may be killed, leaving surviving populations to expand unchecked. Since aphids feed on new growth and the underside of leaves, insecticidal sprays often do not penetrate to the location of the infestation. Additionally, resistance to the major insecticide groups (chlorinated hydrocarbon, organophosphate, carbamate, and pyrethroid) has been documented for some species, probably as a result of the short generation time for these insects (57,58,59).

Leafminers (*Liriomyza trifolii, Liriomyza sativae*). Leafminers are present throughout the growing season, and have a very broad host range including eggplant, celery, spinach, lettuce, melons, cucumber, pumpkin, okra, tomato, pepper, potato, and carrot (22). The adult fly is tiny, and black and yellow in color. The larva is yellow, 1/8 inch long, and lives within the leaf, where it consumes tissue and creates opaque serpentine patterns. Egg to adult life cycle is less than three weeks under optimum conditions; thus, many generations may occur within a year. Young plants are most susceptible to damage.

Melon Thrips (*Thrips palmi*). The melon thrips has caused economic losses in a number of vegetable crops since it was first reported in South Florida (Dade County) in 1990. In addition to attacking squash and other cucurbits such as watermelon, cucumber, and cantaloupe, the melon thrips has severely infested eggplant, pepper, and succulent bean in south Florida. Both adult and immature thrips feed on leaves, stems, flowers and fruit. Feeding damage in squash commonly results in deformation and discoloration of the fruit (10).

Stinkbug (*Nezara viridula*). The southern green stink bug is a sporadic problem for squash producers (9). Both immature and adult bugs feed with piercing-sucking mouthparts. All plant parts are likely to be fed upon, but growing shoots and developing fruit are preferred. Attacked shoots usually wither, or in extreme cases may die. Signs of damage on fruit from the feeding punctures are hard brownish or black spots. These punctures affect the fruit's edible qualities and lower the market value. Young fruit growth is retarded and it often withers and drops from the plant (22).

Southern Armyworm (*Spodoptera eridania*). The forewings of the mature armyworm moth are gray and brown, with irregular dark brown and black markings. Larvae are defoliators and feed gregariously while young, often skeletonizing leaves. As they mature they become solitary and may feed on the surface of fruit. When stressed by a lack of food, they will eat the apical portions of branches and bore into stem tissue (22).

Banded Cucumber Beetle (*Diabrotica balteata*). The adult beetle is green with three transverse yellowish-green bands running across the back. Feeding damage may occur to foliage, blossoms, fruit, and roots. Larvae feed only on the roots. The most frequent forms of serious injury are defoliation by adults and root feeding on plant seedlings by larvae. Banded cucumber beetle is known as a vector of virus diseases in beans, and larval feeding might increase the incidence and severity of Fusarium wilt (20).

Twospotted Spider Mite (*Tetranychus urticae*). The twospotted spider mite is oval in shape, about 0.5 mm long, and may be brown or orange-red, but a green, greenish-yellow or an almost translucent color is the most common. All mites have needle-like piercing-sucking mouthparts. Spider mites feed by penetrating the plant tissue with their mouthparts and are typically found on the underside of the leaf. Spider mites spin fine strands of webbing on the host plant- hence their name. When twospotted spider mites remove the sap, the mesophyll tissue collapses and a small chlorotic spot forms at each feeding site. Continued feeding causes a stippled-bleached effect on the upper surfaces of leaves and later, the leaves turn yellow, gray or bronze. Complete defoliation may occur if the mites are not controlled (22).

Chemical Control

In 1999, 90 percent of responding squash growers surveyed reported insecticide use on 100 percent of their crop.
In 2000, a total of 16,100 pounds of conventional active ingredient were used to control insects in Florida squash (1). Additionally, 6,900 acres of squash were treated with B.t. materials (total amount of active ingredient unknown). Insecticides and miticides registered for use on Florida squash include abamectin (Agri-Mek®), azadirachtin (Azatin®), B.t. (Bacillus thuringiensis), buprofezin (Applaud®), carbaryl (Sevin®), diazinon, endosulfan (Thiodan®/ Phaser®), esfenvalerate (Asana®), cyromazine (Trigard®), dicofol (Kelthane®), thiamethoxam (Actara®/Platinum®), malathion, fenpropathrin (Danitol®), methomyl (Lannate® - summer squash only), naled (Dibrom® - summer squash only), insecticidal oil (Sun Spray®), oxamyl (Vydate®), oxydemeton-methyl (Metasystox-R®), permethrin (Ambush®/ Pounce®), insecticidal soap (M-Pede® - summer squash only), cryolite (Kryocide®), pyrethrin plus rotenone (Pyrellin®), pyrethrin plus piperonyl butoxide (Pyrenone®), spinosad (SpinTor®), imidacloprid (Admire®/Provado®), bifenthrin (Capture®), and pymetrozine (Fulfill®) (19).

Methomyl (Lannate®). Methomyl is a broad-spectrum carbamate insecticide used to manage caterpillars and beetles. The median price of methomyl is $25.12 per pound of active ingredient (ai) and the approximate cost per labeled application (0.33 lb ai/A) is $8.29 per acre (23,54). Methomyl may be applied either one or three days before harvest (PHI= 1 or 3 days depending on rate), and the restricted entry interval (REI) under the Worker Protection Standard is 48 hours. No more than 12 applications may be made to the crop and the material limit is 5.4 lb/ai/acre/crop.

In 1999, 20 percent of surveyed squash growers in Florida applied methomyl to 100 percent of their acreage 2 or 3 times per season. In 2000, a total of 4,600 pounds of methomyl were used on 45 percent of the squash grown in Florida an average of 2.2 times per crop (1).

Endosulfan (Thiodan®). Endosulfan is a cyclodiene chlorinated hydrocarbon insecticide/miticide used to manage aphids, beetles, caterpillars, squash vine borer, whiteflies, and squash bug. The median price of endosulfan is $15.02 per pound of active ingredient and the approximate cost per labeled application (1.0 lb ai/A) is $15.02 per acre (23,54). The PHI and REI for endosulfan are 2 days and 24 hours, respectively. No more than six applications can be made per year and there is a material limit of 3 pounds of active ingredient per year.

In 1999, 20 percent of squash growers in Florida applied endosulfan to 100 percent of their acreage 1 to 6 times per season. In 2000, a total of 11,500 pounds of endosulfan were used on 43 percent of the squash grown in Florida an average of 3.5 times per crop (1).

Bacillus Thuringiensis. The biopesticide *Bacillus thuringiensis* (*B.t.*) is an important management tool for Florida squash growers who use it yearly to manage melonworm and rindworm complex (beet and fall armyworms, cabbage looper, cutworms and other caterpillars that feed on the squash rind). The median price of *B.t.* is $158.12 per pound of active ingredient (54). B.t. may be applied up to the day of harvest (PHI= 0 day), and the REI is 4 hours.

