Crop Time Line for Florida Fresh Market Tomatoes

Prepared by Glades Crop Care, Inc.
May 31, 2002

Revised by Glades Crop Care, Inc.
August 8, 2002

Crop Production

Crop

Fresh market tomatoes (*Lycopersicon esculentum*) have been the cornerstone of Florida's winter vegetable industry for many years. Many varieties of tomato are grown in the state, falling into several categories according to the fruit type and the intended use. The majority of Florida's tomato crop consists of large-fruited varieties, commonly referred to as "round" tomatoes, which are usually harvested at the mature green stage, and treated with ethylene in ripening rooms prior to shipment to northern markets. At the mature green stage, the fruit is completely green, but the internal tissues holding the seeds have begun to soften to the point that no seeds are cut when the fruit is sectioned with a sharp knife. Other types, including cherry, grape and Roma (or saladette) tomatoes are harvested between the "breaker" and red ripe stages. At the breaker stage, 10 percent of the fruit surface appears yellowish or red in color. There are three more intermediate stages recognized by the USDA before the fruit reaches the red stage, in which 90 percent or more of the fruit surface is red. A small, but steadily increasing acreage is devoted to the production of "heirloom" varieties, which are primarily large-fruited, with varying fruit colors and shapes, and which are usually harvested after the breaker stage. Production of heirloom varieties usually occurs in hydroponic greenhouses. Also increasing in recent years is the production of organically grown tomato crops. (USDA, 1991; Glades Crop Care, Inc., unpublished data)

Tomato crops in Florida are produced from transplants. Most transplants are produced within the state of Florida, although some transplants planted in August and September originate in Georgia (Glades Crop Care, Inc., unpublished data). Most of Florida's tomato crop is produced in outdoor fields, where the plants are grown on fumigated, plastic mulched beds. Irrigation is provided by either a perched water table or through drip irrigation tubes. To allow for improved pest management and to avoid soil contact, the crop is supported by wooden stakes and 3 or more ties. Harvesting is performed by hand. Fruits are hauled from the field in wooden or plastic bins holding up to 1000 lb each, or in large gondolas. Although some red-ripe fruit is field packed, the bulk of the fresh market tomato harvest is packed at packinghouses, where the fruit is sized, graded, boxed and placed in ripening rooms to be treated with ethylene gas, which promotes ripening (Glades Crop Care, Inc., unpublished data).

Preliminary information for the 2001-2002 season indicates that by mid-October, fall tomato acreage totaled 10,300 acres, slightly above (103%) the preceding season at the time of reporting (FASS, October, 2001). Winter acreage totaled 12,500 acres statewide, lower by 11% than the preceding season at reporting time (FASS, January, 2002). These preliminary data cover the periods of greatest planting activity, but do not include plantings made during late October and November in the fall or after January in the winter and spring cycles. Typically, plantings made in the late fall are small because of the high risk of severe frost or freeze damage during December and January, when the crops would be at especially sensitive development stages (Glades Crop Care, Inc., unpublished data).

Crop value

Florida's tomato crop makes a large contribution to the value of Florida agriculture in general and of the vegetable industry specifically. For the 2000-2001 growing season, average production of 1,456 25-lb cartons per acre, bringing $9.22 per carton, yielded a total value of $588,021,000 for the season. As in most seasons, the value per carton varied significantly during the season, ranging from $10.86 to $8.53 in the fall and spring seasons, respectively. This represents approximately 40% of the total value of Florida's vegetable production for that season (FASS, February, 2002).

Geographical growing region

During the 2000-2001 growing season, the most recent for which complete information is available, 43,800 acres of fresh market tomatoes were planted throughout the state. These can be broken down into fall and spring/summer crops, with 13,300 acres planted between August and December, 2000, and the remainder, 30,500 acres, planted between January and July, 2001 (FASS, February, 2002). Within Florida, there are several production districts. Production statistics for four of these districts, constituting the bulk of the production area, are provided by the Florida Tomato Committee. Acreage planted during the 2000-2001 season in these districts is as follows: District 1 (Dade County) 3,658 acres, District 2 (East Coast of Florida) 4,255 acres, District 3 (Southwest Florida) 15,180 acres, and District 4 (Tampa Bay Area) 12,817 acres. This totals 35,190 acres planted in these districts, leaving 8,610 acres planted in the remainder of the state, with the bulk of these acres occurring in Florida's Panhandle northwest of Tallahassee (Florida Tomato Committee, 2001).

Typical crop cycle

Tomato production in Florida can be broken into two phases, transplant production and field production. Transplants are typically grown in houses with one- or two-ply polyethylene roofs and side walls that can be lowered to protect the plants from the weather. Styrofoam or hard plastic greenhouse flats filled with growing medium are seeded, and then stacked in a cool dark place for approximately a week to allow the seeds to germinate, after which they are moved to the production houses. Water and fertilizer are usually delivered through overhead booms, which may also be used for pesticide applications. An alternative irrigation method, designed to reduce the spread of bacterial spot disease, involves placing the flats in troughs, which can be filled with water for irrigation and fertilization, thus eliminating the overhead booms. In addition to the overhead booms, tractor-mounted hand guns are used to apply pesticides.

Beginning two to three weeks after seeding, irrigation and fertilization are adjusted to harden the plants. This hardening process is critical if the transplants are to survive the shock of being moved out of the production house to the field. Transplant production usually requires four weeks during summer and early fall. During the cooler winter and early spring months, five or more weeks may be required. Although good survival is usually obtained with planting densities of 100-125 plants per square foot, recent development of mechanized planting machines, which require larger, sturdier transplants, have made densities of 72 plants per square foot more popular. This trend has significantly increased the amount of greenhouse space needed for tomato transplant production in recent years (GCC). Seeding for transplant production begins in mid- to late June (for August and September plantings) and continues through mid March (for the spring crop in the north Florida growing area).

Florida's environment ranges from sub-tropical to temperate, thus allowing some level of tomato production virtually year-round. Two main planting periods occur, except in the Dade County growing area where there is only one. Several factors contribute to this difference with the rest of the state. Dade County has a longer period of warm and wet weather, which favors disease and can have negative environmental impacts on the plants. Also contributing are lower land values and a more direct competition with Mexico. Growers in Dade County are likely to grow tomatoes in different locations if they want to produce tomatoes for a longer period or will produce a different crop after tomatoes. An approximate field planting schedule is presented in Table 1 (GCC). Prior to planting fields are prepared by disking and, in areas with flat terrain, laser leveling is performed every 2 years (GCC, 1999). Transplants are set in beds covered with plastic mulch, which helps maintain favorable soil temperatures and moisture while protecting against fertilizer leaching. Usual plant populations range from 4,000-5,000 plants per acre.

At approximately 4 weeks after transplanting the crop may be pruned, depending on the variety. Pruning entails removing by hand one or more axillary branches from the base of the plant. The number of branches removed depends on the variety and growing conditions. After pruning, the plants are provided with support by staking and tying. Further support strings are applied on roughly 2-week intervals. For exceptionally tall-growing cherry and grape tomato varieties, up to 8 strings may be needed. These tall-growing varieties may also be topped, where the portion of the crop above 6 feet high is removed using clippers or machetes. Topping is performed on less than 20% of the acreage of these varieties in southwest Florida (GCC).

