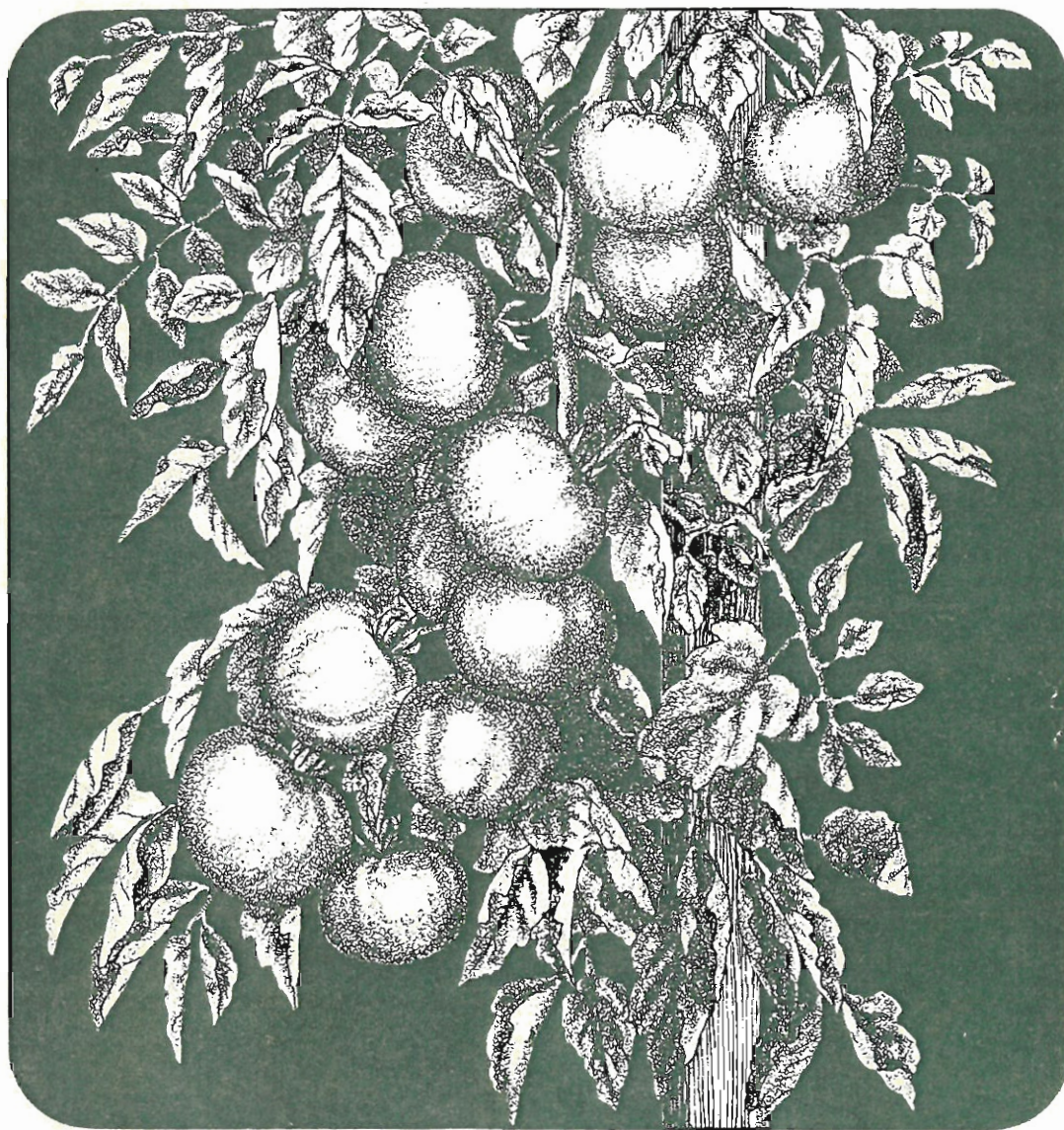


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Editor

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INTRODUCTORY REMARKS

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Greetings and welcome to the twenty-eight Annual Florida Tomato Growers Institute.

Both production increases and competition from outside producers continue to place a challenge in front of the Florida tomato producer. Acreage and production of Florida tomatoes has continued to climb over the past five years. In 1983-84, harvested acreage was 53,712 in Florida with a crop value of \$368 million. In 1987-88, acreage climbed to 76,333, while value of the crop increased by 145% to \$535 million. This represents over a 2.8-fold increase in acreage from the previous 10 year period (27,621 acres in 1977-78) and an increase in value of 437%. Average per carton values have increased only slightly over the past five years from \$6.83 in 1983-84 to \$7.00 in 1987-88.

Increases in production coincide with an expanded tomato harvest season. Tomatoes can be found in Florida fields virtually every month of the year, while harvests last year were initiated in September and continued into July of this year.