In 1999, 50 percent of squash growers in Florida applied B.t. to 100 percent of their acreage 1 to 6 times per season. In 2000, a total of 6,900 acres (60 percent) of Florida-grown squash were treated with B.t. an average of 3.1 times per crop (1).

Oxamyl (Vydate®). Oxamyl is a carbamate insecticide/nematicide that has contact and systemic activity. The compound is used to manage whiteflies, aphids, and leafminers. The median price of oxamyl is $35.23 per pound of active ingredient and the approximate cost per labeled application (1.0 lb ai/A) is $35.23 per acre (23,54). The PHI for oxamyl is 1 day and the REI is 48 hours. The material limit is 6 lb ai/acre/crop. In 1999, 20 percent of squash growers in Florida applied oxamyl to 100 percent of their acreage up to 6 times per season.

Permethrin (Ambush®/Pounce®). Permethrin is a pyrethroid insecticide that has contact and stomach activity. The compound is used to manage all squash arthropods other than mites. The median price of permethrin is $56.32 per pound of active ingredient and the approximate cost per labeled application (0.20 lb ai/A) is $11.26 per acre (23,54). The PHI for permethrin is 0 day, and the REI is 12 hours. The material limit is 1.6 lb ai/acre/crop. In 1999, 30 percent of squash growers in Florida applied permethrin to 100 percent of their acreage 2 or 3 times per season.

Cyromazine (Trigard®). Cyromazine is a triazine compound that inhibits insect growth and it is mainly used to manage leafminers. The median price of cyromazine is $188.00 per pound of active ingredient and the approximate cost per labeled application (0.125 lb ai/A) is $23.50 per acre (23,54). The PHI for cyromazine is 0 day and the REI is 12 hours. In 1999, 10 percent of squash growers in Florida applied cyromazine to 100 percent of their acreage at least one time per season.

Azadirachtin (Azatin®). Azadirachtin is a natural compound derived from the neem tree (Azadirachta indica) that has insect growth regulator activity. The compound is used to manage whiteflies, caterpillars, leafminers, and squash bug. The PHI for azadirachtin is 1 day and the REI is 4 hours. In 1999, 10 percent of squash growers in Florida applied azadirachtin to 100 percent of their acreage 6 times per season.

Malathion (Malathion®). Malathion is an organophosphate insecticide that is used to manage beetles, aphids, pickleworm, mites, squash vine borer, and leafminers. The median price of malathion is $5.44 per pound of active ingredient and the approximate cost per labeled application (0.53 lb ai/A) is $10.20 per acre (23,54). The PHI for malathion is 1 day and the REI is 12 hours. In 1999, 10 percent of squash growers in Florida applied malathion to 100 percent of their acreage 5 times per season.

Carbaryl (Sevin®). Carbaryl is a carbamate insecticide used to manage caterpillars, beetles, leafhoppers, and squash bug. The median price of carbaryl is $7.17 per pound of active ingredient and the approximate cost per labeled application (1.0 lb ai/A) is $7.17 per acre (23,54). The PHI for carbaryl is 0 day and the REI is 12 hours. In 1999, 10 percent of squash growers in Florida applied carbaryl to 100 percent of their acreage 3 times per season.

Pyrethrins + Rotenone (Pyrellin®). These two natural compounds both have contact and stomach activity. The mixture is used to manage aphids, beetles, leafhoppers, leafminers, mites, bugs, whiteflies, and thrips. The PHI for the mixture is 0 day and the REI is 12 hours. In 1999, 10 percent of squash growers in Florida applied Pyrellin® to 100 percent of their acreage 4 times per season.

Alternative Chemicals

In an evaluation of several control measures, the use of Bacillus thuringiensis and mineral oil formulations, both of which are compatible with biological control, showed promise for the management of the major insect pest complex of squash in Florida (42).

Cultural Control

Based on survey results, 10 percent of squash growers reported modifying planting dates, 20 percent adjusted fertilizer rates to avoid favorable insect conditions, 30 percent used insect-resistant varieties, and 40 percent managed pests in ditch banks and non-crop areas. Fifty percent of the growers used rotational/alternate crops and identified/conserved beneficial insects. Eighty percent cited destruction of crop residues to make this the predominant form of cultural insect control. Providing maximum separation between spring and fall crops also helps to minimize survival of whiteflies during the summer (49).

Biological Control

None of the surveyed squash growers reported the use or release of biological control organisms. However, research has been conducted to evaluate squash insect biocontrol.

Silverleaf Whitefly. Between 1990 and 1994, Florida's Biological Control Quarantine Laboratory, Division of Plant Industry imported 15 parasites of the silverleaf whitefly from India, Sudan, Guatemala, Israel, and Hong Kong. Field releases of seven of those parasites were made during that time, including releases of Amitus bennetti, three species of Eretmocerus, and two species of Encarsia. Most were recovered several weeks after their release, having suppressed silverleaf whitefly populations in various areas throughout the state. Some parasites were observed several months after their release, but permanent establishment was not confirmed. Biological control specialists at the Division of Plant Industry have continued to study additional parasites as potential biological controls for the silverleaf whitefly in Florida (43).

Pickleworm and Melonworm. Parasitism of pickleworm and melonworm by native species in South Florida is not sufficient to maintain the pests below economically damaging levels. Researchers in Florida have identified the introduced braconid parasitoid wasp Cardiochiles diaphaniae as a promising biological control agent if it can be established in South Florida, where the pests overwinter. Preliminary research has been conducted on the parasite-host relationship to determine potential hosts in the field and most effective rearing methods (40). Releases have been made, but establishment has yet to be documented (22).

Researchers have also tested insect-infecting (entomopathogenic) nematodes (e.g. Steinernema carpocapsae) for their effectiveness in managing the pickleworm. At the rate of one billion per acre, nematode treatment was as effective as treatment with permethrin, except under high pickleworm populations, when neither treatment was completely effective. The nematodes were able to enter tightly closed buds and blossoms to kill young pickleworm larvae before they moved to the fruit. Variability in yields did not permit adequate evaluation of yield effects, but the researchers considered the use of these nematodes in pickleworm management to be promising (41).

Weed Management

Weed Pests

Weeds can reduce squash yields by competing for light, water, and nutrients. The effect on the squash plant is greatest early in the season, at which time weed management is most critical. Late season weeds can also affect yield by reducing efficiency of harvest operations (21). Weeds are a greater problem in open-grown squash than in mulched bed production where fumigation by methyl bromide has occurred in previous crops. A healthy squash crop generally grows quickly and is able to out-compete weeds (11).

Individual weed species will vary from year to year and from region to region within the state. However, grasses are generally the major weed problem in squash production, the two most important being goosegrass and southern crabgrass (5). Pigweed, lambsquarters, Florida pusley, purslane and nutsedges (yellow and purple) are also common weeds in squash production (5,9).

Goosegrass (*Eleusine indica*). Goosegrass is a summer annual that is found throughout the state (5). The grass is consequently a weed in all of Florida squash production.