The interval between transplanting and harvesting varies according to the season and variety. Crops grown during warm spring and summer months take an average of 10-11 weeks to reach the mature green fruit stage, the stage when most of Florida's crop is harvested. For August and September plantings, this period averages 12 weeks, and may extend to 14 weeks for November and December plantings. For Roma and round tomatoes, harvesting occurs in two phases. Fruits past the breaker stage are removed first, then the mature green fruits are removed. At 10-14 days after the mature green harvest this process is repeated for most acreage. Under exceptionally good market conditions, a third harvest may be taken. Cherry and grape tomatoes are harvested at or near full maturity. As a result, these varieties are harvested on a 2-3 day interval. Similar practices are used for greenhouse-grown tomatoes, which are also harvested near full maturity. After the desired number of harvests the plastic mulch is removed from the beds, and the crop is destroyed quickly by applying an herbicide. After the foliage has desiccated the strings are removed by hand or burned off using a propane-fueled gas burner. Once the stakes have been pulled and stacked the field is disked several times to insure that the crop residue fully decays before the next crop cycle begins (GCC 1999).

Worker Activities

Field preparation - cultivation

Cultivation of fields to be used for tomato production is performed mechanically. Disking is performed several times depending on environmental conditions and field needs. Fields may be laser leveled shortly before planting. Final pre-plant field preparation begins with a final disking, after which irrigation/drainage ditches are dug. These operations involve minimal worker exposure, except where irrigation is supplied by open "V ditches". In these cases, the banks of the V ditches are cut approximately every 100 feet to allow rapid surface water drainage. Most growers cut these "shovel ditches" mechanically, although a few still rely on hand laborers using shovels. Hand labor becomes involved when the shovel ditches are lined with plastic sheets to reduce soil erosion. V ditch irrigation is used on approximately one third of tomato acreage in south Florida. In hilly parts of the state where this is impractical, semi-closed or drip irrigation is used (GCC, 1999).

Hand weeding is seldom needed, given the current practices of plastic mulching and soil fumigation with methyl bromide or an alternative fumigant. Weeds that are not controlled by these means are generally controlled using directed herbicide sprays (GCC).

Field preparation - fumigation and bed preparation

Fumigation and bed preparation will be discussed together, since in most cases the operations occur simultaneously. Where methyl bromide is to be used, the usual procedure is to spread part of the fertilizer, then shape false beds. These operations require only the equipment operators and others involved with filling fertilizer hoppers. The next step is to inject the fumigant, seal the soil surface using a bed press and lay down bands of dry fertilizer on the top of the bed surface. This step usually involves only the driver and possibly one assistant. The final operation involves covering the newly fumigated bed with plastic mulch. Where drip irrigation is used, the drip tubes are also laid down at this time. The mulching operation involves several hand laborers who seal the plastic mulch at the ends of the beds, cut shovel ditches across the newly mulched beds, replace rolls of mulch and repair tears. As most farmers use equipment that prepares three beds at each pass, there is usually a minimum of 10-15 people working on the newly laid beds (GCC).

The use of alternatives to methyl bromide is increasing throughout Florida and may result in changing levels of worker involvement. The most commonly used alternative fumigation techniques involve much the same types of equipment and labor operations. Depending on the fumigant being used, however, worker exposure risks may vary. For example, metam sodium may be applied through drip irrigation tubes, basically limiting exposure to one or two workers involved in operating the injection equipment. Similarly the nematicide1,3 dichloropropene may be applied broadcast under a whole-field tarp. After that tarp is lifted, final bed preparation is performed using only chloropicrin fumigant under the final mulch, where the greatest risk of worker exposure occurs.

Transplant handling

Transplants are handled minimally in order to avoid spreading foliar diseases. During the transplant production cycle, worker involvement begins with filling and seeding the greenhouse flats. This usually involves 6 workers. Placing the flats into the greenhouse and then removing them for shipment may involve up to 8 workers, depending on the size of the planting. Additional workers involved in transplant production include single personnel who perform stand counts, run irrigation equipment, apply pesticides and provide supervision.
Setting transplants in the field is performed in several ways throughout Florida. Over 80% of transplanting is done using a "setting rig". This equipment perforates the plastic mulch at specific intervals, applies a water drench, carries flats of transplants and transports the workers who manually set them into the beds. Such setting operations typically involve at least 14 workers, and can cover 10-15 acres per day.

Mechanical setting rigs involve 8 workers who operate the equipment and place the transplants into the setting mechanism. Besides the lower number of workers needed, mechanical rigs also minimize worker contact with the soil or drench solution. They also travel faster, covering 15-20 acres per day.

A final transplanting method involves puncturing the plastic mulch with a wheel fitted with spikes. Workers then walk through the field and place the transplants into the holes without the benefit of the transportation provided by setting rigs. This method is generally used for small plantings or during rainy weather when drenching the transplants is not necessary.

Irrigation

Worker involvement in irrigation varies according to the production stage and the type of irrigation used. During transplant production, one person is able to perform irrigation for several houses full of transplants. At transplanting, the newly set plants are irrigated with a drench that usually contains a weak fertilizer solution and in some cases a fungicide or insecticide.

Depending on the delivery system, this transplant drench will involve at least one mixer/loader, and the tractor driver. If the drench is applied immediately before the transplant is set in the soil, up to 12 additional workers may be incidentally involved.

In production fields with open ditch irrigation, worker involvement is limited to daily checking of wells used to monitor the depth to the perched water table and operating the pumps and risers used to adjust it. Responsibility for these operations is usually assigned to one person for a small farm or a series of fields.

Semi-closed irrigation involves more hand labor in setting up the system, since water is delivered through a series of buried pipes, which must be connected to taps at the head of each irrigation ditch. This is performed before bed preparation planting and may involve up to 5 people. Once a semi-closed system is operating, worker involvement is usually limited to single-man jobs, including pump operation, water table monitoring, maintenance of the piping system and ditch maintenance, which is performed with tractor drawn plows.

Drip irrigation systems involve workers at several points. While the drip tubes are placed on each bed at the same time as the plastic mulch, final connection to the water delivery system occurs just before or shortly after the transplants are set. The number of workers involved in this operation will vary according to the size of the farm. Daily system operation involves usually one person who is responsible for scheduling and running the pumps and injectors which are used to deliver fertilizer. Additional personnel are used to monitor and maintain system performance, usually involving one or two people daily.

Pruning

Pruning involves removal of one or more branches from the base of the plant. Approximately 90-95% of all tomatoes are pruned, depending on the variety and growing conditions. Exceptions include cherry, grape and sometimes Roma tomato varieties, and plantings that have suffered cold, drought or phytotoxicity stress shortly after transplanting. Pruning occurs at about the fourth week after transplanting, when the first set of flower buds has swollen. This operation requires that a worker touch every plant in his assigned work area. Work crews vary in size according to the size of the field.

Staking and tying

A series of stakes and strings supports the tomato plant above the mulched bed. Although expensive, this improves crop health and productivity and reduces the risk of food-borne illness by keeping the crop from touching the soil. Stakes are usually driven into the beds before the crop is pruned. Crews of 8-10 workers first loosely poke the stakes into the bed. They are followed by similar-sized crews who hammer the stakes firmly into the soil, using mallets, iron pipe stake drivers or, most commonly, pneumatic hammers. The pneumatic hammers are suspended from a boom which usually spans 6 rows. The boom and the air compressor that powers the hammers are pulled through the field by a tractor.

