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Florida Crop/Pest Management Profile: Cantaloupe[1]

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Production Facts

- The melon referred to as "cantaloupe" is actually named muskmelon (*Cucumis melo*, var. *reticulatus*). The term "cantaloupe" is a misnomer that has been used widely in the vegetable industry as a synonym for muskmelon. True cantaloupe (*C. melo*, var. *cantalupensis*) is grown in Europe and is a small fruit with a hard, scaly, or warty skin (1).
- Florida-grown cantaloupe comprises approximately one percent of national cantaloupe acreage (2). The national reported planting acreage in 1997 for cantaloupe ranges between 100,993 acres (3) and 108,099 acres (2).
- In 1997, Florida cantaloupe production occurred on 1,133 acres and 97 farms were involved with the production of this crop (2).
- Hybrid cantaloupe available for Florida planting include "Super Market", "Summet", "Magnum 45", "Primo", "Mission", "Ambrosia", "Athena", "Cordele", and "Eclipse" (4).
- While the state average is 80 hundredweight (cwt.) per acre, new hybrids that should be selected by farmers provide approximately 150 cwt. per acre, and 300 cwt. per acre has been achieved in some trials (4,5). Similarly, gross returns for wholesale melons average $1,500 per acre, but could reach as high as $3,000 per acre. Estimated production cost in 1984 was $750 an acre ($1,500 with the use of plastic mulch and drip irrigation). Break-even price ranges from less than $3.00 per cwt. to over $9.00 per cwt. depending on expected yield (5).

Production Regions

Cantaloupe is produced throughout the state of Florida, but the majority is planted in the central area of the state. In 1997, 28 percent of Florida's cantaloupe farms and 11 percent of the cantaloupe acreage were located in western Florida (Holmes, Jackson, Jefferson, Okaloosa, Walton, and Washington counties). Northern Florida (Alachua, Gilchrist, Marion, and Suwannee counties) accounted for 26 percent of the state's cantaloupe producing farms and 16 percent of total acreage in

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1997. Twenty-seven percent of the state's cantaloupe-producing farms and 59 percent of total cantaloupe acreage were located in west-central Florida (Hillsborough, Hardy, Sumter, and Manatee counties) in 1997. The remainder of production (19 percent of farms and 14 percent of acreage) was distributed throughout the state (2).

Production Practices

Cantaloupe is a warm season species that is adapted to dry conditions, but requires consistent moisture for acceptable yield. The plant needs a long, frost-free season with plenty of sunshine and heat, and relatively low humidity (6). This melon is prone to cracking and rotting in wet climates. Not surprisingly, Arizona, California, and Texas are the main producers of this crop. Generally, cantaloupe are planted after the threat of frost has passed. Retarded growth and reduced yields result if the seedlings are subject to any lengthy periods at 55°F (13°C).

Cantaloupe grows best in a fertile, well-drained slightly acidic sandy or silt loam soil with a pH between 6.0 and 6.5 (6). The soils present in Florida cantaloupe production areas generally fulfill this requirement once the fertility of the soil has been balanced. Excessive levels of nutrients, especially nitrogen, may delay maturity and reduce fruit quality.

Cantaloupe can be either directly seeded or transplanted. The use of transplants has increased since farmers can harvest the melons from seven to ten days earlier than with directly-seeded plants. The earliest harvested melons command top market prices. From 25 to 50 percent of the cantaloupe is grown using plastic mulch and most of this is irrigated with drip irrigation (7,8). However, survey results indicate approximately 90 percent of cantaloupe growers used full-bed plastic mulch system, often with cantaloupe following a high-value crop such as tomato, pepper, or strawberry. The general trend is for mulch and drip irrigation for the central Florida production, and direct seeding on bare ground in the northern and western parts of the state.

Cantaloupe is planted in Florida between mid-December and mid-April, depending on latitude. Growers in south Florida plant anytime from mid-December to March, while in central and north Florida, planting occurs during the first two months of the year or between mid-February and mid-April, respectively (4). The hybrid varieties employed by Florida growers require 70 to 90 days from transplant to maturity (85 to 110 days from seed), and are planted at a depth of 0.5 to 1.0 inch (1.3 to 2.5 cm). The rows are spaced 60 to 72 inches apart (150 to 180 cm) and plants are spaced from 24 to 36 inches apart (60 to 90 cm). Plant population under closest spacing is 4,356 plants per acre, which requires from one to two pounds of seed per acre (4).

Cantaloupe requires approximately one inch (2.5 cm) of water weekly, either from rain or irrigation (5). Ninety percent of cantaloupe-producing farms are irrigated nationally, and 83 percent of cantaloupe acreage is irrigated in Florida (2).