Southern Crabgrass (*Digitaria ciliaris*). Southern crabgrass is a summer annual that poses problems largely in the northern parts of Florida (5).

Amaranths (*Amaranthus* spp). In the principal squash-producing region of the state (Dade County) spiny amaranth (Amaranthus spinosus) and smooth amaranth (Amaranthus hybridus) are the principal amaranth (pigweed) species. Livid amaranth (Amaranthus lividus) occurs in other parts of the state (5).

Lambsquarters (*Chenopodium album*). This summer annual is a potential weed in squash throughout the state (5).

Florida Pusley (*Richardia scabra*). This summer annual has a prostrate growth pattern and weak stems. It is ubiquitous throughout the state, and consequently a potential weed in squash production (5).

Purslane (*Portulaca oleracea*). This summer annual also has a prostrate growth pattern and fleshy, succulent leaves. Distribution and potential are similar to Florida pusley (5).

Nutsedges (*Cyperus esculentus, Cyperus rotundus*). Both yellow (*C. esculentus*) and purple (*C. rotundus*) nutsedge are potential problems in squash production. These plants are able to penetrate through plastic mulch and compete with squash plants for nutrients, light, and water (5).

Chemical Control

Few herbicides are labeled for use on squash. Most are non-selective herbicides used to control weeds in row middles. In 1999, 50 percent of squash growers surveyed reported herbicide use on 100 percent of the crop. Ten percent reported use on 50 percent of their squash crop, and 40 percent used no herbicide at all. In 2000, a total of 300 pounds of active ingredient were used to control weeds in Florida squash (1). Non-selective herbicides labeled for use in Florida squash include glyphosate (Roundup®), paraquat (Gramoxone®), pelargonic acid (Scythe®), and diquat (Diquat®). Selective herbicides labeled for squash in Florida include bensulide (Prefar®), clomazone (Command®/Strategy®), ethalfluralin (Curbit®), and sethoxydim (Poast®). Bensulide and ethalfluralin are pre-emergence compounds and sethoxydim is a post-emergence herbicide (19). As of October, 2002, clethodim and halosulfuron-methyl were registered for squash but products labeled for use on squash were not available in Florida.

Bensulide (Prefar®). Bensulide is used in the management of germinating grasses such as crabgrass, goosegrass, and fall panicum (Panicum texanum). Bensulide is applied pre-plant with incorporation into the soil (19). The median price of bensulide is $13.09 per pound of active ingredient and the approximate cost per labeled application (6.0 lb ai/A) is $78.54 per acre (19,54). The REI for bensulide is 12 hours.

Based on survey results, 30 percent of squash growers in Florida applied bensulide to 100 percent of their acreage 1 or 2 times per season.

Paraquat (Gramoxone®). Paraquat is used for total vegetation control. Paraquat is applied before crop transplant or post-transplant with a shielded sprayer (19). The median price of paraquat is $12.07 per pound of active ingredient and the approximate cost per labeled application (0.94 lb ai/A) is $11.34 per acre (19,54). The REI for paraquat is 12 hours when used as a post-directed spray and 24 hours when the material is used as a harvest aid or plant desiccant. Based on survey results, 20 percent of squash growers in Florida applied paraquat to 100 percent of their acreage 1 time per season and 10 percent of the growers applied paraquat to 50 percent of their acreage 1 time per season. In 2000, a total of 300 pounds of paraquat were used on 2 percent of the squash grown in Florida an average of once per crop (1).

Glyphosate (Roundup®). Glyphosate is another herbicide used for total vegetation control. Glyphosate is applied before crop transplant or post-transplant with a shielded sprayer (19). The median price of glyphosate is $10.00 per pound of active ingredient and the approximate cost per application is $10.00 per acre (19,54). The REI for glyphosate is 12 hours. Based on survey results, 10 percent of squash growers in Florida applied glyphosate to 100 percent of their acreage 2 times per season.

Cultural Control

Based on survey results, 30 percent of squash growers reported establishing healthy plants that shade and out-compete weeds as a cultural control method. Forty percent reported the use of mulch to reduce weed growth. Sixty percent cited use of cultivation to make this the predominant form of cultural weed control.

Disease Management

Disease Pathogens

The principal diseases affecting squash production in Florida are mosaic viruses (papaya ringspot virus W, watermelon mosaic virus 2, and zucchini yellow mosaic virus), powdery mildew, and downy mildew, with some occurrence of wet rot. Diseases with potential for increased occurrence (with methyl bromide loss) include Phytophthora foliar blight and fruit rot. Although disease incidence varies from year to year, annual losses from papaya ringspot virus W, powdery mildew, and downy mildew together total approximately 15 percent (9). While damage from viruses in squash can be severe, their occurrence is more sporadic than powdery and downy mildews (11). Damping-off (caused by *Pythium* spp. and *Rhizoctonia solani*), cucumber mosaic virus, gummy stem blight (caused by *Mycosphaerella citrullina*), Alternaria leafspot (caused by *Alternaria cucumerina*), target spot (caused by *Corynespora cassiicola*), angular leaf spot (caused by *Pseudomonas syringae* pv. *lachrymans*), and southern blight (caused by *Sclerotium rolfsii*) may also be seen occasionally (19,26,27,28,29).

Papaya Ringspot Virus Type W (PRSV-W). Papaya ringspot virus type W, formerly known as watermelon mosaic virus 1, is a potyvirus. It is the primary viral disease of squash in South Florida. While it does not occur every year, it may be widespread in some years. Its occurrence also depends somewhat on specific field conditions (such as potential for host plants near the field), so that in a particular year, some squash plantings may be virus-free while others experience a high incidence. Overall, the virus affects approximately 30 percent of squash acreage in Florida (9,11).

The virus occurs later in North Florida, during the summer and fall, particularly during the principal watermelon season (30). Viruses on squash in Florida are generally more common later in the season, primarily affecting older plants (11). While affected leaves on young plants may show chlorotic and mosaic symptoms, older plants experience mottling, stunting, and deformation of leaves. Fruits become distorted and mottled in color (27).

Although leafminers have been shown to be capable of transmitting PRSV-W, aphids are the primary vectors. Aphids spread papaya ringspot virus from other cucurbit crops (watermelon, cantaloupe, and cucumber), as well as weed hosts within the state. Creeping cucumber (*Melothria pendula*) is a major weed host for papaya ringspot virus in South Florida, and balsam apple (*Clusia rosea*) and ivy gourd (*Coccinea grandis*) also harbor the virus (27,30). Insecticidal sprays to control the aphids (principally Myzus persicae) that transmit the viral diseases in cucurbit crops such as squash have proven futile. Aphids transmit these viruses in a stylet-borne, nonpersistant manner, meaning that an aphid can pick up virus particles on its mouthparts (stylet) from an infected plant and transfer them to a healthy plant without the virus entering the aphid's body. This type of transmission can occur within seconds, and insecticides are therefore ineffective in preventing virus spread, since the aphids can spread the virus before the insecticide can kill the aphid (9,31). In fact, using insecticides to control aphids may worsen viral incidence by disturbing the aphids and increasing spread of the viruses. Extension programs in Florida have emphasized the futility of spraying to control aphids, and growers generally follow those recommendations (32). Many squash growers in Florida use paraffinic oil (JMS Stylet Oil®), which inhibits the attachment of the virus when aphids probe infected plants with their stylets. Growers, who use it on approximately one-third of squash acreage in the state, apply the oil frequently and keep foliage (especially new growth) covered with it. Research has shown the oil to be effective, but it must be applied before aphids appear and may therefore be applied in some years in the absence of the virus (9).