Round tomatoes are usually tied three or four times, depending on crop height. Tall-growing varieties may receive up to eight ties. The first tie is usually applied shortly after pruning has occurred, around the opening of the first blooms. Subsequent ties are added at roughly two-week intervals. The fourth tie, if needed is applied just before or immediately following the first harvest. Tying tomatoes involves pulling the twine from its storage box and through a wand with a hole at either end. The loose end of the twine is anchored to the stake at the end of the row. Then, using the wand to reach over the top of the stakes, the string is wrapped around each stake along one side of the row. At breaks in the row, usually at shovel ditches, the worker turns around and repeats the process along the other side of the row. Usually each worker is assigned a group of rows to tie, and the size of the tying crew varies according to the acreage to be tied.

Pesticide application

During transplant production pesticide applications are made using either the overhead irrigation boom or a tractor-mounted hand gun. Where the boom is used, only one person is usually involved in making the application. For hand gun applications, one or two persons may be needed.

Following fumigation and bed preparation, several pesticide application methods are available during the field phase. The most common of these are tractor-drawn boom sprayers and injection through drip irrigation lines. Usually only one person is involved with either of these application methods, i.e., one person performs mixing, loading and makes the final application. A few operations mix pesticides in a nurse tank for distribution to several pieces of spray equipment. In these cases, an additional person is involved. Finally, most farms have at least one supervisory person who takes care of scheduling, oversight and maintenance for the application crew.

Other application methods may be used, especially for soil applied fungicides and insecticides, depending on the pesticide being used and the need for accuracy and uniformity of application. During transplanting, pesticides, especially imidacloprid, used to manage the silverleaf whitefly, may be added to the transplant water along with a starter fertilizer. This solution is applied to the soil through a hollow wheel fitted with spikes. The spikes puncture the plastic mulch and make a hole to accept the transplant. Where mechanical setters have been put into use, worker exposure to this solution is minimal. Where old-style setting rigs are used, workers are required to wear protective clothing, notably gloves.

Harvesting

Fresh market tomatoes are harvested by hand. Harvesting crews vary in size from as few as 12 workers to more than 100, depending on the grower's needs. In harvesting mature green tomatoes, the typical practice is to assign one worker to one side of each row. The tomatoes are removed from the plant, placed in a harvesting bucket and carried to the harvesting truck. There they are placed in a gondola or into bins and hauled to the packinghouse. In addition to the harvesters, a driver and one or two "dumpers" work on the truck, and the harvest crew leader provides supervision. Mature green tomatoes are usually harvested twice with 10 to 14 days between harvests.

Red-ripe fruit harvesting from fields destined for mature green harvesting occurs on roughly the same schedule, and involves approximately the same number of workers. Fruit handling is greater with red-ripe harvesting, since these are usually field-packed. Thus each fruit will be handled twice, once by the picker and once by the sorter/packer. Harvesting of heirloom, cherry and grape tomatoes differs little from that of mature green tomatoes, except that, because of the smaller fruit size and generally smaller acreage in each planting, the pace of the harvest is slower, with each harvester handling fewer plants. However, these varieties are harvested on 2- to 3-day intervals compared to the longer interval with mature green tomatoes.

Crop destruction

The need to manage Silverleaf Whiteflies and the highly destructive Tomato Yellow Leaf Curl Virus they transmit makes rapid crop destruction a necessity once harvesting is finished. The usual practice is to desiccate the crop as quickly as possible by removing the plastic mulch, curtail irrigation and apply an herbicide. These operations usually occur within a week after the final harvest. When the crop is desiccated, the strings are cut or burned and the stakes are removed. Worker involvement is greatest in removing mulch, followed by cutting strings and removing stakes. For the latter two operations, worker involvement is variable because of varying levels of mechanization.

Scouting

Nearly all of Florida's tomato acreage is scouted regularly by farm personnel or independent professionals (GCC, 1999). Standard practice, based on professional experience and recommendations from the University of Florida, is to scout fields twice per week (GCC, unpublished data; Pernezney, et al., 1996). Although evaluation techniques may vary among farm personnel or professional services, scouts handle many plants throughout the day accumulating 6 - 7 hours of plant contact. While workloads may vary, scouts will be active at least 5-6 days per week at the peak of the season in any of the production areas. Approximately 50 professional tomato scouts currently work in Florida, along with an estimated 20 farm personnel. Even though scouts have been exempted from the requirements of the Worker Protection Standards, most employ a certain level of personal protection eg., appropriate attire and gloves, because of frequent crop handling.

Pesticide type used in the crop (active ingredient)

A survey of pesticide use in tomatoes was conducted by Glades Crop Care, Inc. in 1999, covering the 1997-98 growing season (GCC, 1999). The results of that survey are summarized in Tables 3, 4 and 5. The information in these tables summarizes pesticide use in the major production areas of southern Florida. While pesticide programs in Florida tomatoes follow the basic pattern shown in Table 5, one significant regional difference bears mention. This is the use of methamidophos for management of western flower thrips and Tomato Spotted Wilt Virus in Northern Florida. Whereas the use of this insecticide has been practically eliminated in the southern part of the state, its use is vital in the Panhandle area. There most acreage receives nearly the full amount allowed by the label (GCC).

The pesticide profile for Florida's tomato crop has changed somewhat since then with the addition of several new active ingredients and shifts in soil fumigant use. New insecticides include indoxacarb for armyworm and tomato pinworm control and include pyriproxifen,

buprofezin, pymetrozine and thiamethoxam for the control of silverleaf whiteflies. Soil fumigant use has begun shifting from the nearly exclusive use of methyl bromide and chloropicrin with the increasing use of alternatives, including primarily 1, 3-dichloropropene and metam sodium. The use of pebulate, an old herbicide which was infrequently used in recent years, has increased as part of the most frequently recommended methyl bromide alternative program in addition to 1,3-dichlorpropene. In the past few months, Gavel 75DF, a packaged mixture of mancozeb and zoxamide, has been used in a few fields to control late blight (GCC).
An updated summary of active ingredients is presented in Table 6.

Pests and Their Impact

In a survey conducted in 1999, south Florida growers were asked to list those pests that had a significant impact on their tomato crops. All growers described levels of pest activity, the frequency with which they occur and the damage they produce. The impact of key pests on the tomato production system was significant, with growers' estimates of potential yield loss totaling 24.6%. A 25% loss over the long term not only strains the economic well being of the farming industry, but puts pressure on south Florida's fragile environment. One expression of this is the greater acreage that therefore must be farmed to meet market demands, as well as the additional inputs needed to keep losses from going higher.

The economic impact of these pests costs growers 9056 pounds of tomatoes per acre, or over 4½ tons, which at 1997-98 prices equaled $3,382 per acre in lost revenue. Of the surveyed growers' 9293 acres the revenue loss to pests totaled over $31 million annually. Clearly growers are justified in their pest management efforts, given the magnitude of these losses (GCC, 1999).

Insects

Silverleaf Whitefly (*Bemisia argentifolii):* The silverleaf whitefly ranked highest for both acreage infested (90.9%) and lost yield (2.3%). Yield loss was attributed to 1) lost plant vigor and Tomato Irregular Ripening, a malady caused exclusively by the feeding of immature silverleaf whiteflies and 2) vectoring geminiviruses, primarily Tomato Yellow Leaf Curl Virus. The vector is controlled adequately with chemical insecticides, although lapses in cultural control practices can result in high pest populations and excessive disease levels. The primary chemical control is imidacloprid (Admire, Provado, Bayer), although thiamethoxam (Platinum, Actara, Syngenta) has been applied in some fields on a trial basis. Chemical alternatives to imidacloprid are used 6 to 8 weeks after transplanting, when the efficacy of the initial imidacloprid application declines. These include endosulfan, several pyrethroids, such as esfenvalerate (Asana, DuPont) and permethrin (Ambush, Syngenta; Pounce, FMC), which may be tank-mixed with methamidophos (Monitor, Bayer), and the biorational soap or detergent. Soap is especially favored when adult whiteflies increase during the harvest. Use of the reduced risk insecticide, pymetrozine (Fulfill, Syngenta) and the insect growth regulators, buprofezin (Applaud, Aventis) and pyriproxyfen (Knack, Valent) has been adopted, at least on a trial basis on most farms (GCC, 1999 and unpublished data).