Cucurbits have separate female and male flowers, with the male flowers appearing prior to female flowering. For the female flowers to produce fruit, pollen from the male flower must be transferred to the female flower by insects. Generally, satisfactory pollination occurs when one strong beehive is present for every two acres of cantaloupe. Flowers of cantaloupe and other cucurbits open just after sunrise and close in the late afternoon or early evening. Therefore, pesticide applications to the crop during flowering must be made before sunrise or at dusk/after dark to avoid negatively affecting bee activity (4).

Growers in Florida harvest cantaloupe from mid-March through June, with the most active time of harvest occurring from mid-April through May. The melons may be harvested at full slip (melon easily separates from stem) or at half to three-quarters slip. The full slip melons are fully mature and are channeled to local fresh market, while the other melons are often trucked to areas such as the Midwest (1,5). Based on weather, pests, and economics, melons are generally hand-harvested no more than four times within a crop, separated by one or two weeks. As a general practice, cantaloupe is picked and packed directly into containers without rinsing (7). To prevent cracking, the melons should

be hydrocooled or forced-air cooled. Florida cantaloupe is often packed in 40-pound, two-layer boxes and can be held for approximately two weeks at temperatures from 36 to 41°F (2 to 5°C) at the three-quarter slip stage. The melons can be held at even slightly cooler temperature at full maturity (1).

Based on 1999 survey results, 83 percent of cantaloupe growers conduct scouting and monitoring activities while performing routine tasks in the field. Fifty percent of the growers conduct scouting activities on a scheduled basis (generally once a week for insects and diseases, every two or three weeks for weeds, and monthly for nematodes). Only eight percent of cantaloupe growers reported not scouting at all.

Insect/Mite Management

Insect/Mite Pests

The principal pests on cantaloupe in Florida are the silverleaf whitefly, pickleworm, melonworm, melon thrips, leafminers, and aphids. Minor and occasional pests include squash bug, stink bugs, squash vine borer, southern armyworm, banded cucumber beetle, and twospotted spider mite. Insects and mites that may occasionally be seen on cantaloupe 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, yellowstriped armyworm), flea beetles, grasshoppers, lygus bugs, saltmarsh caterpillar, squash beetle, tobacco budworm, and wireworms (9,10).

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, including cantaloupe (9,11).

Adult whiteflies are small (0.8 mm) feather-winged insects that inhabit and feed on the undersurface of leaves by penetrating the tissue and removing plant sap with their piercing-sucking mouthparts. The white color of the adults is attributed to the secretion of wax on the body and wings. The silverleaf whitefly can be distinguished from the greenhouse and bandedwing whiteflies by the manner in which the wings are folded. The silverleaf whitefly holds its wings at a roof-like angle, whereas the wings are held flat against the body in the other two species (10).

While feeding, female whiteflies lay stalked, cigar-shaped eggs deposited singly or in small clusters on the undersides of leaves. Eggs are whitish-yellow when newly laid and turn brown prior to hatching. 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 (9). Development time from egg to adult is about three weeks at 80°F (27°C). The host range of silverleaf whitefly includes over 500 species of plants from 74 plant families (10).

Feeding damage exhibited by host plants includes vine/leaf abnormalities, chlorosis, and fruit malformation. The silverleaf whitefly has also been implicated in the spread of tomato mottle virus, tomato yellow leaf-curl virus, and bean golden mosaic virus (10).

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 not found in the field during the day, instead residing in woods or weedy areas. Female moths lay 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 hatching occurs 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.

Although pickleworm larvae often attack cucurbit fruit, cantaloupe is not a preferred host. However, pickleworm larvae sometimes burrow into the melon but more often feed on the surface, causing "rindworm" damage (12).

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, leaving the veins and creating a lace-like appearance. For less favored hosts such as cantaloupe, the larvae may burrow into the melon or feed on the rind - causing "rindworm" damage (13).

MELON THRIPS (*Thrips palmi*) The melon thrips is a Southeast-Asian flying insect that is capable of reproducing in greenhouses throughout the southeastern United States, but can be a field pest south of Orlando. Melon thrips can complete a life cycle in approximately 20 days at 30°C, and the insect has a preference for young vegetation (of the cucurbit or solanaceous family), thus creating problems for spring and fall vegetable growers. As one crop matures, thrips move to other crops which are just emerging.

The adult is about 1 mm long, and pale yellow or whitish in color with a black line running down the back. Numerous setae cover the body. Female thrips lay an average of 50 eggs, which are pale white and bean shaped, in slits which it has made in leaf tissue. One end of the egg protrudes from the slit. Hatching at 32°C occurs in about four days.

The larvae go through two instars with a development time of four days at 32°C. Unlike the adults, larvae feed in groups on older plant tissue, particularly along the leaf midrib and veins. Pupation consists of a prepupal and pupal stage, which take place in the dirt or leaf litter, and this process takes about three days at 32°C.