Watermelon Mosaic Virus 2. Watermelon mosaic virus 2, also a potyvirus, is the principal viral disease on squash in Central and North Florida. Although it has been known to cause considerable damage at all times of squash production, late spring or fall plantings seem to be more susceptible than early spring plantings of squash (30). Symptoms of watermelon mosaic virus 2 are similar to those of papaya ringspot virus (27).

Aphids are the principal vectors of watermelon mosaic virus, although transmission by leafminers can also occur. The virus is spread to squash from other cucurbit crops and from weed hosts. Alyceclover (Alysicarpus vaginalis) is an important host, particularly in North Florida. In addition, lupine (Lupinus spp.), hairy indigo (Indigofera hirsuta), and English pea (Pisum sativum) can all harbor watermelon mosaic virus in Florida (27,30).

Zucchini Yellow Mosaic Virus. Zucchini yellow mosaic virus, a potyvirus that first appeared in Florida in 1981, now occurs sporadically throughout the state. Signs of infection appear between 7 and 12 days after inoculation, and are similar to those of papaya ringspot virus or watermelon mosaic virus. However, zucchini yellow mosaic virus can severely distort infected plants. The shape, size, and color of leaves and fruit can be greatly affected, with foliar signs appearing like hormonal herbicide (e.g. 2,4-D) injury. Severe malformation and stunting of fruits may occur, and yields can be greatly reduced (30,33).

Zucchini yellow mosaic virus is also transmitted by aphids. In addition to affecting squash, the virus can cause mosaic symptoms in cantaloupe, cucumber, and watermelon. The wild cucurbit creeping cucumber (M. pendula) is an important host and may be a reservoir of the virus (30,33).

Powdery Mildew [caused by *Sphaerotheca fulginea* (*Erysiphe cichoracearum)*]. Powdery mildew occurs to some extent every year on Florida squash. Although it may not be economically damaging in all affected plantings, it is present in approximately 70 percent of squash acreage (9). The disease usually does not appear until later in the season, and older leaves and stems are most affected. Premature loss of foliage can result in yield loss, which is proportional to the severity of the disease and the length of time that plants are infected (11,35).

The first sign of powdery mildew is the presence of small, white spots on older leaves. As the disease progresses, the spots merge and large areas of white, powdery fungal growth appear on the upper leaf surface. Spores from the powdery masses are carried by wind to nearby plants. Severely infected leaves eventually turn yellow, then brown, and may die, leaving fruits exposed to sunburn. The disease may also kill young stems. The fungus does not attack the fruit directly, but if the disease is severe before the fruit mature, premature ripening may occur and yield will be reduced. If the disease occurs only in the last three weeks before harvest, yield will not be affected, and no control measures are necessary (20,26,27,35).

Powdery mildew is most severe under conditions of greater humidity, particularly during periods of heavy dew. However, the fungus can also reproduce under dry conditions, so it can become severe during the drier winter and spring months in Florida (35).

Control of powdery mildew is difficult, because highly effective measures are not available. Chlorothalonil provides only limited control of the disease, and resistance to benomyl has been documented, although there has been some reversion back to benomyl-sensitive strains of the fungus. Some growers are returning to the use of sulfur, which provides moderate levels of control, and this gap in control has been identified by extension personnel (9). Mineral oil (JMS Stylet Oil®) can also be effective in reducing the establishment of this fungus (58).

Downy Mildew (caused by *Pseudoperonospora cubensis*). Downy mildew is another important disease of squash in Florida, affecting approximately 30 percent of acreage each year (9). Like powdery mildew, it generally does not occur until the plants are older, especially when seeds have been treated (11). The disease reduces yield and fruit quality and can kill plants if they are infected early (36).

The first signs of downy mildew on squash leaves appear as pale green or yellowish areas on the upper surface, with grayish spore masses on the corresponding lesion on the lower surface. The spots, which are generally angular, become brighter yellow as time progresses. A downy fungal growth, ranging in color from whitish to grayish to light blue, can be seen on the lower leaf surface at each spot when the leaf is wet. Spores are produced primarily within that growth. As the disease progresses, leaves that are severely infected will turn brown and die. The fungus does not occur directly on the fruits, but improper coloration and tastelessness can result (27,36).

The disease is spread as spores are dispersed from leaf to leaf and from plant to plant by the wind. Greatest spore movement occurs between late morning and midday. When a spore lands on a wet leaf surface, it germinates and enters the leaf tissue. After four to seven days, a new spot, or lesion, is formed. If uncontrolled, the cycle continues and disease severity increases. Once downy mildew appears in a squash field, it is difficult to control, so fungicidal sprays must be preventative, beginning before the disease is seen (36).

Disease severity is greatest during wet conditions. Additionally, optimal conditions for disease development include nighttime temperatures of 55 to 75°F (13 to 24°C) and relative humidity greater than 90 percent. In South Florida, downy mildew is less severe during winter plantings than during fall and spring plantings, when infection may occur very early in the season. In North Florida, downy mildew epidemics do not usually occur until the flowering period because of cool nighttime temperatures during the spring months (36).

Wet Rot (caused by *Choanephora cucurbitarum*). Wet rot occurs every year in Florida, but only during part of the year, generally from late August to the middle of October. The disease, also called blossom rot, affects primarily the flowers and fruits of squash. Yellow squash types are the most susceptible. The fungus first appears on blossoms of summer squash and moves to the fruit, which turns dark at the blossom end, progressively moving throughout the fruit. The fungus covering the rotted area has the appearance of many black-headed pins, and the tissue underneath becomes rotted, particularly under moist conditions. The disease is most severe during warm, wet periods (9,20,27,34).

Crops affected by wet rot in addition to squash include okra, southern pea, and occasionally cucumber, bean, and pepper. Cotton, althea (Rose-of-Sharon), and hibiscus are additional hosts. Spores of the fungus can overwinter in soil and crop debris. The primary infection cycle on squash is thought to be initiated by wind dissemination of spores, and insects or wind may contribute to secondary spread of the disease. Within the squash crop, bees as well as striped and spotted cucumber beetles transport spores from one flower to another (34).