Increased acreage and production have placed emphasis on improved marketing, reduced production costs, and expanded markets. Urbanization of Florida's more productive farm land, problems with pesticide use and regulation, water-quality and quantity restrictions, environmental stresses, and, most recently, pest pressure from sweet potato whitefly continue to plague the industry and have added to production costs and have caused direct field losses.

By the tomato industry working together with IFAS, DACS and the USDA, many of these new problems are beginning to be solved or lessened. The future will bring increased pressures and will demand more indepth answers to these questions which encroach Florida tomato production efficiency.

The faculty of IFAS, whether at the county or state level, are committed to insure a long life for Florida's tomato industry. The IFAS staff sincerely hopes that this year's Tomato Institute is informational to all those who attend. We look forward to hearing your needs in an effort to better serve you.

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TOMATO AND SQUASH RIPENING DISORDERS - THEIR RELATIONSHIP TO
EACH OTHER AND TO THE SWEET POTATO WHITEFLY

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A special task force committee was initiated to study vegetable production problems in Florida on May 9, 1988. It was comprised of 19 IFAS research and extension faculty and headed by Drs. Don Maynard and Bill Zettler. The committee was asked to assess tomato irregular ripening and squash silverleaf disorders which were occurring in South Florida that spring and to assess the potential threat of lettuce infections yellows virus which was causing major damage in the California lettuce industry and which is spread by sweet potato whitefly. Virus in lettuce had not been observed, however both irregular ripening and silverleaf, in their present form, were observed as new problems in Florida. Their cause was unknown but the incidence of the disorders correlated with the appearance of unusually high populations of sweet potato whitefly in 1987-88.

The Task Force met twice on May 24 and June 21, 1988 and recommended that:

- 1) Growers throughout Florida be made aware of the sweet potato whitefly, its increased populations, potential as a virus vector, and need for early control measures.
- 2) That growers should be aware that there was a strong correlation between sweet potato whitefly and the incidence of the tomato and squash disorders.
- 3) That growers continue to index lettuce seed for virus and that they constantly monitor both the whitefly and incidence of virus in production fields.
- 4) That research be undertaken to study fruit symptomatology in tomato, to reproduce the irregular ripening symptoms, and to conduct surveys to determine the extent of the disorders on Florida produce.

The task force was subsequently disbanded after filing their report in July 1988.

On September 13, 1988 I was requested by the offices of the Deans for Research and Extension to initiate a working group, with the objective of obtaining and generating interest of IFAS research and extension personnel in discussing and solving fruit ripening disorders in tomato and squash and to study control measures for sweet potato whitefly.

On October 10, 1988 a group of 30 IFAS research and extension faculty and representatives from the agricultural farming sector

met to discuss 1) the current status of the disorders, 2) possible causes of the disorders, 3) identification of whether conditions causing the two disorders were linked, 4) what effect whiteflies have on either disorder and 5) identification of whether plant pathogens had any linkage to the disorders.

A follow-up meeting with IFAS administrators was held on May 1, 1989 to inform them of the status of the problem. The working group was expanded to include everyone working on sweet potato whitefly, tomato irregular ripening, and silver leaf in squash. A meeting was held to update the working group on current research on June 21, 1989 and included attendance by 35 persons representing IFAS research, IFAS extension, USDA, DACS, and the Florida vegetable and flower industries.

The information which follows relates what is known or not known about tomato irregular ripening, its relationship to sweet potato whitefly and silver leaf in squash. The two disorders, although found on different species with different symptomology, cannot be separated and thus will be discussed briefly in the narrative which follows.

Theories on possible causes of the ripening disorders include:

- 1) Plant stress caused by environmental factors
- 2) Air pollution
- 3) Plant nutrition
- 4) Whitefly

Plant Stress

Silver leaf in squash was first reported by Burger *et al* in 1983, and was said to be different from the genetic silver leaf-mottling that is found in several cucurbit species. Silver leaf on squash could affect fruit color and reduce yields. Paris *et al* (1987) reported that low soil moisture increased the severity of silvering.

Silver leaf was reported in tomato by Grimbly and Thomas in 1977, and was said to be related to low temperatures in the greenhouse. Unfortunately, fruit quality and yields from silver-leafed tomato plants were never reported.

Both types of silver leaf in squash (Burger, *et al*. 1988) and tomato (Grimbly, 1977) had similar effects on leaf anatomy. Burger's group also reported that chlorophyll, CO₂ uptake and photosynthesis were reduced in silvered leaves of squash.

Although leaf anatomy of squash with silver leaf in Florida was similar to that described by Burger's group (Narayanan, 1989 unpublished), no relationship between temperature or drought stress could be observed under field or greenhouse conditions for both tomatoes and squash grown in Florida. Thus, under the

conditions studied in Florida, it does not appear that environmental stress causes silver leaf or the tomato ripening disorder in Florida.