Since melon thrips prefer leaves, these structures are generally the most affected, progressing from chlorosis through necrosis, and ending with abscission of the leaves. If infestations are high enough, the crop may have a bronzed appearance in

the field. Although there is a preference for leaves, fruit scarring, deformation, and abortion have been observed (14).

APHIDS (*Aphis gossypii*, *Myzus persicae*, *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. Adults are often wingless, but nymphs develop into winged adults if the plant condition deteriorates or if it becomes overcrowded.

In addition to the damage caused by direct feeding in the phloem, and the potential for mold growth on honeydew, 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 as well in crops such as cantaloupe. This process may only take seconds, as the aphid probes the plant to determine suitability. Consequently, insecticides may have little effect on virus transmission.

In addition to virus transmission, aphid feeding does cause 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.

Aphids in Florida are naturally controlled by parasitic wasps, ladybird beetle larvae, and syrphid fly larvae. However, if non-selective insecticides are used, these predators may be killed, thus 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 (10,11,15,16).

LEAFMINERS (*Liriomyza trifolii*, *Liriomyza sativae*) Agromyzid flies of the genus *Liriomyza* in Florida are small (1.5-2.0 mm long) and mostly shiny black expect for yellow markings on portions of the head and abdomen. The adult female fly punctures upper leaf surfaces with its ovipositor, and deposits eggs in the tissue. The yellow maggots grow to a length of 3 mm, feeding on leaf tissue and making serpentine mines in the upper leaf surface. After two weeks of feeding, the larvae cut through the leaf cuticle and drop to the soil surface to pupate. The life cycle in Florida may be as short as 18 days (10,11,17).

Historically, leafminers in Florida were naturally controlled by parasitic wasps. However, if non-selective insecticides are used, predatory wasps may be killed, thus leaving leafminer populations to expand unchecked. Consequently, infestations are often more severe late in the season. Signs indicative of heavy infestation include leaves covered with tunnels (mines) and defoliation (10,11).

Chemical Control

In 1999, 92 percent of responding cantaloupe growers surveyed reported insecticide use on 100 percent of their crop. Insecticides and miticides registered for use on Florida cantaloupe include azadirachtin (Azatin®), *Bacillus thuringiensis* (Javelin®/Mattch®), carbaryl (Sevin®), azinphos-methyl (Guthion®), diazinon, abamectin (Agri-Mek®), dichloropropene (Telone®), endosulfan (Thiodan®/Phaser®), dimethoate, fenpropathrin (Danitol®), esfenvalerate (Asana®), cyromazine (Trigard®), dicofol (Kelthane®), malathion, methomyl (Lannate®), naled (Dibrom®), insecticidal oil (Sun Spray®), methoxychlor (Methoxychlor®), oxamyl (Vydate®), oxydemeton-methyl (Metasystox-R®), permethrin (Ambush®/ Pounce®), rotenone (Rotenox®/Rotacide®), insecticidal soap (M-Pede®), cryolite (Kryocide®), pyrethrin plus rotenone (Pyrellin®), pyrethrin plus piperonyl butoxide (Pyrenone®), spinosad (SpinTor®), imidacloprid (Admire®/Provado®), bifenthrin (Capture®), and pymetrozine (Fulfill®) (4).

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 and the approximate cost per application is $22.61 per acre (4,18). Methomyl may be applied up to 3 days before harvest (PHI= 3 days), and the restricted entry interval (REI) under the Worker Protection Standard is 48 hours. No more than 12 applications may be made and the material limit is 5.4 lb ai/acre/crop (19). In 1999, 42 percent of surveyed cantaloupe growers in Florida applied methomyl to 100 percent of their acreage between one and three times per season.

ENDOSULFAN (Thiodan®) Endosulfan is a cyclodiene chlorinated hydrocarbon insecticide 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 application is $14.64 per acre (4,18). The PHI and REI for endosulfan are 2 days and 24 hours, respectively. No more than 6 applications may be made per year and the material limit is 3 lb ai/acre/year (20). In 1999, 17 percent of surveyed cantaloupe growers in Florida applied endosulfan to 100 percent of their acreage two times per season.

ESFENVALERATE (Asana®) Esfenvalerate is a broad-spectrum synthetic pyrethroid insecticide used to manage beetles, caterpillars, leafhoppers, squash vine borer, and stink/lygus bugs. The median price of esfenvalerate is $163.64 per pound of active ingredient and the approximate cost per application is $8.10 per acre (4,18). The PHI for esfenvalerate is 3 days and the REI is 12 hours. No more than 0.25 lb ai/acre/season may be applied (19). In 1999, 17 percent of surveyed cantaloupe growers in Florida applied esfenvalerate to 100 percent of their acreage two or three times per season.