Phytophthora Foliar Blight/fruit Rot (caused by *Phytophthora capsici*). Phytophthora blight occurs sporadically but is increasing in importance in Florida squash production. Since it is a soil-borne disease, it is likely to become a greater problem when methyl bromide is no longer available (9). The fungus causes seed rot and seedling blight in many solanaceous and cucurbit crops, including pepper, eggplant, tomato, cantaloupe, cucumber, summer squash, pumpkin, and watermelon. The pathogen's wide host range also includes chayote, marigold, and papaya. In addition to damping-off, foliar blights and fruit rots can occur on mature plants, with signs varying by host species (37).

In summer squash, which is highly susceptible, the first sign is the development of water-soaked lesions, which expand quickly on the leaves. Dieback of shoot tips, wilting, and shoot rot can be followed by rapid death of the plant. Fruits may develop dark, water-soaked areas and may be covered with the white growth of the fungus. Disease development can be very rapid under favorable conditions, resulting in extensive losses when the disease occurs (37).

The fungus survives in the soil, on host plant debris, or on seed. Production of thick-walled spores (oospore) help it to survive unfavorable periods in the soil, while production of a more mobile type of spore (zoospore) helps it to spread by wind and water. Dissemination may also occur by contaminated soil or equipment. When surface moisture is present, zoospores landing on host plants can invade the plant's tissue. Signs may be present in three to four days after infection under ideal conditions, which include warm, wet weather. The disease can develop especially rapidly in the presence of high rainfall and standing water. While the fungus can grow at temperatures from 7 to 37°C (46 to 99°F), zoospore production is maximal at 24°C (75°F), and subsequent disease development is optimal at temperatures from 24 to 32°C (75 to 90°F) (37,38).

Researchers in Florida have evaluated several fungicides for the control of Phytophthora blight and fruit rot of summer squash, finding greatest control from metalaxyl applied as a soil drench, despite a phytotoxic effect resulting in yellowing of leaf edges. Metalaxyl/chlorothalonil and metalaxyl/mancozeb drenches resulted in fair to good control, whereas drenches of etridiazole, etridiazole/thiophanate methyl, and fosetyl-aluminum gave inconsistent results. Application of all fungicides once to foliage and stems before infestation of the fungus provided poor to no control. However, three applications of metalaxyl to foliage and stems before infestation resulted in complete control of the disease (38).

Post-Harvest Diseases

Pythium fruit rot/cottony leak is the most common post-harvest disease on squash in Florida. The fruit rot begins in the field, where the disease also produces a rotting of the crown in older squash plants (9). Bacterial soft rot (caused by Erwinia carotovora) also occurs occasionally. Once within the fruit tissue, the bacteria multiply in the spaces between cells and produce enzymes that destroy the material holding plant cells together, separating the cells and weakening the cell walls. Signs begin as watersoaking and softening around the infection point. The squash becomes soft, and the inner tissue liquifies, eventually escaping as the outer skin collapses. Humid conditions (high relative humidity, high rainfall or poor drying conditions) and temperatures from 73 to 95°F (22 to 35°C) are optimal for the development of soft rot (9,17,39).

Squash in Florida is susceptible to several other post-harvest diseases, including Alternaria rot (caused by Alternaria alternata), Fusarium rot, and Rhizopus storage rot. Alternaria rot is a problem under cool, damp storage conditions, where it can produce a black mold over the squash's surface. A white or pinkish white mold appears as a result of Fusarium rot, which gives the infected tissue a bitter taste. Finally, Rhizopus rot softens the internal squash tissue and gives it a sour odor and taste. The pathogens responsible for these post-harvest decays are obligate parasites, which normally enter the squash through openings made by mechanical damage. They may also enter natural openings in contaminated water (17,26).

Chemical Control

In 1999, 80 percent of squash growers surveyed reported fungicide use on 100 percent of the crop. Twenty percent reported no fungicide use at all. In 2000, a total of 89,800 pounds of active ingredient were used to control fungi in Florida squash (1).

Fungicides registered for use on Florida squash include mefenoxam (Ridomil Gold®), maneb (Manex®), mancozeb (Dithane®/Manzate®-summer squash only), Bacillus subtilis (Serenade®), Gliocladium virens, kaolin (Surround®), chlorothalonil (Echo®), thiophanate-methyl (Topsin®), fosetyl aluminum (Aliette®), copper (Kocide®/Champ®), sulfur, thiram (seed treatment only), zoxamide (Gavel®- summer squash only), trifloxystrobin (Flint®), and azoxystrobin (Quadris®) (19). As of October, 2002, peroxyacetic acid, myclobutanil, and triflumizole were registered for squash but products labeled for use on squash were not available in Florida.

Chlorothalonil (Echo®). Chlorothalonil is a broad-spectrum nitrile fungicide used by Florida squash growers primarily in the management of downy mildew, Phytophthora blight, and powdery mildew (9). The median price of chlorothalonil is $10.32 per pound of active ingredient and the approximate cost per labeled application (2.7 lb ai/A) is $27.42 per acre (19,54). The PHI and REI for chlorothalonil are both 48 hours.

Based on survey results, 30 percent of squash growers in Florida applied chlorothalonil to 100 percent of their acreage 3 times per season. In 2000, a total of 18,200 pounds of chlorothalonil were used on 44 percent of the squash grown in Florida an average of 3.2 times per crop (1).

Benomyl (Benlate®). Benomyl is a systemic, benzimidazole fungicide used to control gummy stem blight. The median price of benomyl is $32.40 per pound of active ingredient and the approximate cost per labeled application (0.25 lb ai/A) is $8.10 per acre (19,54). The PHI and REI for benomyl are both 24 hours.

Based on survey results, 10 percent of squash growers in Florida applied benomyl to 100 percent of their acreage 2 times per season. The registrant for this product announced the voluntary cancellation of benomyl in the spring of 2001.

Mancozeb (Dithane®/Manzate®). Mancozeb is an ethylenebisdithiocarbamate (EBDC) fungicide. Mancozeb can only be used for summer squash and it is employed to control anthracnose, downy mildew, and Phytophthora blight. The median price of mancozeb is $4.80 per pound of active ingredient and the approximate cost per labeled application (2.4 lb ai/A) is $11.52 per acre (19,54). A maximum of 19.2 pounds of active ingredient may be applied to the crop. The PHI and REI for mancozeb are 5 days and 24 hours, respectively.

Based on survey results, 20 percent of squash growers in Florida applied mancozeb to 90 or 100 percent of their acreage 3 or 8 times per season. In 2000, a total of 23,500 pounds of mancozeb were used on 60 percent of the squash grown in Florida an average of 3 times per crop (1).

Mefenoxam (Ridomil Gold®). Mefenoxam is isomer resolved metalaxyl. Consequently, survey results for these two compounds were blended. Mefenoxam is an acylalanine systemic fungicide used to control Pythium seedling blight, downy mildew, and Phytophthora blight. The median price of mefenoxam is $157.00 per pound of active ingredient and the approximate cost per labeled application (1.0 lb ai/A) is $157.00 per acre (19,54). The PHI and REI for mefenoxam are 0 day and 48 hours, respectively.