Air Pollution

In 1988, Simons et al reported a detailed description of silver leaf in squash as found in South Florida. These authors suggested that air pollutants might induce or cause silver leaf in squash. As of this writing, silver leaf in squash can be found in almost every county in Florida. Further, the symptoms of silver leaf can be induced and reversed in the laboratory 'at will' by placing whitefly nymphs on and off squash leaves. Tomato irregular ripening has been reported in most production areas of Florida and has been observed in tomatoes shipped to Florida from Mexico. The symptoms of silver leaf do not, in any way, resemble those of any known symptoms caused by air pollutants (Stoffella, 1988 unpublished). Further, pollutants which can cause plant injury have generally been found to be at low levels in the areas where leaf silvering has occurred. It seems highly unlikely that air pollution plays a major role in causing either vegetable disorder.

Plant Nutrition

Field trials have been conducted in Homestead by Drs. Narayanan and Bryan, in Immokalee by Dr. Mueller and Ft. Pierce by Dr. Stoffella to determine if potassium (K) fertility could induce irregular ripening in tomato. Fertility trials which altered N:K ratios and, more specifically, K fertilizer rates had no effect on the induction of irregular ripening symptoms, even in fields where irregular ripening could be induced by the presence of sweet potato whitefly. Thus, K fertility probably has no major relationship to the vegetable disorders in tomato and squash.

Whitefly

Throughout the previously mentioned reports, one common factor has been continuously present, although generally not quantified in most of the studies. This was the ever presence of sweet potato whitefly. Moreover, the initial observance of squash and tomato ripening disorders occurred at the same time sweet potato whitefly was observed as a major pest in Florida fields (Price et al 1989).

Maynard and Brown (1988) reported that irregular ripening occurred on tomatoes grown in the southwest area, the east coast and Homestead, Florida in 1987-88. The problem was not observed until the fruit were beginning to ripen. This observation was further brought out in a December 10, 1988 article in the Packer, which exclaimed that shippers "would be content if the disease outbreak (of fall 1987 and spring 1988) would remain a freak incident". Unfortunately, neither the problem nor the sweet potato whiteflies have gone away.

At the time of the Maynard/Brown report in September 1988 no irregular ripening was reported from the Palmetto-Ruskin or Quincy production areas. Irregular ripening was observed in Palmetto-Ruskin by the spring of 1989, however it was still not observed in Quincy as of that date, although sweet potato whiteflies have been identified to be in the Quincy vicinity (Olson, 1989 personal communication). The presence of sweet potato whitefly has always coincided with observations of silver leaf or irregular ripening. In other words, neither disorder has been observed in the complete absence of sweet potato whitefly.

Irregular ripening (and/or silver leaf) could be associated with the sweet potato white fly as:

- a) damage caused by simple feeding
- b) devitalization of the plant due to general or specific feeding
- c) injection of or response to a toxin produced by the sweet potato whitefly
- d) a virus, or some related pathogen vectored by the sweet potato whitefly.

With regard to the above possibilities, direct association of feeding by the adult sweet potato whitefly may not have the greatest causal relationship to silver leaf or the tomato irregular ripening. Research conducted at the Central Florida Research and Education Center by Dr. Lance Osborne and USDA Postdoctorate Dr. K.A. Hoelmer has shown that silver leaf symptoms in squash were observed after 10 days of feeding by adults or 3-5 days after feeding by nymphs. In order to determine if adult whiteflies could cause leaf silverying symptoms, Hoelmer 'pulsed' whitefly adults onto plants creating a continuous adult feeding while removing all eggs and other developmental stages of the insects from the caged plants. No symptoms were induced on the squash plants. If eggs were placed on a leaf, symptoms developed on leaves two to three nodes above the area where nymphs began feeding. If all whiteflies are removed from plants with leaf silverying, subsequent new growth is normal. As few as four nymphs can cause damage and 20-30 nymphs can cause extreme leaf silverying on the plant.

Dr. Hoelmer feels that sweet potato whitefly adults do not cause leaf silverying to occur rapidly and, in fact, adults may not be able to induce silver leaf.

Drs. Price, Kring, and Schuster at the Gulf Coast Research and Education Center have studied the relationship of sweet potato whitefly to irregular ripening and silver leaf in squash and methods to manage the whitefly. Using acorn squash, they could expose a single leaf down to a single cotyledon and obtain symptoms by limited nymph feeding periods. The larger the leaf

area and/or the greater the number of nymphs and crawlers the greater the amount of damage that occurred.

These findings on squash seem to agree with Dr. Dave Schuster's and Dr. Tom Mueller's (Research Director, CMC Farms) observations on tomato wherein greater numbers of whitefly had to be present in order to observe irregular ripening on the fruit. Internal symptoms of irregular ripening can generally be detected before observance of external symptoms. This pattern of defective ripening seems to coincide with increased numbers of whitefly on individual plants.

Dr. Mueller has found that as the population density of whiteflies on tomato plants increases so does the population of whitefly on flowers. The direct relationship of this to irregular ripening in the fruit is unknown. Dr. Mueller has observed that without sweet potato whitefly, irregular ripening in tomato cannot be found.