BACILLUS THURINGIENSIS (Mattch®/Javelin®) The biopesticide *Bacillus thuringiensis* (B.t.) is an important management tool for Florida melon 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 melon rind). The median price of B.t. is $158.12 per pound of active ingredient (18). B.t. may be applied up to the day of harvest (PHI= 0 day), and the REI is 4 hours (4,21). In 1999, 33 percent of surveyed cantaloupe growers in Florida applied B.t. to 100 percent of their acreage between five and ten times per season.

PERMETHRIN (Ambush®/Pounce®) Permethrin is a pyrethroid insecticide that has contact and stomach activity (22). The compound is used to manage all cantaloupe insects other than mites. The median price of permethrin is $56.32 per pound of active ingredient and the approximate cost per application is $11.26 per acre (4,18). The PHI for permethrin is 0 day, and the REI is 12 hours. No more than 1.6 lb ai/acre/season may be applied (23,24). In 1999, 42 percent of surveyed cantaloupe growers in Florida applied permethrin to 100 percent of their acreage between one and three times per season.

CYROMAZINE (Trigard®) Cyromazine is a triazine compound that inhibits insect growth and it is mainly used to manage leafminers (22). The median price of cyromazine is $227.15 per pound of active ingredient and the approximate cost per application is $28.39 per acre (4,25). The PHI for cyromazine is 0 day and the REI is 12 hours. No more than six applications can be made during the season (23). In 1999, 8 percent of surveyed cantaloupe growers in Florida applied cyromazine to 50 percent of their acreage one time per season.

ABAMECTIN (Agri-Mek®) Abamectin is a fermentation product derived from *Streptomyces avermitilis* that has insect stomach poison and contact activity (22). The compound is used to manage mites and leafminers. The median price of abamectin is $6,156.00 per pound of active ingredient and the approximate cost per application is $115.43 per acre (4,18). The PHI for abamectin is 7 days and the REI is 12 hours. In addition to a season material limit of 0.056 lb ai/acre, abamectin cannot be applied in less than 20 gallons of water per acre and no more than two sequential applications of the material are to be made per season (23). In 1999, 8 percent of surveyed cantaloupe growers in Florida applied abamectin to 100 percent of their acreage once per season.

PYRETHRINS + ROTENONE (Pyrellin®) These two natural compounds both have contact and stomach activity (22). The mixture is used to manage aphids, beetles, leafhoppers, leafminers, mites, bugs, whiteflies, and thrips (4). The PHI for the mixture is 0 day and the REI is 12 hours. In 1999, 8 percent of surveyed cantaloupe growers in Florida applied Pyrellin® to 100 percent of their acreage three times per season.

Alternative Chemicals

Several new reduced impact chemicals have been registered for use in melon crops. Messenger® (harpin protein), Cinnacure® (cinnamaldehyde), and Mycotrol® (*Beauveria bassiana*) are three products which are just now being assessed for insect management. New systemic insecticides (imidacloprid, pymetrozine) are very effective and have minimal effects on natural enemies. 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, 10 percent of cantaloupe growers reported modifying planting dates, 30 percent adjusted fertilizer rates to avoid favorable insect conditions and 30 percent used insect-resistant varieties. Sixty percent of the growers identified/conserved beneficial insects and 70 percent managed pests in ditch banks and non-crop area. Ninety percent cited destruction of crop residues and use of rotational/alternate crops to make these the co-dominant forms of cultural insect control. In addition, research has been conducted which examined the use of squash as a trap crop for cantaloupe and watermelon (26).

Biological Control

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

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 (27).

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, but no releases were made (28).

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 (29).

Weed Management

Weed Pests

Weeds can reduce cantaloupe yields by competing for light, water and nutrients. This effect is greatest early in the season (the first month of growth after emergence), at which time weed management is most critical. Late season weeds will generally not reduce melon yields, but may reduce efficiency of harvest operations (30,31). Weeds are a greater problem in open-grown cantaloupe than in mulched bed production, where fumigation by methyl bromide has occurred in previous crops.

Individual weed species will vary from year to year and from region to region within the state. Pigweeds (*Amaranthus* spp.) and grasses are generally the major weed problems in cantaloupe production (32). Florida pusley, purslane and nutsedges (yellow and purple) are also common weeds in cantaloupe production (32).

GOOSEGRASS (*Eleusine indica)* Goosegrass is a summer annual that is found throughout the state (32). The grass is consequently a potential weed in all of Florida cantaloupe production.

SOUTHERN CRABGRASS (*Digitaria ciliaris*) Southern crabgrass is a summer annual that poses problems largely in the northern parts of Florida (32).