Alternative practices for silverleaf whitefly and TYLCV management include prompt crop destruction, field selection and crop scheduling. High land values and marketing demands make the latter two practices difficult to implement. However, most growers conscientiously destroy fields shortly after harvesting is completed. (GCC, 1999).

Lepidpoterous larvae: Several species of lepidopterous larvae are common tomato pests in south Florida and include the beet armyworm, *Spodoptera exigua*, and the southern armyworm, *S. eridania*. The tomato pinworm, *Kieferia lycopersicella*, has, through improved management methods, declined in importance in south Florida in recent years. These three species infested up to 77.2% of the surveyed acreage, and caused losses of 1.2% (GCC, 1999). Fruit feeding is important, although defoliation by the southern armyworm can reduce crop vigor. Control relies heavily on *Bacillus thuringiensis* based products, often applied every 3-4 days during peak populations. Traditionally, methomyl (Lannate, DuPont) or chlorpyrifos (Lorsban, Dow AgroSciences) were applied to eliminate mature larvae, which are less susceptible to B.t., but with the recent introduction of the reduced risk spinosad (Spintor, Dow AgroSciences), tebufenozide (Confirm,) and indoxacarb (Avaunt, DuPont) use of these materials has been reduced. Tomato pinworm control has been greatly enhanced in recent years by pheromones, used in traps for monitoring populations and for mating disruption when thresholds have been exceeded.

Leafminer (*Liriomyza* spp.): Leafminer larvae feeding inside the leaf tissue cause reduced leaf surface and predispose the plant to attack by disease pathogens. Growers estimated losses to leafminers at over 1% with 89.5% of their acreage infested. Although losses were relatively low, control costs were significant (GCC, 1999). Current resistant management practice includes rotation of avermectin (Agrimek, Syngenta), cyromazine (Trigard, Syngenta) and spinosad. An average of 2 applications is needed to maintain control for a given planting. Applications are more frequent during the critical spring crop establishment period, when high numbers of leafminer adults invade newly planted fields from the adjacent fall crop. An encouraging development in alternatives for leafminer control has resulted from the high level of control of whiteflies and worms by the “soft” chemistries of imidacloprid and *B.t.*, respectively, resulting in increased activity of parasitic wasps, *Diglyphus* sp, which parasitize the larvae and thus help control leafminers. Because of the parasitic activity of the wasps, leafminer control sprays are needed less often and later in the crop than in the past.

Thrips (*Frankliniella spp., especially western flower thrips (WFT), F. occidentalis):* Thrips infest tomatoes primarily during the spring months when they often invade fields in massive numbers. Population peaks are often correlated to flowering in alternate hosts, such as citrus. Economic damage in southwest Florida is usually limited to minor egg-laying wounds on the fruit. In other parts of the state, primarily north Florida, the transmission of Tomato Spotted Wilt Virus is a major concern. This disease is transmitted by several species of thrips, of which WFT is the most important. Because of insecticide resistance in this species, a rigorous insecticide application regimen is needed. While spinosad has been found to be partially effective against WFT, tank mixtures of pyrethroids with methamidophos are applied frequently as part of a pesticide resistance management rotation. Such use of methamidophos in Florida is limited to the northern growing area (GCC, 1997 and unpublished data).

Plant diseases

Bacterial Spot: Bacterial spot disease, caused by *Xanthomonas campestris* pv *vesicatoria*, is currently the most destructive causing defoliation, fruit damage and reduced fruit set if flower parts become infected. The disease is spread rapidly by splashing rainfall and mechanically, such as during pruning or other hand-labor operations. In 1999, the estimated loss to this disease was 8.7% of potential yield, with 97.2% of the acreage affected (GCC, 1999). Control practices include prompt crop destruction after harvesting is completed, attention to field sanitation, control of volunteer tomatoes, sanitation for hand laborers and the application of tank mixes of copper and mancozeb. The pathogen's tolerance to copper-based fungicides hampers chemical control of bacterial spot. The addition of mancozeb to copper in the spray tank improves the efficacy of the copper fungicide, but the results are often inadequate. Alternatives to this fungicide standard include a viral pathogen of the bacterial spot pathogen, Agriphage (Agri-phi, Logan, Utah) and systemic acquired resistance chemistry currently under development (Messenger, Eden Biosciences; Actigard, Syngenta). Bacteriaphage treatment is widely used successfully in transplant houses but acceptance in the field has been slow primarily due to special requirements for efficacy to apply while dew is on the plant and temperatures are cool. Such applications require spraying before sunrise, which is difficult.

Early Blight and Target Spot: Fungal diseases affecting foliage and fruit, early blight (*Alternaria solani*) and target spot (*Corynespora cassiicola*), rank next in importance to bacterial spot. Target spot is more severe in the fall, when extended periods of leaf wetness, required for disease development, are more likely. Early blight is more severe during cooler, drier conditions in the winter and early spring. Early blight and other *Alternaria* diseases are controlled with copper and mancozeb, while target spot control requires well timed applications of chlorothalonil. The only effective alternative fungicides are the strobilurin fungicides, azoxystrobin (Quadris, Syngenta). This new, reduced risk fungicide family is effective against early blight, but provides inadequate control of target spot (GCC, 1999).

Late blight *(Phytophthora infestans):* Late blight occurs sporadically during the cool winter and spring months and can cause rapid and severe defoliation and fruit damage if improperly treated. Several biotypes of the pathogen occur. Due to differential susceptibility to fungicides among these biotypes, control practices may need to be tailored to the situation. The US 17 biotype, which has most recently attacked tomatoes in south Florida, is best controlled using chlorothalonil. Alternative fungicides, such as the strobilurins and dimethomorph (Acrobat, BASF) may not provide the same level of disease control, but have been incorporated into a rotation to reduce risks of pesticide resistance along zoxamide (Gavel, Dow AgroSciences), which recently received an emergency registration. Losses to late blight were low during the 1997-98 season, but long-term growers estimate 9.6% of acreage affected and 1.1% yield lost (GCC, 1999 and unpublished data).

Fusarium crown rot (*Fusarium oxysporum f sp radicis-lycopersici):* In the 1999 survey, Fusarium crown rot (FCR) affected 40% of the surveyed acreage, causing an average yield loss of 2.6%. This disease reduces crop vigor and causes plant loss throughout the crop cycle. Most destruction occurs in the final weeks of production when fruit sizing and harvesting stress the plant's root system. Control of FCR relies on several practices, beginning with proper soil fumigation (67:33 methyl bromide:chloropicrin is preferred, although 1-3 dichlopropene (Telone, Dow Agrosciences) has also proven effective when formulated with chloropicrin) followed by avoiding root damage through close attention to water and fertilizer management. The use of crown rot resistant varieties is increasing, but is currently not widely accepted due to horticultural characteristics that make these varieties less competitive than standard varieties (GCC, 1999 and unpublished data).