Dr. Yan Narayanan of the Tropical Research and Education Center has found a double stranded RNA (ds RNA), a tool used for identification of virus in plants. The ds RNA has been found in both squash and tomato leaves and fruit of tomato. If the plants were not infested with sweet potato whitefly the ds RNA could not be found. The ds RNA could also be found in seeds obtained from fruit which suffered from irregular ripening.

The same double stranded RNA can be isolated from tobacco infested with whitefly and thus it does not appear that the ds RNA is endogenous in these plants since there are several species involved.

Extracts from nymphs and adults contain RNA that hybridizes with RNA extracted from whitefly-infested plants. This means that the ds RNA found in symptomatic plants is vectored by both nymphs and adults.

Use of radioactive probes have also shown that the ds RNA is graft-transmissible in tomato.

Many weeds were collected from tomato and squash fields. Preliminary studies showed that weeds such as Lantana and *Amaranthus spinosa* (with low whitefly infestations) contain detectable ds RNA. In contrast, *Euphorbia cyathophora* (with high whitefly infestations) contain no detectable ds RNA.

Similar ripening disorders have been observed in other fruits. Apple scar skin causes apples to color in blotchy patterns (Coy, 1989). The disease was difficult to detect and symptoms are not apparent until after fruit set. Apple scar skin is caused by a viroid or virus like particle which until recently was extremely difficult to detect. Viroids differ from RNA viruses in that they have no protective protein coat, and thus are extremely small in

size. Viroids have the ability to force a cell to duplicate the viroid's RNA instead of its own.

Drs. Jeff Shapiro and Ray Yakomi, USDA, Orlando are investigating the possibility that a causal agent which is either toxic or enzymatic might cause the irregular ripening and/or silver leaf. At present they are trying to devise an *in vivo* assay wherein they might isolate a toxic agent from pumpkin then reinject the toxin into a plant to observe the plant reaction and symptoms. They have also detected double stranded RNA 12-13 days after the appearance of silver banding in pumpkin leaves. At this time it cannot be scientifically proven that a virus is or is not present and acts as a causal agent for silver leaf and/or irregular ripening.

Summary

Squash silverleaf and tomato irregular ripening are associated with sweet potato whitefly.

The sweet potato whitefly must be managed and controlled based on IPM and intelligence mediated control practices (i.e. removal of plant hosts, programmed spraying based on whitefly populations by alternating chemicals initiated at the beginning of the cropping season).

A review and description of the disorders and general recommendations for control can be found in IFAS Extension Fact Sheet VC-37 (Maynard and Cantliffe, 1989).

References

- Burger, Y., A. Schwartz, and H.S. Paris. 1988. Physiological and anatomical features of the silvering disorder of Cucurbita. J. Hort. Sci. 63:635-640.
- Coy, R. 1989. Tracking the elusive viroid. Agricultural Research. May:4-7.
- Grimby, P.E. 1977. Tomato silvering, its anatomy and chimerical structure. J. Hort. Sci. 52:469-473.
- Grimby, P.E. and B.J. Thomas. 1977. Silvering, a disorder of the tomato. J. Hort. Sci. 52:49-57.
- Maynard, D.N. and R.L. Brown. 1988. Irregular ripening: A new threat to the Florida tomato industry. 1988 Florida Tomato Institute. W. Stall ed. SS-VEC-801-29-30.
- Maynard, D.N. and D.J. Cantliffe. 1989. Squash silverleaf and tomato irregular ripening: New vegetable disorders. Vegetable Crops Fact Sheet VC-37.
- Paris, H.S., H. Nerson, and Y. Burger. 1987. Leaf silvering of Cucurbita. Can. J. Plant Sci. 67:593-598.

Price, J.F., D.J. Schuster, and J.B. Kring. 1989. Successful management of sweet potato whitefly in commercial flower production. GCREC (University of Florida) Res. Rept. BRA 1989-9.

Simons, J.N., P.J. Stoffella, K.D. Shuler, and R.N. Raid. 1988. Silver leaf of squash in South Florida. Proc. Fla. State Hort. Soc. 101:397-399..

Thompson, T. 1988. Irregular ripening still a mystery. The Packer. Dec. 10. pg. 3C.

Management of the Sweetpotato Whitefly on Tomato

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The sweetpotato whitefly has been noted in Florida since the late 1800's but has only been considered a pest in the state since late 1986 (Hamon and Salguero 1987). At that time it was heavily infesting ornamental greenhouse and saranhouse crops, particularly poinsettia. The insect was found heavily infesting eggplant and cucurbits on the middle east coast in the spring of 1987. By the fall of that year, the insect was detected in all tomato growing regions of the state but was present in relatively low numbers. The first outbreak of the sweetpotato whitefly in Florida tomatoes began in the late fall of 1987 in southwest Florida and continued in the spring of 1988. In that season, losses were estimated to be at least \$15 million. Annual losses to tomatoes in Florida, including increased control costs as well as direct fruit losses, are conservatively estimated to be at least \$25 million.