AMARANTHS (*Amaranthus* spp) In the southern region of the state (Miami-Dade County) smooth amaranth (*Amaranthus hybridus*) and spiny amaranth (*Amaranthus spinosus*) are the principal amaranth (pigweed) species. However, livid amaranth (*Amaranthus lividus*) occurs in this and other parts of the state (32).

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 melon production (32).

PURSLANE (*Portulaca oleracea*) This summer annual also has a prostrate growth pattern and fleshy, succulent leaves. Distribution and potential are similar to Florida pusley (32).

NUTSEDGES (*Cyperus esculentus, Cyperus rotundus*) Both yellow (*C. esculentus*) and purple (*C. rotundus*) nutsedge are potential problems in cantaloupe production. These plants are able to penetrate through plastic mulch and compete with melon plants for nutrients, light, and water (32).

Chemical Control

Few herbicides are labeled for use on cantaloupe. Most are non-selective herbicides used to control weeds in row middles. However, in 1999, 50 percent of responding cantaloupe growers surveyed reported herbicide use on 100 percent of the crop. Eight percent reported use on 50 or 80 percent of their crop, and 34 percent used no herbicide at all. Non-selective herbicides labeled for use in cantaloupe include glyphosate (Roundup®), paraquat (Gramoxone®), pelargonic acid (Scythe®), and diquat (Diquat®). Selective herbicides labeled for cantaloupe in Florida include bensulide (Prefar®), naptalam (Alanap®), ethalfluralin (Curbit®), and sethoxydim (Poast®). Bensulide, naptalam, and ethalfluralin are pre-emergence compounds and sethoxydim is a post-emergence herbicide (30).

SETHOXYDIM (Poast®) Sethoxydim is an oxime herbicide used in the management of grass weeds. It can be applied directly over the cantaloupe crop. The median price of sethoxydim is $47.45 per pound of active ingredient and the approximate cost per application is $13.29 per acre (18,30). The PHI is 14 days and the REI is 12 hours. Based on survey results, 8 percent of cantaloupe growers in Florida applied sethoxydim to 60 percent of their acreage 1 time per season.

PARAQUAT (Gramoxone®) Paraquat is a bipyridinium herbicide used for total vegetation control. Paraquat is applied before crop transplant or post-transplant with a shielded sprayer (30). A special local needs label in Florida allows up to three applications per season. The median price of paraquat is $12.07 per pound of active ingredient and the approximate cost per application is $11.35 per acre (18,30). 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, 25 percent of cantaloupe growers in Florida applied paraquat to 100 percent of their acreage 1 or 2 times per season.

GLYPHOSATE (Roundup®) Glyphosate is a phosphorylated amino acid herbicide used for total vegetation control. Glyphosate is applied before crop transplant or post-transplant with a shielded sprayer (30). The median price of glyphosate is $10.95 per pound of active ingredient and the approximate cost per application is $10.95 per acre (18,30). The REI for glyphosate is 12 hours. Based on survey results, 17 percent of cantaloupe growers in Florida applied glyphosate to 100 percent of their acreage 1, 2, or 3 times per season. Eight percent applied glyphosate 1 time to 80 percent of their acreage.

Cultural Control

Based on survey results, 58 percent of cantaloupe growers reported establishing healthy plants that shade and out-compete weeds as a cultural control method. Sixty-seven percent reported the use of mulch to reduce weed growth and this same percentage cited use of cultivation to make this and mulch use the co-dominant forms of cultural weed control.

Disease Management

Disease Pathogens

The principal diseases affecting cantaloupe production in Florida include viruses (papaya ringspot virus type W, watermelon mosaic virus 2, zucchini yellow mosaic virus) and bacterial/fungal diseases such as gummy stem blight, and downy mildew. Diseases with potential for sporadic outbreaks include *Phytophthora* blight, *Alternaria* leaf spot, angular leaf spot, anthracnose, and powdery mildew. *Cercospora* leaf spot, *Fusarium* wilt, bacterial soft rot (caused by *Erwinia carotovora*), target leaf spot (caused by *Corynespora cassiicola*), scab (caused by *Cladosporium cucumerinum*), and southern blight (caused by *Sclerotium rolfsii*) may also affect production occasionally (33,34,35,36).

VIRUSES Papaya ringspot virus type W (PRSVW) was formerly known as watermelon mosaic virus 1. It is more prevalent in south and central Florida. While it does not occur every year, it may be widespread in some years. Its occurrence also depends somewhat on the presence of wild cucurbit species such as creeping cucumber (*Melothria pendula*), balsam apple (*Clusia rosea*), and ivy gourd (*Coccinea grandis*) that serve as the primary hosts. The virus occurs later in north Florida, during the summer and fall, particularly during the principal watermelon season. PRSVW is not seed-borne, and is transmitted primarily by aphids and to some extent by leafminers. These insects can spread PRSVW from other cucurbit crops (watermelon, squash, and cucumber), as well as the weed hosts (37).