Southern Bacterial Wilt (*Pseudomonas solanacearum*) Southern bacterial wilt infects tomato roots and the lower stem at the soil line. Plants become stunted, then rapidly wilt and die. The soil-borne bacterial pathogen is especially prevalent in northern Florida and has numerous weed and crop hosts. It spreads by ditch or run-off water and normally infects roots through wounds caused by cultivation or nematodes. The pathogen can also move through water in the soil. Root-to-root infections also occur. This disease is favored by warm (86-90ºF) and wet weather in late spring or early fall. It favors high fertility levels and a low soil pH. The pathogen persists in field soil for many years. Long crop rotations and the use of resistant varieties are the only practical control methods (GCC, unpublished data).

Tomato Yellow Leaf Curl Virus (TYLCV): Symptoms of TYLCV are usually severe. Initial symptoms include marginal bands of chlorotic tissue in the new growth. These young leaves become cupped and stunted. This stunting can be severe, resulting in tomato plants that look like broccoli. Flowers produced following infection are likely to abort, thus eliminating further production from infected plants. Management considerations are discussed under silverleaf whiteflies above (GCC, 1999 and unpublished data)

Tomato Spotted Wilt Virus (TSWV): TSWV is transmitted in a persistent manner by several species of thrips. In Florida these include the tobacco thrips, *Frankliniella fusca*, the western flower thrips, *F. occidentalis* and the onion thrips, *Thrips tabaci*. The Florida flower thrips, *F. bispinosa* has been shown to be capable of transmitting the disease in the laboratory, but its importance as a vector in the field has not been demonstrated. The disease cycle in the host is peculiar, as the virus can only be acquired during the thrips larval stage. Transmission is only possible during the adult stage.

TSWV has a very large host list, containing over 300 species. Symptoms include death of the growing points, necrotic ringspotting and bronzing of foliage and characteristic ringspotting on fruits. In north Florida, the peanut crop serves as a significant reservoir for TSWV inoculum, which is reintroduced into vegetable crops annually by thrips migrating from peanut volunteers. Such a prevalent reservoir has not been identified in south Florida, where disease levels are typically much lower. TSWV incidence is sporadic in Dade County.

Owing to the complex disease cycle, management of TSWV requires several strategies, including locating fields away from possible inoculum sources, using resistant varieties and disease-free transplants (GCC, 1997).

Weeds

In addition to volunteer tomatoes, which serve as plant disease reservoirs, the most important weeds in Florida tomatoes are black nightshade, *Solanum nigrum*, and nutsedge, *Cyperus* spp., followed by grasses. Losses to weeds arise primarily through competition for resources, which results in reduced crop vigor. Generally methyl bromide fumigation provides adequate control of nutsedge. Directed sprays of paraquat dichloride (Gramoxone Extra, Syngenta) and metribuzin (Sencor, Bayer) generally provide adequate control of nightshades, grasses and other weeds. Alternatives to these herbicides are available. Perhaps the most promising is glyphosate (Roundup, Monsanto) used as a chemical fallowing material during the off season. With the impending loss of methyl bromide, the use of pebulate (Tillam, Syngenta) in combination with 1, 3-dicloropropene is required to manage nutsedges, which are not controlled by this fumigant (Gilreath, et al., 1997; GCC, 1999 and unpublished data).

Nematodes

Root Knot Nematode (*Meloidogyne spp.)*: The major nematode pest of tomato is the root knot nematode, which produces characteristic root galls and can limit yields. Their impact in recent years has been minor because of the high efficacy of methyl bromide fumigation. The most promising alternative to methyl bromide at present is 1,3-dichloropropene (Telone, Dow AgroSciences). Field testing is under way throughout south Florida and Telone is expected to become widely used when methyl bromide is phased out. Recent surveys indicate that root knot nematode infestations can be sporadic and highly localized, thus presenting the possibility of achieving control with spot treatments (Noling, 1997; GCC, 1999 and unpublished data).

Post harvest pests

The major post-harvest pest affecting fresh market tomatoes is soft rot caused by *Erwinia* sp. bacteria. There are no pesticide treatments specifically applied to manage soft rot. Rather its incidence is managed by production of fruits that are free of insect or plant disease damage. Further protection is afforded by the use of proper sanitation and temperature control during the packing process (Kucharek & Bartz, 1994).

Graphical Crop Timeline

Graphical Tomato Production Timeline for Southwest Florida.

Activity	Jan				Feb				Mar				Apr				May				Jun				Jul				Aug				Sep				Oct											
Field Preparation	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1							
Disking	x	x	x	x																							x	x	x	x	x	x	x	x	x	x	x	x	x	x	x							
Leveling	x	x	x	x																							x	x	x	x	x	x	x	x	x	x	x	x	x	x	x							
Fumigation, Bedding	x	x	x	x																									x	x	x	x	x	x	x	x	x	x	x	x	x							
Transplant Production																																																
Seeding	x	x	x	x	x	x	x	x	x	x													x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x							
Irrigation	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x							x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x							
Pesticide Applications	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x							x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x							
Shipping	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x											x	x	x	x	x	x	x	x	x	x	x	x	x	x							
Field Production																																																
Transplanting	x	x	x	x	x	x																									x	x	x	x	x	x	x	x	x		x							
Pruning		x		x	x	x	x	x	x	x																									x	x	x	x	x	x	x							
First Tie		x		x	x	x	x	x	x	x																									x	x	x	x	x	x	x							
Second Tie		x		x		x	x	x	x	x	x	x																									x	x	x	x	x							
Third Tie		x		x		x		x	x	x	x	x	x	x																									x	x	x							
Fourth Tie	x		x		x		x	x	x	x	x	x	x	x	x																										x							
Harvesting	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x																												
Pesticide Application	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x											x	x	x	x	x	x	x	x	x	x	x							
Remove Mulch	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x																									
Burndown	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x																									
Remove Strings, Stakes	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x																								

Graphical Crop Timeline

Graphical Tomato Production Timeline for South Florida.

Activity	Jan				Feb				Mar				Apr				May				Jun				Jul				Aug				Sep				Oct											
Field Preparation	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1							
Disking																															x	x	x	x	x	x	x	x	x	x	x							
Leveling																															x	x	x	x	x	x	x	x	x	x	x							
Fumigation, Bedding																																	x	x	x	x	x	x	x	x	x							
Transplant Production																																																
Seeding																														x	x	x	x	x	x	x	x	x	x	x	x							
Irrigation																															x	x	x	x	x	x	x	x	x	x	x							
Pesticide Applications																															x	x	x	x	x	x	x	x	x	x	x							
Shipping																																			x	x	x	x	x	x	x							
Field Production																																																
Transplanting																																			x	x	x	x	x	x	x							
Pruning	x		x																																				x	x	x							
First Tie	x		x																																				x	x	x							
Second Tie	x	x	x			x																																			x							
Third Tie	x	x	x			x		x																																								
Fourth Tie	x	x	x	x	x		x		x																																							
Harvesting	x	x	x	x	x	x	x	x	x	x	x	x	x	x																																		
Pesticide Applications	x	x	x	x	x	x	x	x	x	x	x	x	x	x																					x	x	x	x	x	x	x							
Remove Mulch					x	x	x	x	x	x	x	x	x	x	x																																	
Burndown					x	x	x	x	x	x	x	x	x	x	x	x																																
Remove Strings, Stakes					x	x	x	x	x	x	x	x	x	x	x	x	x																															

Graphical Crop Timeline

Graphical Tomato Production Timeline for Central and East Coast Florida.