Reports on the biology and management of this pest on tomato have been presented at the last two meetings of the Tomato Institute (Schuster and Price 1987, Price et al. 1988). The information presented in those reports will be summarized and updated with new data in this report. It is stressed that any management program for the sweetpotato whitefly must integrate all available methods of control and must not rely solely upon one control tactic.

Biology

Sweetpotato whitefly adults are small insects about 1/32 inch long with pale yellow bodies and white wings. They resemble small flies but are more closely related to aphids since both adults and immatures possess piercing-sucking mouthparts. Adults prefer the undersides of upper leaves where they deposit minute, cigar-shaped eggs. Newly hatching nymphs called 'crawlers' have well-developed legs and are the only mobile immature lifestage. After finding a suitable feeding site on the lower surfaces of leaflets, the crawlers insert their mouthparts, begin feeding and usually do not move again. The subsequent nymphal stages are flattened, oval scales and the final resting, or pupal, stage is more convex and elliptical with large, conspicuous red eyes. Developmental time from egg to adult on tomato is about three weeks at 80°F (Coudriet et al. 1985).

The host range of the sweetpotato whitefly includes over 500 species of plants including numerous weeds and cultivated vegetable, agronomic and ornamental crops (Greathead 1986). Vegetables most

often attacked include those in the families Solanaceae (including tomato, eggplant and pepper), Cucurbitaceae (including cucumber, melons and squash) and Malvaceae (including okra). Although the list of weed hosts is extensive and includes numerous species found in Florida, preliminary investigations reveal that a relatively small number of species are infested with large numbers. These species include spurge, ceasarweed, nightshade, morning glory, hairy indigo and primrose willow.

Damage

Both adult and nymphal sweetpotato whiteflies feed on the lower surfaces of leaflets by sucking sap with their piercing-sucking mouthparts. Chlorotic spots may appear around feeding sites on the upper surfaces of leaflets, particularly on succulent plants. Whitefly adults and nymphs produce honeydew upon which sooty mold can grow. Heavily infested plants may become unthrifty and may lose leaves. Direct feeding of adults on fruit may result in small, raised spots about 1/16 to 1/8 inch in diameter. The spots are white on immature fruit and remain yellow as fruit ripen. Worldwide, the sweetpotato whitefly is best known as a pest of tomato for its ability to transmit certain virus diseases.

In Florida, the most important damage on tomato associated with the sweetpotato whitefly has been external, irregular ripening of fruit and increased severity of internal white tissue. Recent field cage studies in the fall of 1988 and the spring of 1989 at Gulf Coast Research & Education Center (GCREC) have confirmed these field observations. In cages in which the sweetpotato whitefly was released and in which no attempt to control the whitefly was made, symptoms of external irregular ripening occurred. In cages in which no sweetpotato whiteflies were released, no symptoms were apparent. In yet other cages in which the whitefly was released but in which an attempt to control the whitefly was made before external fruit symptoms appeared, symptoms were greatly reduced.

Adults have been observed ovipositing on tomato flowers under heavy infestations; however, greenhouse studies have not confirmed a link between flower infestations and the development of the irregular ripening disorder. Very few immatures hatching from eggs on flowers survive.

The causative factor(s) of irregular ripening is(are) not known at this time but may be due to a toxin or to a pathogen. In May of 1988, tomato plants grown whitefly-free at GCREC were exposed to whitefly adults in tomato fields in southwest Florida that were showing irregular ripening symptoms. Other similarly grown plants were exposed to caged whiteflies from the above field for two weeks. None of the plants produced fruit showing irregular ripening symptoms.

Studies are underway at GCREC to isolate sweetpotato whiteflies that do not cause irregular ripening of tomato. If such a strain or strains can be isolated, transmission studies will be conducted

to elucidate the nature of the irregular ripening disorder.

Scouting

Any management program of the sweetpotato whitefly should be based upon the initial detection and subsequent monitoring of populations. Information regarding the densities of adult and immature stages indicates the success of current management techniques and further indicates the need to switch or intensify management techniques.

Since adult whiteflies are attracted to yellow surfaces, such surfaces coated with a sticky substance have been used to trap and monitor adults. Studies at GCREC and on a commercial tomato farm have been conducted to evaluate effects of trap type and height and the effects of the diurnal response of adults on the numbers of adults captured. Flat traps placed horizontally on the bed surface were equivalent to or better than cylindrical traps placed vertically. Both flat and cylindrical traps indicated similar population fluctuations.

Cylindrical traps placed at or near the soil surface captured more adults than traps placed 22 or 44 inches above the soil surface. However, later in the tomato season, traps placed at 44 inches in tomato field middles captured more adults than traps placed at 22 inches or at the soil surface. This contrasted with the field edge where traps placed at or near the soil surface captured more late in the season.

Cylindrical traps monitored hourly at monthly intervals in infested tomatoes indicated that captures peaked at about 0900 to 1000 hr regardless of the time of the year. Trap captures in September or May were higher earlier in the day and tended to remain higher later in the day than captures in November or January. This diurnal variation in trap captures complicates monitoring adults with sticky traps since, for any specific field, traps would need to be placed in the field after 0900 hr for retrieval that day or placed in the field for some interval of 24 hr.