Based on survey results, 30 percent of squash growers in Florida applied mefenoxam to 100 percent of their acreage 1 or 3 times per season. In 2000, a total of 200 pounds of active ingredient (metalaxyl) were used on 13 percent of the squash grown in Florida an average of 1.4 times per crop (1).

Maneb (Manex®). Maneb is another EBDC fungicide that is used for control of downy mildew and anthracnose. The median price of maneb is $3.67 per pound of active ingredient and the approximate cost per labeled application (1.6 lb ai/A) is $5.87 per acre (19,54). A maximum of 12.8 pounds of active ingredient may be applied to the crop. The PHI and REI for maneb are 5 days and 24 hours, respectively. Based on survey results, 40 percent of squash growers in Florida applied maneb to 100 percent of their acreage up to 5 times per season. In 2000, a total of 16,800 pounds of maneb were used on 32 percent of the squash grown in Florida an average of 3.4 times per crop (1).

Copper (Kocide®/Champ®). Copper has long been used as a fungicide and can be applied in multiple forms (e.g. copper hydroxide, copper sulfate). Copper is used for control of downy mildew. The median price of copper hydroxide is $2.11 per pound of active ingredient and the approximate cost per labeled application (5 lb ai/A) is $10.55 per acre (19,54). The PHI and REI for copper hydroxide are 5 days and 48 hours, respectively. Based on survey results, 20 percent of squash growers in Florida applied copper hydroxide to 100 percent of their acreage at least once per season. In 2000, a total of 2,400 pounds of active ingredient (copper hydroxide) were used on 5 percent of the squash grown in Florida an average of 4.9 times per crop (1).

Sulfur. Sulfur also has long been used as a fungicide. Sulfur is used for control of powdery mildew. The median price of sulfur is $0.88 per pound of active ingredient and the approximate cost per labeled application (10 lb ai/A) is $8.80 per acre (19,54). The REI for sulfur is 24 hours and there is no PHI. In 2000, a total of 28,700 pounds of sulfur were used on 27 percent of the squash grown in Florida an average of 4.3 times per crop (1).

Fosetyl-aluminum (Aliette®). Fosetyl-aluminum (fosetyl-Al) is a metal-containing organic phosphate compound that is used for control of downy mildew and Phytophthora blight. 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 (19,54). A maximum of 7 applications of active ingredient may be applied to the crop. The PHI and REI for fosetyl-Al are 1 day and 12 hours, respectively. Based on survey results, 10 percent of squash growers in Florida applied fosetyl-Al to 100 percent of their acreage 2 times per season.

Azoxystrobin (Quadris®). Azoxystrobin is a naturally-derived compound that is used for control of downy and powdery mildew as well as gummy stem blight. The median price of azoxystrobin is $118.76 per pound of active ingredient and the approximate cost per application is $29.69 per acre (19,54). A maximum of 1.5 pounds of active ingredient may be applied to the crop. The PHI and REI for azoxystrobin are 1 day and 4 hours, respectively. Based on survey results, 10 percent of squash growers in Florida applied azoxystrobin to 100 percent of their acreage at least once per season.

Cultural Control

Based on survey results, 10 percent of squash growers reported modification of planting date and disinfection (of shoes and hands) as cultural disease control methods. Thirty percent adjusted plant spacing, 40 percent managed ditch bank and non-crop land pests, and 50 percent used rotational/alternate crops. Seventy percent reported planting as far from other cucurbit crops as possible as a cultural management tool. Eighty percent of growers cited use of disease-resistant varieties and crop residue management to make these the co-dominant forms of cultural disease control. Other cultural control methods include maintenance of adequate fertility, soil moisture, and pH, as well as planting on well drained soil (27,34).

Post-Harvest Control

Careful handling during and after harvest, removal of infected squash during grading, harvesting plants when dry, and adequate temperature maintenance can all aid in minimizing losses from post-harvest decays (17,39). Some growers use chlorinated water to wash the fruit (9).

Nematode Management

Nematode Pests

Plant-parasitic nematodes are microscopic roundworms, generally found in soils, which primarily attack plant roots. 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 (25). Root-knot nematodes are the principal nematode pest of squash. Sting nematodes can also be a problem (24).

Root-knot Nematodes (*Meloidogyne* spp.). Root-knot nematodes enter the host plant as second stage juveniles and settle within the root to establish a feeding site. At the feeding site, secretions from the nematode cause the surrounding plant cells to enlarge and multiply, producing the characteristic galls associated with root-knot attack. The female develops within the root, living for as long as several months, and laying hundreds to several thousand eggs that are released into the soil. Low temperatures or dry soil conditions may slow the hatching of eggs (24,25). Root deformation results in signs that include stunting, wilting, chlorosis, and yield loss. Additionally, the gall tissue is more susceptible to secondary infections such as root rot (25).

Sting Nematodes (*Belonolaimus* spp.). These nematodes are ectoparasites, remaining outside the plant root and feeding superficially at or near the root tip by penetrating the root with a long stylet. Affected root tips turn yellow and later necrotic, with cavities forming and the root tip swelling slightly. Damage from feeding inhibits root elongation and causes roots to form tight mats and appear swollen, resulting in a stubby or coarse root appearance. Under severe infestations, new root growth is killed in a way that resembles fertilizer salt burn (24,25)

Chemical Control

In 1999, 20 percent of squash growers surveyed reported nematicide use on 100 percent of the crop. Ten percent reported nematicide use on 50 percent of the crop, and 70 percent used no nematicide at all. Usually, growers who produce squash under polyethylene mulch after a first crop of pepper, eggplant, or tomato fumigate the first crop with methyl bromide, the effect of which partially carries through the squash crop (11). Fumigant nematicides registered for use on squash include 1,3-dichloropropene (Telone®), chloropicrin (Telone®), and methyl bromide (Meth-O-Gas®). Non-fumigant nematicides include oxamyl (Vydate®), carbofuran (Furadan®), metam sodium (Metam®/Vapam®), chitin (Clandosan®), and harpin protein (Messenger®).

Methyl Bromide (Meth-O-Gas®). A detailed discussion regarding methyl bromide is present in the crop profiles for higher value commodities such as tomato or eggplant. However, based on survey results, 40 percent of squash growers in Florida employed methyl bromide either primarily for squash or for another crop that squash followed. The growers used this treatment on 100 percent of their acreage 1 time per season to control nematodes, diseases, weeds, and insects. In 2000, 14 percent of growers used methyl bromide once at a rate of 145 pounds per acre (1). Total state use for 2000 was 229,400 pounds (1).

Metam Sodium (Metam®/Vapam®). After application of this material, moisture is required to initiate a hydrolysis reaction that forms methylisothiocyanate - which is a volatile biocidal gas. Ten percent of squash growers employed metam sodium once a season to control nematodes, diseases, and weeds.