Activity	Jan				Feb				Mar				Apr				May				Jun				Jul				Aug				Sep				Oct											
Field Preparation	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1							
Disking	x	x	x	x																							x	x	x	x	x	x	x	x	x	x	x	x	x	x	x							
Leveling	x	x	x	x																							x	x	x	x	x	x	x	x	x	x	x	x	x	x	x							
Fumigation, Bedding	x	x	x	x																									x	x	x	x	x	x	x	x	x	x	x	x	x							
Transplant Production																																																
Seeding	x																						x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x							
Irrigation	x	x	x	x	x	x																		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x							
Pesticide Applications	x	x	x	x	x	x																		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x							
Shipping	x	x	x	x	x	x																						x	x	x	x	x	x	x	x	x	x	x	x	x	x							
Field Production																																																
Transplanting				x	x	x																						x	x	x	x	x	x	x	x	x												
Pruning								x	x	x																						x	x	x	x	x	x	x	x	x								
First Tie								x	x	x																						x	x	x	x	x	x	x	x	x								
Second Tie										x	x	x																						x	x	x	x	x	x	x	x							
Third Tie												x	x	x																						x	x	x	x	x	x							
Fourth Tie														x	x	x																						x	x	x	x							
Harvesting																x	x	x	x	x																				x	x							
Pesticide Application				x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x								x	x	x	x	x	x	x	x	x	x	x	x	x	x							
Remove Mulch																x	x	x	x	x	x	x	x																									
Burndown																x	x	x	x	x	x	x	x																									
Remove Strings, Stakes																x	x	x	x	x	x	x	x	x																								

Graphical Crop Timeline

Graphical Tomato Production Timeline for North Florida.

Activity	Jan				Feb				Mar				Apr				May				Jun				Jul				Aug				Sep				Oct											
Field Preparation	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1							
Disking							x	x	x	x	x	x													x	x	x	x	x	x	x	x																
Leveling							x	x	x	x	x	x													x	x	x	x	x	x	x	x																
Fumigation, Bedding									x	x	x	x	x	x													x	x	x	x	x	x																
Transplant Production																																																
Seeding																																																
Irrigation																																																
Pesticide Applications																																																
Shipping																																																
Field Production																																																
Transplanting											x	x	x	x	x	x													x	x	x	x	x	x														
Pruning														x	x	x	x	x	x														x	x	x	x	x	x										
First Tie														x	x	x	x	x	x														x	x	x	x	x	x										
Second Tie																x	x	x	x	x	x														x	x	x	x	x	x								
Third Tie																		x	x	x	x	x	x														x	x	x	x	x							
Fourth Tie																				x	x	x	x	x	x															x	x							
Harvesting																						x	x	x	x	x	x														x							
Pesticide Application											x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x							
Remove Mulch	x	x	x																							x	x	x	x	x	x																	
Burndown	x	x	x																							x	x	x	x	x	x																	
Remove Strings, Stakes	x	x	x																								x	x	x	x	x	x																

Bibliography

Florida Agricultural Statistics Service. February 4, 2002. Vegetables: Acreage, Production and Value. Florida Agricultural Statistics Service 1222 Woodward Street, Orlando, FL 32803.
Florida Agricultural Statistics Service. January 15, 2002. Vegetables: Winter Acreage. Florida Agricultural Statistics Service 1222 Woodward Street, Orlando, FL 32803.
Florida Agricultural Statistics Service. October 10, 2001. Vegetables: Acreage-Fall Quarter. Florida Agricultural Statistics Service 1222 Woodward Street, Orlando, FL 32803.
Florida Tomato Committee. 2001. Annual Report, 2000-2001. Florida Tomato Committee, P.O. Bo 140635, Orlando, FL 32814-0635.
Frantz, G., and T. Fasulo. 1997. Thrips Knowledgebase. Available at http://www.gladescropcare.com/pg1.html
Gilreath, J.P., J.P. Jones, J.W. Noling, and P.R. Gilreath. 1997. Alternatives to methyl bromide for management of weeds. 1997 Florida Tomato Institute Proceedings. C.S. Vavrina, P.R. Gilreath and J.W. Noling, Editors. University of Florida, Gainesville, PRO 110, Pages 34-35.
Glades Crop Care, Inc. 1999. Crop Profile for South Florida Tomatoes. Available at http://www.gladescropcare.com/CP_tomatoes.pdf
Kucharek, T. and J. Bartz. 1994. Bacterial Soft Rots of Vegetables and Agronomic Crops. Fact Sheet PP-12, Plant Pathology Department, Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida.
Noling, J.W. 1997. Alternatives to methyl bromide for nematode control. 1997 Florida Tomato Institute Proceedings. C.S. Vavrina, P.R. Gilreath and J.W. Noling, Editors. University of Florida, Gainesville, PRO 110, Pages 27-29.
Pernezny, K, D. Schuster, P. Stansly, G. Simone, V. Waddill, J. Funderburk, F. Johnson, R. Lentini, and J. Castner. 1996. Florida Tomato Scouting Guidewith Insect and Disease Identification Keys. University of Florida, available at http://FTSG.ifas.ufl.edu/intro.html.
United States Department of Agriculture/Agricultural Marketing Service. 1991. United States Standards for Grades of Fresh Tomatoes. 14 pp

Table 2. Planting schedule for Florida tomato production. “XX” indicates the period of greatest planting activity. “X
periods when planting occurs but at a lower intensity.

Growing Region	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
North Florida			XX	X			XX					
Central Florida/East Coast	X	XX					X	XX	X			
Southwest Florida	XX	X						X	XX	XX	XX	X
South Florida									X	XX	X	X

Table 3. Pesticide active ingredients applied to fall tomato crops and to tomato farms where no planting break was c
1997-98. From GCC, 1999

Pesticide type	FQPA List [z]	Active ingredient	Acres treated at least once	% of crop treated at least once	Average lb AI used per treated acre	Average number of applications	Average application rate (lb AI/A)	Ap	
								Low	
Fum		Chloropicrin	5954.00	99.58%	38.95	1.00	38.95		
Fum		Methyl Bromide	5954.00	99.58%	169.55	1.00	169.55		
Fung	b	Chlorothalonil	5771.00	96.52%	9.62	8.28	1.19		
Fung	b	Mancozeb	5691.00	95.18%	13.93	20.83	0.77		
Fung	b	Maneb	338.00	5.65%	15.95	12.50	1.03		
Fung	c	Benomyl	349.00	5.84%	0.25	1.33	0.17		
Fung		Azoxystrobin	2209.75	36.96%	0.22	2.30	0.10		
Fung		Bacteriaphage	24.00	0.40%	8.00E+10	4.00	2.00E+10	2.(	
Fung		Copper Ammonium Carbonate	210.00	3.51%	0.20	2.00	0.10		
Fung		Copper Hydroxide	5854.00	97.91%	19.54	19.87	1.06		
Fung		Copper Oxychloride	275.00	4.60%	7.98	7.00	1.14		
Fung		Copper Sulfate	404.00	6.76%	12.99	13.00	0.93		
Fung		Fosetyl Al	1273.00	21.29%	3.58	1.50	2.24		
Fung		Mefenoxam	3545.00	59.29%	0.14	1.22	0.14		
Fung		Propamocarb Hydrochloride	165.00	2.76%	0.78	1.00	0.78		