Watermelon mosaic virus 2 is generally more prevalent in the north central part of Florida. In contrast to PRSVW, the primary source of this virus in unknown, although it has a wide range of hosts. Aphids are the principal vectors of watermelon mosaic virus, although mechanical transmission by plant sap and transmission by leafminers can also occur. The virus is spread to cantaloupe 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 (37,38).

Zucchini yellow mosaic virus, a disease that infected cucurbit crops the entire length of the state in 1983, now occurs sporadically. Signs can be similar to those of PRSVW or watermelon mosaic virus 2. Although zucchini yellow mosaic virus is transmitted mechanically by plant sap, aphids are the primary vector. The wild cucurbit creeping cucumber (*M. pendula*) is an important host and may be a reservoir of the virus (37,39).

Insecticidal sprays to control aphids that transmit the viral diseases in cucurbit crops have proven futile. Aphids transmit these viruses in a stylet-borne, non-persistent manner, meaning that an aphid can pick up virus particles on its stylet from an infected plant and transfer them to a healthy plant without the virus entering the aphid's body. There is

little delay time from when the aphid acquires the virus to when it transmits it, and the aphid is able to transmit the virus for only a short period of time. This type of transmission can occur within seconds, and insecticides are therefore ineffective in preventing virus spread (33). In fact, using insecticides to control aphids may worsen viral incidence by disturbing the aphids and increasing spread of the viruses. The use of reflective mulches can substantially delay or reduce the incidence of viral diseases by repelling insect vectors.

GUMMY STEM BLIGHT (caused by *Mycosphaerella citrullina*) Cantaloupe is frequently infected by gummy stem blight, which is more prevalent during wet crop seasons. The infection may occur at any stage of growth and signs can occur on all plant parts, except the roots. Signs first appear as brown spots on leaves, or as a light to dark brown sometimes gummy lesion on the main stem. The tissue may also appear watersoaked. Wilting and death may ensue if the infection is severe. Both sexual (ascospore) and asexual (pycnidiospore) spore stages are produced after the initial infection. The ascospores have the ability to serve as wind-borne primary sources of inoculum, while the pycnidiospores function in secondary spread. The fungus can be spread through infected transplants or from wild cucurbits (40).

DOWNY MILDEW (caused by *Pseudoperonospora cubensis*) Downy mildew is another important disease of cantaloupe in Florida. Like powdery mildew, it does not generally occur until the plants are older. The disease reduces yield and fruit quality and can kill plants if they are infected early. The first signs of downy mildew on leaves appear as pale green or yellowish spots 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 melons, but improper coloration and reduced sugar content may reduce the price of the fruit. Optimal conditions for disease development include nighttime temperatures from 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 (41).

PHYTOPHTHORA FOLIAR BLIGHT/ FRUIT ROT (caused by *Phytophthora capsici*) *Phytophthora* blight historically occurred sporadically in Florida, but during wet years, it can become the limiting factor in vegetable production in general. During the wet spring growing season in 1998, reductions in cantaloupe production in Lee, Hendry, Collier, and Manatee county ranged from 3 to 60 percent (42). 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 (43). The fungus survives in the soil, on host plant debris, or on seed. Production of thick-walled spores (oospores) help it to survive unfavorable periods in the soil, while production of a more mobile type of spore (zoospores) 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 (43).

ALTERNARIA LEAF SPOT (caused by *Alternaria cucumerina*) Cantaloupe is sensitive to *Alternaria* leaf spot, and quality and sweetness may be affected if the fungus is not controlled. Leaf spots begin as small pale to bright yellow or tan flecks on the upper leaf surface. The spots may be surrounded by light green or yellow halos. Concentric rings appear in the spots as they enlarge, giving a "target spot" appearance. A greasy or watersoaked

perimeter may also surround the spots. The spots enlarge to 1- to 2-cm lesions which are somewhat circular to irregularly-lobed and light brown-black in color. The dark areas contain small spores which are easily dispersed by wind. If the disease becomes severe, leaf curling, defoliation, premature ripening, lower yields, and fruit deformity may result. Overripe and sunscalded fruit are especially susceptible to infection. Sunken spots up to 3-cm in length with a greenish-black color are typical signs of fruit rot. Dew period is critical for the establishment of *Alternaria* leaf spot, with very high rates of spore penetration after 10 to 24 hours of wetness. Infection can occur from 41 to 95°F (5 to 35°C) with the optimum for infection being a nighttime temperature of 68°F (20°C) (36,44).