Returning to a sample site more than once on any given sample date is obviously not time-efficient for scouting. Leaving traps in the field for some multiple of 24 hrs is a viable alternative; however, traps left for long periods of may accumulate a large amount of wind-driven soil or debris or large numbers of other insects also attracted to yellow.

We currently recommend using either flat or cylindrical traps placed in fields for 2-3 days, depending upon the scouting interval. Traps on field edges should be placed at or near the soil surface season-long. Traps placed in the interior of the field should be placed at the soil surface when the plants are small but should be raised as the plants grow.

The distributions of immature whiteflies on the undersides of terminal leaflets on main stems and lateral stems have also been

evaluated at GCREC. The majority of immatures are located on leaves six to nine counting from the top; however, there is sufficient variation between the numbers of immatures on leaflets on main stems and on leaflets of laterals and between plants that further studies will be conducted.

Currently, we are recommending that estimates of densities of immatures be made on the terminal leaflet of the 7th or 8th leaf from the top of any stem. This corresponds to the same leaf node recommended for evaluating leafminer larval densities. Thus, we are recommending also that the three terminal leaflets on one stem of each of the six contiguous plants selected per two acres for estimating leafminer densities be utilized for estimating whitefly immature densities.

Cultural Control

Management of the sweetpotato whitefly must be initiated before an infestation occurs. Cultural manipulations of tomato crops are not generally capable of exerting complete control of the whitefly by themselves; however, when integrated into a total management program, they can delay, inhibit, avoid or reduce whitefly populations so that they are more manageable.

Transplant Production

Sweetpotato whiteflies may infest a tomato crop by way of the transplants or by other host plants growing in the vicinity of the tomato crop. Thus, management must begin in the transplant production facility and not in the field. Production structures should be located away from infested areas if possible and should be screened to exclude invading whitefly adults. Our recent investigations have shown that screening must be finer than 32 x 32 mesh but can be larger than 64 x 64 mesh. The benefit of using screen this fine must be balanced against the potential for heat build-up in the facility due to reduced air flow. Where possible, alternative cooling methods should be considered to alleviate this concern.

Adults may enter production structures through open entry ways. All access to structures should be kept closed or screened and those that are used frequently should have a double entry vestibule installed. Yellow sticky traps should be placed within the vestibule to capture adults that have penetrated the outside entry of the vestibule.

Workers moving into or among individual structures should avoid wearing yellow clothing or transporting equipment of this color since adults will be attracted to these surfaces and could catch a ride into structures. Transplants should be inspected prior to planting to ensure that they are free of whitefly adults or immatures.

Land Preparation and Field Maintenance

Whitefly adults may also invade fields after they are planted by migrating from infested weeds or crops. Fields should not be established in (double cropped) or near infested weeds or crops. Land preparation should be initiated at least a month before transplanting and should include the destruction of weeds and volunteers on non-crop areas including the immediate field perimeter, ditches, roadways, fallow fields, etc. Frequent discing of fields prior to fumigating will ensure that volunteer plants and weeds do not become established long enough to support whitefly populations. Weed management must continue throughout the crop and should include non-crop areas as well as the fields themselves.

Plastic Mulch

UV reflective plastic mulches (aluminum film laminated or painted onto plastic film) have been evaluated at GCREC since the fall of 1987 in anticipation of the sweetpotato whitefly problem. These films are well-known for their ability to repel alighting aphids and to delay the appearance of viruses the aphids transmit. Our studies indicate that the effects of aluminum mulch on whiteflies is not as great as the effects on aphids (Schuster and Kring 1988). Nevertheless, the mulches do result in fewer whitefly adults alighting on plants and do delay the build-up of populations of immatures. They are not sufficient in themselves to control the sweetpotato whitefly but as an adjunct to other control measures can contribute meaningfully to the overall management of the pest.

Post-harvest Activities

Sweetpotato whitefly populations continue to develop on crop plants after commercial harvest is completed and can later infest other crops or weeds. Weeds thus infested can serve as reservoirs for tomatoes planted in the following season. Whiteflies must be managed in fields opened for u-pick.

Once harvest activities are completed, it is imperative that crops be destroyed immediately. Turning off irrigation water is too slow in killing plants and permits the continued development of whitefly populations. The application of a contact herbicide rapidly kills vines and reduces the numbers of sweetpotato whitefly adults emerging from treated foliage; however, it does not eliminate emerging adults. An insecticide or insecticidal combination that is toxic to both adults and immatures (see Table 1) should be applied either prior to or in conjunction with the application of a labelled herbicide (see the discussion on weed management elsewhere in these proceedings).