Pesticide type	FQPA List [z]	Active ingredient	Acres treated at least once	% of crop treated at least once	Average lb AI used per treated acre	Average number of applications	Average application rate (lb AI/A)	Ap	
								Low	
Fung		Sulfur	210.00	3.51%	19.47	7.33	2.47		
Herb		Diquat Dibromide	586.00	9.80%	0.38	1.33	0.30		
Herb		Glyphosate	1393.00	23.30%	1.25	1.00	1.25		
Herb		MCDS	1495.00	25.00%	33.71	1.00	33.71		
Herb		Metribuzin	4886.00	81.72%	0.61	1.13	0.54		
Herb		Paraquat Dichloride	5732.00	95.87%	0.96	1.53	0.71		
Herb		Sethoxydim	118.00	1.97%	0.23	1.00	0.23		
Ins/Mit	c	Carbaryl	125.00	2.09%	3.00	3.00	1.00		
Ins/Mit	c	Methomyl	2617.50	43.78%	0.74	1.65	0.50		
Ins/Mit	c	Oxamyl	600.00	10.04%	1.50	3.00	0.50		
Ins/Mit	o	Chlorpyrifos	1035.00	17.31%	0.44	1.25	0.38		
Ins/Mit	o	Dimethoate	38.00	0.64%	2.50	5.00	0.50		
Ins/Mit	o	Methamidophos	443.15	7.41%	1.33	1.00	1.33		
Ins/Mit		Avermectin	3704.00	61.95%	0.01	1.75	0.01		
Ins/Mit		Bt aizawi	900.00	15.05%	0.50	6.33	0.09		
Ins/Mit		Bt engineered	4610.00	77.10%	1.35	8.38	0.14		
Ins/Mit		Bt kurstaki	3526.00	58.97%	0.26	6.64	0.05		
Ins/Mit		Crop Oil	1806.00	30.21%	2.05	1.40	1.35		
Ins/Mit		Cyfluthrin	521.00	8.71%	0.08	2.50	0.05		
Ins/Mit		Cyhalothrin	1832.85	30.65%	0.10	3.50	0.03		
Ins/Mit		Cyromazine	2729.00	45.64%	0.16	1.27	0.13		
Ins/Mit		Detergent	1375.00	23.00%	1.94	3.50	0.69		
Ins/Mit		Endosulfan	1709.00	28.58%	2.37	3.15	0.79		
Ins/Mit		Esfenvalerate	909.00	15.20%	0.16	4.60	0.04		
Ins/Mit		Garlic/Sugar/Capsaicin	25.00	0.42%	9.70	2.00	4.85		
Ins/Mit		Imidacloprid	5954.00	99.58%	0.29	1.28	0.22		
Ins/Mit		Neem oil	7.50	0.13%	8.19	3.00	2.73		
Ins/Mit		Permethrin	1144.50	19.14%	0.87	9.50	0.10		

Pesticide type	FQPA List [z]	Active ingredient	Acres treated at least once	% of crop treated at least once	Average lb AI used per treated acre	Average number of applications	Average application rate (lb AI/A)	Ap	
								Low	
Ins/Mit		Piperonyl Butoxide	202.00	3.38%	3.00	12.00	0.25		
Ins/Mit		Spinosad	2394.50	40.05%	0.21	1.92	0.09		
Nem		Chitin	25.00	0.42%	132.00	1.00	132.00		

[z] b = B2 Carcinogen, c = Carbamate, o = Organophosphate

Table 4. Pesticide active ingredients applied to spring tomato crops. 1997-98. From GCC, 1999.

Pesticide type	FQPA list [Z]	Active ingredient	Acres treated at least once	% of crop treated at least once	Average lb AI used per treated acre	Average number of applications	Average application rate	Low	
Fung	b	Chlorothalonil	3189.00	96.23%	11.13	11.56	0.99		
Fung	b	Mancozeb	3264.00	98.49%	15.39	28.63	0.64		
Fung	b	Maneb	25.00	0.75%	16.60	6.00	1.13		
Fung	c	Benomyl	888.00	26.80%	0.71	2.00	0.29		
Fung		Azoxystrobin	1100.00	33.19%	0.35	3.75	0.09		
Fung		Bacteriaphage	25.00	0.75%	5.62E+11	10.00	5.62E+10	5.(	
Fung		Copper Hydroxide	3289.00	99.25%	24.37	26.00	1.06		
Fung		Copper Sulfate	203.00	6.13%	12.99	13.00	0.93		
Fung		Dimethomorph	223.00	6.73%	0.20	1.00	0.20		
Fung		Fosetyl Al	425.00	12.82%	5.36	2.00	2.68		
Fung		Mefenoxam	2203.00	66.48%	0.15	1.40	0.12		
Fung		Propamocarb Hydrochloride	301.75	9.11%	1.42	1.67	0.86		
Fung		Sulfur	25.00	0.75%	33.00	15.00	2.20		
Fum	b	Metam Sodium	25.00	0.75%	95.40	1.00	95.40		
Fum		Chloropicrin	3289.00	99.25%	28.40	1.00	28.40		
Fum		Methyl Bromide	3289.00	99.25%	181.04	1.00	181.04		
Herb		Diquat Dibromide	113.00	3.41%	0.38	1.00	0.38		
Herb		Glyphosate	400.00	12.07%	1.00	1.00	1.00		
Herb		MCDS	1100.00	33.19%	34.88	1.00	34.88		
Herb		Metribuzin	3189.00	96.23%	0.47	1.00	0.47		
Herb		Paraquat Dichloride	3066.00	92.52%	1.30	1.50	1.00		
Herb		Permethrin	316.00	9.54%	1.60	17.00	0.10		
Herb		Sethoxydim	101.50	3.06%	0.28	1.00	0.28		
Ins/Mit	c	Methomyl	1325.00	39.98%	0.68	1.67	0.38		
Ins/Mit	o	Chlorpyrifos	200.00	6.04%	0.50	1.00	0.50		
Ins/Mit	o	Dimethoate	25.00	0.75%	2.50	5.00	0.50		
Ins/Mit	o	Methamidophos	1336.75	40.34%	0.83	1.00	0.83		

Pesticide type	FQPA list [z]	Active ingredient	Acres treated at least once	% of crop treated at least once	Average lb AI used per treated acre	Average number of applications	Average application rate	Low	
Ins/Mit		Avermectin	2948.00	88.96%	0.02	2.58	0.01		
Ins/Mit		BTA	775.00	23.39%	0.46	4.50	0.10		
Ins/Mit		BTE	2976.00	89.80%	1.03	7.75	0.14		
Ins/Mit		BTK	1814.00	54.74%	0.28	5.63	0.05		
Ins/Mit		Crop Oil	1998.00	60.29%	4.05	2.13	1.75		
Ins/Mit		Cyhalothrin	1030.05	31.08%	0.08	2.50	0.03		
Ins/Mit		Cymoxanil	35.00	1.06%	0.18	2.00	0.09		
Ins/Mit		Cyromazine	1566.00	47.25%	0.28	2.20	0.13		
Ins/Mit		Detergent	1375.00	41.49%	1.94	3.50	0.69		
Ins/Mit		Endosulfan	709.75	21.42%	2.65	3.00	0.90		
Ins/Mit		Esfenvalerate	1826.00	55.10%	0.16	4.40	0.04		
Ins/Mit		Garlic/Sugar/Capsaicin	25.00	0.75%	9.70	2.00	4.85		
Ins/Mit		Imidacloprid	3289.00	99.25%	0.29	1.67	0.19		
Ins/Mit		Neem oil	7.50	0.23%	8.19	3.00	2.73		
Ins/Mit		Piperonyl Butoxide	203.00	6.13%	4.00	16.00	0.25		
Ins/Mit		Spinosad	339.50	10.24%	0.13	1.50	0.09		
Ins/Mit		TPW Pheromone	25.00	0.75%	0.04	1.00	0.04		
Nem		Chitin	25.00	0.75%	132.00	1.00	132.00		

Deleted: 132.00

[z] b = B2 Carcinogen, c = Carbamate, o = Organophosphate

Table 5. Primary chemical control practices employed against tomato pests in south Florida, 1997-98. **Boldface** ind ingredients on the FQPA target list. From GCC, 1999.