POWDERY MILDEW [caused by *Erysiphe cichoracearum* (*Sphaerotheca fulginea*)] Powdery mildew occurs to some extent every year on Florida cantaloupe. 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. This loss of foliage usually results in lower fruit sugar with subsequent reduction in quality. 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. 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, making it a potential disease during the drier winter and spring months in Florida (45).

ANGULAR LEAF SPOT (caused by *Pseudomonas syringae* pv. lachrymans) This disease can affect cantaloupe leaves, stems, and fruit. Spots on the leaves are irregular in shape, angular, and watersoaked. Free moisture allows the bacteria to ooze from the spots which, upon drying, leaves a white residue. These spots of dead tissue will occasionally drop away from the healthy tissue leaving irregular holes in the leaves (36).

ANTHRACNOSE (caused by *Colletotrichum lagenarium*) This disease can also attack all plant parts. The signs of infection first appear on the foliage as small, yellow, water-soaked spots which enlarge rapidly and turn brown. The dead tissue dries and may crack and fall out. On the stems, the lesions are elongated. On the fruits, dark, circular, sunken lesions appear, varying in size with age. During wet weather the center of the spots often show a pinkish color due to production of spores (36).

Chemical Control

In 1999, 75 percent of cantaloupe growers surveyed reported fungicide use on 100 percent of the crop. Eight percent reported use on 50 percent of the crop and 17 percent reported no fungicide use at all. Fungicides registered for use on cantaloupe include mefenoxam (Ridomil Gold®), metalaxyl (Ultra Flourish®), maneb (Manex®), mancozeb (Dithane®/ Manzate®), chlorothalonil (Bravo®/Echo®), benomyl (Benlate®), carbonic acid (Armicarb®), thiophanate-methyl (Topsin®), fosetyl aluminum (Aliette®), copper (Kocide®/Champ®), sulfur, thiram (seed treatment only), and azoxystrobin (Quadris®) (4).

CHLOROTHALONIL (Bravo®/Echo®) Chlorothalonil is a broad-spectrum nitrile fungicide used by Florida cantaloupe growers primarily in the management of gummy stem blight, *Alternaria* leaf spot, and powdery mildew (4). The median price of chlorothalonil is $10.32 per pound of active ingredient and the approximate cost per application is $23.22 per acre (4,18). The PHI and REI for chlorothalonil are both 48 hours. Based on survey results, 67 percent of cantaloupe growers in Florida applied chlorothalonil to 100 percent of their acreage between 3 and 6 times per season.

MANCOZEB (Dithane®/Manzate®) Mancozeb is an ethylenebisdithiocarbamate (EBDC) fungicide. Mancozeb is employed to control gummy stem blight, *Alternaria* leaf spot, and downy mildew (4). The median price of mancozeb is $4.80 per pound of

active ingredient and the approximate cost per application is $11.52 per acre (4,18). 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, 25 percent of cantaloupe growers in Florida applied mancozeb to 100 percent of their acreage between 4 and 8 times per season.

MEFENOXAM (Ridomil Gold®)/ **METALAXYL** (Ultra Flourish®) Mefenoxam is isomer resolved metalaxyl. Consequently, survey results were blended together for these products. Mefenoxam is an acylalanine systemic fungicide used to control *Pythium* seedling blight, downy mildew, and gummy stem blight. The median price of mefenoxam is $157.00 per pound of active ingredient and the approximate cost per application is $157.00 per acre (4,18). The PHI and REI for mefenoxam are 0 day and 48 hours, respectively. Based on survey results, 17 percent of cantaloupe growers in Florida applied mefenoxam to 100 percent of their acreage 2 or 3 times per season.

MANEB (Manex®) Maneb is another EBDC fungicide that is used for control of gummy stem blight, *Alternaria* leaf spot, anthracnose, and downy mildew. The median price of maneb is $3.67 per pound of active ingredient and the approximate cost per application is $5.87 per acre (4,18). 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, 17 percent of squash growers in Florida applied maneb to 100 percent of their acreage up to 6 times per season.

COPPER (Kocide®/Champ®) Copper has long been used as a fungicide and can be applied in multiple forms (copper hydroxide, copper sulfate, etc.). Copper is used for control of downy mildew (usually with mefenoxam) and angular leaf spot. The median price of copper hydroxide is $2.11 per pound of active ingredient and the approximate cost per application is $1.70 per acre (4,18). The PHI and REI for copper hydroxide are both 24 hours. Based on survey results, 17 percent of cantaloupe growers in Florida applied copper to 100 percent of their acreage twice per season.

FOSETYL-ALUMINUM (Aliette®) Fosetyl-aluminum (fosetyl-Al) is an aluminum ester of alkylphosphonate 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 (4,18). 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, 8 percent of cantaloupe growers in Florida applied fosetyl-Al to 100 percent of their acreage once per season.