Cultural Control

Based on survey results, 20 percent of squash growers reported using solar sterilization, planting nematode-resistant varieties, and destroying crop roots. Thirty percent practiced sanitation (e.g. cleaning equipment before moving areas). Seventy percent of growers cited use of crop rotation to make this the predominant form of cultural nematode control.

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Acknowledgements

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

- **Mary Lamberts**, Extension Agent IV, University of Florida, Miami-Dade county extension Office, Homestead;
- **Michael Aerts**, Assistant Director, Environmental and Pest Management Division, Florida Fruit and Vegetable Association, Orlando, Florida;
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Support for Florida's Crop/Pest Management Profile project and this publication was provided by a Pest Management Alternatives Program (PMAP) grant and a Pest Management Centers grant from the USDA-CSREES.

References

1. United States Department of Agriculture National Agricultural Statistics Service. (July 2001). Agricultural Chemical Usage - 2000 Vegetable Summary. Available: http://www.nass.usda.gov/fl/rtoc0h.htm.

2. United States Department of Agriculture National Agricultural Statistics Service. (January 2001). Vegetables 2000 Summary. Available: http://www.nass.usda.gov/fl/rtoc0h.htm.

3. Smith, S.A. and Taylor, T.G. Production Costs for Selected Florida Vegetables 1999-2000. Circular 1202, Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida.

4. Florida Agricultural Statistics Service. (2001 February). Florida Agricultural Statistics 1999-2000 Vegetables Acreage, Production, and Value. Florida Agricultural Statistics Service, Orlando, FL.

5. Personal communication with Bill Stall, Weed Scientist, Horticultural Sciences Department, University of Florida, Gainesville. June 8, 1999.

6. U.S. Dept. of Agriculture/National Agricultural Statistics Service. (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

7. Florida Agricultural Statistics Service. (2001 February). Vegetables, Acreage, Production and Value. Florida Agricultural Statistics Service, Orlando, FL. Available: http://www.nass.usda.gov/fl/rtoc0h.htm.

8. Florida Agricultural Statistics Service. (1998 August). Farm Cash Receipts and Expenditures - 1997. Florida Agricultural Statistics Service, Orlando, FL. Available: http://www.nass.usda.gov/fl/rtoc0.htm.

9. Personal communication with Ken Pernezny, Plant Pathologist, University of Florida Everglades Research and Education Center, Belle Glade, Florida. May 20, 1999.

10. Seal, D.R. and Baranowski, R.M. (1992). Effectiveness of Different Insecticides for the Control of Melon Thrips, Thrips palmi Karny (Thysanoptera: Thripidae) Affecting Vegetables in South Florida. Proc. Fla. State Hort. Soc. 105:315-319.

11. Personal communication with Ken Shuler, Vegetable Extension Agent, Palm Beach County Extension Service. May 27, 1999.

12. Hochmuth, G.J., Hewitt, T.D., and Ruppert, K.C. (1997 July). Alternative Opportunities for Small Farms: Pumpkin Production Review. Extension Administration Fact Sheet RF-AC023. Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida. Available: http://edis.ifas.ufl.edu/AC023.

13. Stephens, J. M. (1994 May). Chayote -- Sechium edule (Jacq.) Sw. Horticultural Sciences Department HS-579. Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida. Available: http://edis.ifas.ufl.edu/mv046.

14. Stephens, J.M. (1994 May). Squash, Banana -- Cucurbita maxima Duch. Horticultural Sciences Department HS-673. Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida. Available: http://edis.ifas.ufl.edu/mv140.

15. Stephens, J.M. (1994 April). Calabaza -- Cucurbita moschata Duch. Ex Lam. Horticultural Sciences Department HS-572. Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida. Available: http://edis.ifas.ufl.edu/mv039.

16. Stephens, J.M. (1994 May). Gourd, Ornamental -- Lagenaria spp., Cucurbita spp., and Luffa spp. Horticultural Sciences Department HS-606. Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida. Available: http://edis.ifas.ufl.edu/mv073.

17. Gull, D.D. (n.d.). Handling Florida Vegetables, Summer Squash. Horticultural Sciences Department SS-VEC-930, Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida, Gainesville.

18. Bewick, T.A. (1994 March). Squashes: Uses and Production. Horticultural Sciences Department Fact Sheet HS-721. Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida.

19. Hochmuth, G.J., Maynard, D.N., Vavrina, C.S., Stall, W.M., Kucharek, T.A., Webb, S.E., Taylor, T.G., Smith, S.A., and Smajstrla, A.G. (2000 December). Cucurbit Production in Florida. Horticultural Sciences Department HS 725. Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida. Available: http://edis.ifas.ufl.edu/CV123.

20. Pollack, S. (1996 February). Squash and Pumpkin: An Economic Assessment of the Feasibility of Providing Multiple-Peril Crop Insurance. Prepared by the Economic Research Service, U.S. Dept. of Agriculture, for the Federal Crop Insurance Corporation.

21. Stall, W.M. (1999 March). Weed Control in Cucurbit Crops (Muskmelon, Cucumber, Squash, and Watermelon). Horticultural Sciences Department Fact Sheet HS-190. Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida. Available: http://edis.ifas.ufl.edu/wg029.

22. Personal communication with John Capinera, Entomologist and Chairman, Department of Entomology and Nematology, University of Florida, March 26, 1999 & March, 2001.

23. Johnson, F. (1997 August). Insect Management in Squash. Entomology and Nematology Department ENY-441. Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida. Available: http://edis.ifas.ufl.edu/IG040.

24. Noling, J.W. (1997 March). Nematode Management in Cucurbits (Cucumber, Melons, Squash). Entomology and Nematology Department Fact Sheet ENY-25. Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida. Available: http://edis.ifas.ufl.edu/NG025.

25. Noling, J.W. (2000 December). Nematodes and Their Management. Entomology and Nematology Department ENY-625. Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida. Available: http://edis.ifas.ufl.edu/CV112.

26. Alfieri, S.A., Jr., Langdon, K.R., Kimbrough, J.W., El-Gholl, N.E., and Wehlburg, C. (1994 April). Diseases and Disorders of Plants in Florida. Bulletin No. 14. Florida Department of Agriculture and Consumer Services, Division of Plant Industry, Gainesville, Florida.

27. Simone, G.W. (1999 June). Disease Control in Squash (Cucurbita pepo, C. maxima, C. moschata, and C. mixta). Plant Pathology Department V3-49. Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida. Available: http://edis.ifas.ufl.edu/PG055.

28. Pernezny, K., and Simone, G.W. (1993 December). Target Spot of Several Vegetable Crops. Plant Pathology Department PP-39. Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida. Available: http://edis.ifas.ufl.edu/vh052.

29. Kucharek, T. (1994 March). Alternaria Leafspot of Cucurbits. Plant Pathology Department PP-32. Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida. Available: http://edis.ifas.ufl.edu/VH016.