Observations this past spring suggested that whitefly adults may migrate distances greater than those encountered in the confines of a single farm. In one instance, the numbers of adults captured on yellow sticky traps in a newly planted tomato field were three to four times greater than what was anticipated from previous

experience. There were few or no whitefly immatures present on the seedlings and they had been in the ground less than two weeks. Furthermore, inspections of weed hosts on the perimeter of the field revealed few whitefly adults or immatures present. Therefore, it was concluded that the whitefly adults were not originating from the field or the weeds and that the adults were migrating from a nearby tomato field. The nearest such field was five miles away and had been abandoned but not destroyed. When it was finally treated with a herbicide, the numbers of adults trapped in the newly planted field dropped to 1/3 or 1/4 of their previous levels. Although this does not constitute a clear cause and effect, it does suggest that adults may migrate and that there should be a cooperative effort among neighboring growers of all susceptible crops (not just tomato crops) in managing the whitefly and its host plants.

Host Plant Resistance

No commercially available cultivars of tomato are known to be resistant to either the sweetpotato whitefly or the associated irregular ripening disorder. Fruit from heavily infested cherry tomato plants appear to exhibit symptoms of the disorder but eventually appear to ripen normally. Germplasm derived from crosses between wild species of tomato and the cultivated tomato has been developed at GCREC for resistance to the leafminer and for horticultural characteristics. Some of this germplasm also has demonstrated resistance to the sweetpotato whitefly in the field. Unfortunately, this germplasm is not horticulturally acceptable and will not be available for commercial production for several years.

Insecticidal Control

In response to the threat of the sweetpotato whitefly to ornamental crops and in anticipation of the development of the problem on tomatoes and other vegetables, greenhouse and laboratory screenings of insecticides were initiated in 1987 at GCREC. Poinsettia was chosen as the test plant since the whitefly problem, as it existed at the time, was focused on that crop. Insecticides selected for evaluation initially included only those with some crop registrations but were not restricted to those registered only on ornamentals. Insecticides registered for vegetables only or vegetables and ornamentals were also included. Thus, immediate recommendations on currently available and legal insecticides could be made. Subsequently, insecticidal combinations and new insecticides have been evaluated in attempts to find treatments for improved whitefly control on tomatoes. In the trials, each insecticide or insecticidal combination was evaluated for toxicity to adults, eggs (and hatching crawlers), small and large nymphs and pupae. Poinsettia remains the test plant so that the results of later evaluations with new materials can be compared with the results of earlier evaluations.

Results of these continuing evaluations are summarized in Tables 1 & 2. Insecticides or insecticide combinations that are currently registered for use on Florida tomatoes and that produced $\geq 90\%$

mortality of at least one lifestage of the whitefly are listed in Table 1. Of these products, only Thiodan, Safer's Insecticidal Soap and Thirethrin are registered for greenhouse use. There apparently was a misconception that the insecticides previously reported were the only ones evaluated; however, approximately 50 insecticidal treatments have been evaluated. Therefore the list of products evaluated that aren't registered on tomatoes or that did not produce at least 90% mortality of at least one whitefly lifestage are presented in Table 2.

Beginning in the spring of 1987, insecticides which appeared promising in the greenhouse and laboratory evaluations, new insecticides and insecticides which were being promoted to growers by commercial firms but had not yet been evaluated, were evaluated on field-grown tomatoes by GCREC researchers and cooperators. The results of these trials are presented in Tables 3-10. Three of the trials were conducted on commercial farms with two of them being conducted with commercial application equipment (Tables 4,5,7 and 8). Three other trials using hand-held application equipment on smaller plots at IFAS research centers were also conducted.

In every trial, at least one insecticide or insecticide combination resulted in fewer whitefly immatures on foliage compared to untreated checks. Although there were reductions in the extent of irregular ripening, no treatment eliminated the disorder. Symptoms of fruit from treated plots were much more severe in small plot trials (Tables 3,6,9 and 10) than in large plot trials (Tables 5 and 8). This was particularly true in the small plot trial in a commercial field (Table 3) where whitefly adults quickly re-infested plots after spraying. Therefore, the severity of the disorder resulting from specific treatments in small plots would be expected to be lower when the treatments are applied to larger areas.

New insecticides or insecticides that had not been evaluated in the greenhouse and laboratory trials that appeared effective in controlling the whitefly in the field trials include Brigade (a pyrethroid) (Table 10) and Endocide Plus (a combination of Thiodan and Parathion) (Table 6). Agri-Mek appeared ineffective in a small plot trial in a commercial field (Table 3) but has since appeared effective in both small plots (Table 6) and in large plots under commercial conditions (Tables 7 & 8). In this latter situation, Agri-Mek was alternated weekly with Thiodan. Guthion was effective against small nymphs in the laboratory studies (Table 1) but was ineffective in whitefly management in a field trial (Table 3). Alternations of insecticides of different classes (see comments below) were evaluated in commercial fields using commercial application equipment and were found to result in reduced populations of whitefly immatures and in reduced irregular ripening (Tables 4,5,7 and 8).