AZOXYSTROBIN (Quadris®) Azoxystrobin is a naturally-derived compound that is used for control of downy and powdery mildew as well as anthracnose and gummy stem blight. The median price of azoxystrobin is $118.76 per pound of active ingredient and the approximate cost per application is $28.58 per acre (4,18). A maximum of 1 pound of active ingredient may be applied to the crop and no more than 4 applications can be made per season. The PHI and REI for azoxystrobin are 1 day and 4 hours, respectively. Based on survey results, 8 percent of cantaloupe growers in Florida applied azoxystrobin to 100 percent of their acreage twice per season.

BENOMYL (Benlate®) Benomyl is a systemic, benzimidazole fungicide, now canceled, that was used to control gummy stem blight, powdery mildew, and anthracnose. The median price of benomyl is $32.40 per pound of active ingredient and the approximate cost per application is $8.10 per acre (4,18). The PHI and REI for benomyl are both 24 hours. Based on survey results, 8 percent of cantaloupe growers in Florida applied benomyl to 100 percent of their acreage twice per season. The registrant for this product announced the voluntary cancellation of benomyl in the spring of 2001.

Alternative Chemicals

Several new "reduced impact" chemicals have been registered for use in melon crops. Messenger® (harpin protein) and Cinnacure® (cinnamaldehyde) are two products which are just now being assessed for disease management. In addition to the harpin protein, a strain of *Bacillus pumilus* is being studied to determine if it is also capable of stimulating systemically acquired resistance (46). Armicarb-100® contains potassium bicarbonate and is labeled for a broad range of foliar diseases including powdery mildew.

Cultural Control

Based on survey results, 8 percent of cantaloupe growers reported rogueing virus-infected plants. Seventeen percent modified planting date, 25 percent adjusted spacing, and 42 percent reported planting as far from other cucurbit crops as possible. Fifty percent reported using disease-resistant varieties and managing ditch bank and non-crop land pests. Seventy-five percent of growers cited use of rotational/alternate crops and crop residue management to make these the co-dominant forms of cultural disease control.

Post-Harvest Control

Careful handling during and after harvest, removal of infected cantaloupe during grading, and adequate temperature maintenance can all aid in minimizing losses from post-harvest decays. Post-harvest disease organisms which can cause rotting include *Alternaria*, *Cladosporium*, *Fusarium*, and *Rhizopus* (1).

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. Root-knot nematodes are the principal nematode pest of cantaloupe. Sting nematodes can also be a problem (47).

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. 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 (47).

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 (47)

Chemical Control

Fifty percent of cantaloupe growers surveyed reported nematicide use on 100 percent of the crop. Sixteen percent reported nematicide use on 50 or 80 percent of the crop, and 34 percent used no nematicide at all. Fumigant nematicides registered for use on cantaloupe include 1,3-dichloropropene

(Telone®), chloropicrin (in Telone® or in conjunction with methyl bromide), and methyl bromide (Meth-O-Gas®). Non-fumigant nematicides include oxamyl (Vydate®), and metam sodium (Metam®). Usually, growers who produce cantaloupe under plastic mulch after a first crop of peppers, eggplant, or tomato fumigate the first crop with methyl bromide, the effect of which carries through the melon crop.

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, 50 percent of cantaloupe growers in Florida employed methyl bromide/chloropicrin. This material was used on 50 percent of cantaloupe acreage by 8 percent of the growers and on 100 percent of the acreage by the other 42 percent. The application is only made once per season to control nematodes, diseases, insects, and weeds.

METAM SODIUM (Metam®) After application of metam sodium, moisture is required to initiate a hydrolysis reaction that forms methylisothiocyanate - which is a volatile biocidal gas. Seventeen percent of cantaloupe growers employed metam sodium once a season either by soil incorporation or through irrigation to control nematodes, diseases, and weeds.

DICHLOROPROPENE (Telone®) Telone® II and Telone® C-17 are for retail sale and use only by applicators who have completed the Dow AgroSciences training program or persons under their direct supervision (47). Eight percent of cantaloupe growers employed Telone® II to control nematodes.

Alternative Chemicals

Several new "reduced impact" chemicals have been registered for use in melon crops. Messenger® (harpin protein) and Blue Circle® (*Burkholderia cepacia*) are two products which are just now being assessed for nematode management.

Cultural Control

Based on survey results, 8 percent of cantaloupe growers reported using solar sterilization. Seventeen percent reported other non-chemical methods (flooding or deep sub-soiling) as nematode management practices. Twenty five percent planted nematode-resistant varieties. One-third of growers reported the use of sanitation and destruction of crop roots as nematode management strategies. Ninety two percent of cantaloupe growers cited use of crop rotation, to make this the predominant form of cultural nematode control.

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