30. Kucharek, T., Purcifull, D. and Hiebert, E. (1996 September). Viruses That Have Occurred Naturally in Agronomic and Vegetable Crops in Florida. University of Florida Plant Protection Pointers. Extension Plant Pathology Report No. 7. Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida. Available: http://plantpath.ifas.ufl.edu/takextpub/ExtPubs/pp7.pdf [1 April 2013].

31. Agrios, G.N. (1988). Plant Pathology. 3rd ed. Academic Press, Inc., New York.

32. Personal communication with Thomas Kucharek, Plant Pathologist, University of Florida Plant Pathology Department, Gainesville. March 31, 1999.

33. Schubert, T.S. and Ritchie, J.J. (1984 May). Zucchini Yellow Mosaic Virus. Plant Pathology Circular No. 259. Florida Department of Agriculture and Consumer Services, Division of Plant Industry, Gainesville, Florida.

34. Kucharek, T. and Simone, G. (1994 March). Wet Rot of Vegetable Crops. Plant Pathology Department Fact Sheet PP-11. Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida. Available: http://edis.ifas.ufl.edu/VH011.

35. Pohronezny, K. and Stall, W.M. (1994 April). Powdery Mildew of Vegetables. Plant Pathology Department Fact Sheet PP-14. Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida. Available: http://edis.ifas.ufl.edu/vh014.

36. Kucharek, T. (1994 March). Downy Mildew of Cucurbits. Plant Pathology Department Fact Sheet PP-2. Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida. Available: http://edis.ifas.ufl.edu/VH006.

37. McGovern, R.J., Kucharek, T.A., and Mitchell, D.J. (1994 May). Vegetable Diseases Caused by Phytophthora capsici in Florida. Plant Pathology Department SP159. Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida. Available: http://edis.ifas.ufl.edu/VH045.

38. Jones, J.P. and McGovern, R.J. (1994). Effect of Temperature and Fungicides on the Development of Phytophthora Blight and Fruit Rot of Squash. Proc. Fla. State Hort. Soc. 107:147-150.

39. Kucharek, T. and Bartz, J. (1994 March). Bacterial Soft Rots of Vegetables and Agronomic Crops. Plant Pathology Department Fact Sheet PP-12. Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida. Available: http://edis.ifas.ufl.edu/VH012.

40. Smith, H.A., Capinera, J.L., Peña, J.E., and Linbo-Terhaar, B. (1994). Parasitism of Pickleworm and Melonworm (Lepidoptera: Pyralidae) by Cardiochiles diaphaniae (Hymenoptera: Braconidae). Environmental Entomology 23(5):1283-1293.

41. Webb, S.E. and Capinera, J.L. (1995). Management of Pickleworm with Entomopathogenic Nematodes. Proceedings of the Florida State Horticultural Society 108:242-245.

42. Webb, S.E. (1993). Management of Insect Pests of Squash. Proceedings of the Florida State Horticultural Society 106:165-168.

43. Nguyen, R. and Bennett, F.D. (1995). Importation and Field Release of Parasites Against Silverleaf Whitefly, Bemisia argentifolii (Bellows and Perring) in Florida from 1990-1994. Proceedings of the Florida State Horticultural Society 108:43-47.

44. Simons, J.N., Stofella, P.J., Shuler, K.D., and Raid, R.N. (1988). Silver-leaf of Squash in South Florida. Proceedings of the Florida State Horticultural Society 101: 397-399.

45. Maynard, D.N. and D.J. Cantliffe. (1989). Squash Silverleaf and Tomato Irregular Ripening: New Vegetable Disorders in Florida. Vegetable Crops Fact Sheet VC-37. Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida, Gainesville, Florida.

46. Yokomi, R.K., Hoelmer, K.A., and Osborne, L.S. (1990). Relationship Between the Sweetpotato Whitefly and the Squash Silverleaf Disorder. Phytopathology 80:895-900.

47. Schuster, D.J., Kring, J.B., and Price, J.F. (1991). Association of the Sweetpotato Whitefly with a Silverleaf Disorder of Squash. HortScience 26(2):155-156.

48. Shuster, D.J., Polston, J.E., and Price, J.F. (1992). Reservoirs of the Sweetpotato Whitefly for Tomatoes in West-central Florida. Proceedings of the Florida State Horticultural Society 105:311-314.

49. Stansly, P.A. (1995). Seasonal Abundance of Silverleaf Whitefly in Southwest Florida Vegetable Fields. Proceedings of the Florida State Horticultural Society 108:234-242.

50. Webb, S.E. and Linda, S.B. (1992). Evaluation of Spunbonded Polyethylene Row Covers as a Method of Excluding Insects and Viruses Affecting Fall-grown Squash in Florida. Journal of Economic Entomology 85(6):2344-2352.

51. Prabhaker, N., Toscano, N.C., and Coudriet, D.L. (1989). Susceptibility of the Immature and Adult Stages of the Sweetpotato Whitefly (Homoptera: Aleyrodidae) to Selected Insecticides. Journal of Economic Entomology 82:983-988.

52. Yokomi, R.K., Jiménez, D.R., Osborne, L.S., and Shapiro, J.P. (1995). Comparison of Silverleaf Whitefly-induced and Chlormequat Chloride-induced Leaf Silvering in Cucurbita pepo. Plant Disease 79:950-955.

53. Personal Communication with Mary Lamberts, Dade County Extension Agent, Homestead, FL. August 16, 1999.

54. DPRA. (2001 March). AGCHEMPRICE, Current U.S.A. Prices of Non-Fertilizer Agricultural Chemicals. Summary Edition. DPRA Incorporated, Manhattan, KS.

55. Capinera, J.L. (2000 October). Pickleworm. Department of Entomology and Nematology, University of Florida, and Florida Department of Agriculture and Consumer Services, Division of Plant Industry Featured Creatures Website. Available: http://entomology.ifas.ufl.edu/creatures/veg/pickleworm.htm

56. Capinera, J.L. (2000 October). Melonworm. Department of Entomology and Nematology, University of Florida, and Florida Department of Agriculture and Consumer Services, Division of Plant Industry Featured Creatures Website. Available: http://entomology.ifas.ufl.edu/creatures/veg/leaf/melonworm.htm

57. Capinera, J.L. (2000 November). Melon Aphid. Department of Entomology and Nematology, University of Florida, and Florida Department of Agriculture and Consumer Services, Division of Plant Industry Featured Creatures Website. Available: http://entomology.ifas.ufl.edu/creatures/veg/aphid/melon_aphid.htm

58. Personal communication with Susan Webb, Entomologist, Department of Entomology and Nematology, University of Florida, Gainesville. July 28, 1999.

59. Glades Crop Care. (2000 December). Pest Management Solutions to Sustain High-Value Florida Vegetable Production. Pest Management Alternatives Program Final Report No. 98-34381-6856. Available: http://www.gladescropcare.com/PMAP_report.html [1 April 2013].