Pest	Primary control practice (Chemical name)	Trade name	Formulation	% of crop treated	Type of application	Average application rate (lb AI/A)	Average # of applications	
Diseases								
Bacterial Spot	**Mancozeb**	**Dithane DF**	**75% DF**	**95.18**	**Foliar Spray**	**0.77**	**20.83**	
	Copper Hydroxide	Kocide 101	77% WP	97.91	Foliar Spray	1.06	19.8	
Early Blight	**Mancozeb**	**Dithane DF**	**75% DF**	**95.18**	**Foliar Spray**	**0.77**	**20.8**	
	Copper Hydroxide	Kocide 101	77% WP	97.91	Foliar Spray	1.06	19.8	
Fusarium Crown Rot	Methyl Bromide			99.58	Fumigation Injection	169.55	1.0	
	Chloropicrin			99.58	Fumigation Injection	38.95	1.0	
Late Blight	Chlorothalonil	Bravo 720	6 lb AI/gal EC	96.52	Foliar Spray	1.19	8.2	
Pythium	Mefenoxam	Ridomil Gold EC	4 lb AI/ gal EC	59.29	Pre-plant Banded Spray, Post plant Injection or Spray	0.14	1.2	
Southern Blight	Methyl Bromide			99.58	Fumigation Injection	169.55	1.0	
	Chloropicrin			99.58	Fumigation Injection	38.95	1.0	
Target Spot	Chlorothalonil	Bravo 720	6 lb AI/gal EC	96.52	Foliar Spray	1.19	8.2	
Verticillium Wilt	Methyl Bromide			99.58	Fumigation Injection	169.55	1.0	
	Chloropicrin			99.58	Fumigation Injection	38.95	1.0	
Virus Diseases	Imidacloprid	Admire 2E	2 lb AI/gal EC	99.58	Transplant Drench or Foliar Spray	0.22	1.2	
White Mold	Methyl Bromide			99.58	Fumigation Injection	169.55	1.0	
	Chloropicrin			99.58	Fumigation Injection	38.95	1.0	
Insects								
Aphids	Imidacloprid	Admire 2E	2 lb AI/gal EC	99.58	Transplant Drench or Foliar Spray	0.22	1.2	
Armyworms	Bacillus thuringiensis	Dipel, Agree	Several	93.24	Foliar Spray	0.09	7.1	
Leafminers	Avermectin	Agrimek	0.15 lb AI/gal EC	61.95	Foliar Spray	0.01	1.7	
Silverleaf Whiteflies	Imidacloprid	Admire 2E	2 lb AI/gal EC	99.58	Transplant Drench or Foliar Spray	0.22	1.2	
Stinkbugs	Endosulfan	Thiodan 3EC	6 lb AI/gal EC3	28.58	Foliar Spray	0.79	3.1	
Thrips	Spinosad	SpinTor 2SC	2 lb AI/gal	40.05	Foliar Spray	0.09	1.9	

Pest	Primary control practice (Chemical name)	Trade name	Formulation	% of crop treated	Type of application	Average application rate (lb AI/A)	Average # of applications	
Tomato Pinworms	Bacillus thuringiensis	Dipel, Agree	Several	93.24	Foliar Spray	0.09	7.1	
Root Knot Nematode	Methyl Bromide			99.58	Fumigation Injection	169.55	1.0	
	Chloropicrin			99.58	Fumigation Injection	38.95	1.0	
Weeds								
Eclipta	Paraquat dichloride	Gramoxone	2.5 lb AI/gal EC	95.87	Directed Spray	0.71	1.5	
	Metribuzin	Sencor	75% DF	81.72	Directed Spray	0.54	1.1	
Grasses	Paraquat dichloride	Gramoxone	2.5 lb AI/gal EC	95.87	Directed Spray	0.71	1.5	
	Metribuzin	Sencor	75% DF	81.72	Directed Spray	0.54	1.1	
Nightshade	Paraquat dichloride	Gramoxone	2.5 lb AI/gal EC	95.87	Directed Spray	0.71	1.5	
	Metribuzin	Sencor	75% DF	81.72	Directed Spray	0.54	1.1	
Nutsedge	Methyl Bromide			99.58	Fumigation Injection	169.55	1.0	
	Chloropicrin			99.58	Fumigation Injection	38.95	1.0	
Parthenium	Paraquat dichloride	Gramoxone	2.5 lb AI/gal EC	95.87	Directed Spray	0.71	1.5	
	Metribuzin	Sencor	75% DF	81.72	Directed Spray	0.54	1.1	
Pigweed	Paraquat dichloride	Gramoxone	2.5 lb AI/gal EC	95.87	Directed Spray	0.71	1.5	
	Metribuzin	Sencor	75% DF	81.72	Directed Spray	0.54	1.1	
Pusley	Paraquat dichloride	Gramoxone	2.5 lb AI/gal EC	95.87	Directed Spray	0.71	1.5	
	Metribuzin	Sencor	75% DF	81.72	Directed Spray	0.54	1.1	
Ragweed	Paraquat dichloride	Gramoxone	2.5 lb AI/gal EC	95.87	Directed Spray	0.71	1.5	
	Metribuzin	Sencor	75% DF	81.72	Directed Spray	0.54	1.1	
Sesbania	Paraquat dichloride	Gramoxone	2.5 lb AI/gal EC	95.87	Directed Spray	0.71	1.5	
	Metribuzin	Sencor	75% DF	81.72	Directed Spray	0.54	1.1	
Smart Weed	Paraquat dichloride	Gramoxone	2.5 lb AI/gal EC	95.87	Directed Spray	0.71	1.5	
	Metribuzin	Sencor	75% DF	81.72	Directed Spray	0.54	1.1	

Table 6. Pesticide active ingredients currently used in Florida tomato crops.

Soil Fumigants	Fungicides	Insecticides	Herbicides	Nematicides
1,3-dichlorporpene	Azoxystrobin	Avermectin	Diquat Dibromide	Chitin
Chloropicrin	Bacteriaphage	Bacillus thuringiensis	Glyphosate	Oxamyl
Metam Sodium	Benomyl	Buprofezin	MCDS	
Methyl Bromide	Chlorothalonil	Carbaryl	Metribuzin	
	Copper Ammonium Carbonate	Chlorpyrifos	Paraquat Dichloride	
	Copper Hydroxide	Crop Oil	Pebulate	
	Copper Oxychloride	Cyfluthrin	Sethoxydim	
	Copper Sulfate	Cyromazine		
	Cymoxanil	Detergent		
	Dimethomorph	Dimethoate		
	Fosetyl Al	Endosulfan		
	Mancozeb	Esfenvalerate		
	Maneb	Garlic/Sugar/Capsaicin		
	Mefenoxam	Imidacloprid		
	Propamocarb Hydrochloride	Indoxocarb		
	Zoxamide	Lambda-cyhalothrin		
		Methamidophos		
		Methomyl		
		Neem oil		
		Permethrin		
		Piperonyl Butoxide		
		Pymetrozine		
		Pyriproxifen		
		Spinosad		
		Sulfur		
		Tebufenozide		
		Thiamethoxam		
		TPW Pheromone		