There are a number of factors growers should take into consideration when developing an insecticide program for their farms. Before selecting and applying any insecticide, growers should read the label thoroughly. The insecticide label is the law

and insecticides cannot be used contrary to the label. Some of the insecticides listed in Tables 2-10 are not registered on tomatoes and cannot be used. These insecticides are included only to illustrate the scope of research completed and the range of susceptibility of the sweetpotato whitefly to a broad base of insecticides.

Thorough coverage of lower surfaces of leaves with insecticides is essential, since all lifestages of the whitefly occur on the undersides of foliage and since eggs, sessile nymphs and pupae do not move and must be impinged by contact insecticides. Since whiteflies are sucking pests, only systemic insecticides are ingested. Vydate is the only systemic insecticide listed in Table 1.

Resistance of the sweetpotato whitefly to organophosphate and synthetic pyrethroid insecticides has been reported in California (Prabhaker et al. 1985). In order to avoid or inhibit the development of resistance in the insect in Florida, it is recommended that insecticides of different classes be selected and that they be alternated. Various alternations including pyrethroids (Ambush, Asana XL), a chlorinated hydrocarbon (Thiodan), potassium salts of fatty acids (Safer's Insecticidal Soap) and a carbamate (Vydate) were effective in managing both the sweetpotato whitefly and irregular ripening under commercial conditions in south Florida (Tables 4,5,7 and 8).

Since all lifestages of the sweetpotato whitefly will probably be present in tomato fields, growers should select insecticides or insecticide combinations or alternations that kill adults and immatures. Applications should be made weekly when the insect first appears and increased to twice weekly if populations increase. No action thresholds for timing insecticidal applications are available at the present time.

Some of the insecticidal products listed in Table 1 and evaluated in the field trials have restrictions on their labels limiting the amount of active ingredient that can be applied to a crop. These include Ambush, Asana, Pounce, Pydrin, Vydate, Thiodan and the combination of Monitor and Pounce. When applying insecticides frequently, one may need to alternate among three or more different insecticides to avoid exceeding label restrictions. Growers are again encouraged to consult product labels before applying any pesticide.

Biological Control

Biological control of the sweetpotato whitefly has been studied for many years at various sites around the world. Several species of small parasitic wasps have been recovered on various host plants in Florida. A biological control project has recently been initiated at GCREC to identify and evaluate such parasites occurring in Florida and elsewhere in the Caribbean. Promising parasite species will be evaluated for their ability to attack the whitefly on a variety of host plants. Susceptibility of promising parasites

to selected insecticides commonly utilized on tomatoes will be determined so that the parasites can be integrated into existing pest management programs. If promising parasites from the Caribbean are found, they will be considered released in Florida to aid in management of the sweetpotato whitefly.

A pathogenic fungus has been recovered in the greenhouse and may be effective in managing the sweetpotato whitefly in transplant production facilities (Osborne, personal communication). The fungus has not been recovered in the field. It is still under investigation and is not commercially available.

Although the sweetpotato whitefly has only been a pest of Florida tomatoes for about a year and a half, it is likely to continue as a problem for years to come. Integrating cultural and insecticidal control tactics offers the best approach to successfully managing the pest. Reliance solely upon insecticides could lead to the development of resistance in the whitefly and compound an already bad situation. Biological control and host plant resistance offer encouragement for the successful long-term management of the pest in the future.

Precautions

Commercial products are mentioned in this publication solely for the purpose of providing specific information. Mention of a product does not constitute a guarantee or warranty of the products by the Agricultural Experiment Station or an endorsement over products not mentioned.

This publication also reports research involving pesticides. It does not contain recommendations for their use, nor does it imply that the uses discussed here have been registered. All uses of pesticides must be registered by appropriate state and federal agencies before they can be recommended.

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References Cited

- Coudriet, D. L., N. Prabhaker, A. N. Kishaba and D. E. Meyerdirk. 1985. Variation in developmental rate on different hosts and overwintering of the sweetpotato whitefly, Bemisia tabaci (Homoptera: Aleyrodidae). Environ. Entomol. 14:516-519.
- Greathead, A. H. 1986. Host plants. Pages 17-25 In M. J. W. Cook, ed. Bemisia tabaci--a literature survey on the cotton whitefly with an annotated bibliography. C.A.B. Int. Inst. Biol. Control. London. 121 pp.
- Hamon, A. B. and V. Salguero. 1987. Bemisia tabaci, sweetpotato whitefly, in Florida (Homoptera: Aleyrodidae: Aleyrodinae). Fla. Dept. Agric. & Consumer Services Entomol. Circ. 292. 2 pp.
- Prabhaker, N., D. L. Coudriet and D. E. Meyerdirk. 1985. Insecticide resistance in the sweetpotato whitefly, Bemisia tabaci (Homoptera: Aleyrodidae). J. Econ. Entomol. 78: 748-752.
- Price, J. F., D. J. Schuster and J. B. Kring. 1988. Management of the sweetpotato whitefly on tomato crops in South Florida. Univ. Fla., IFAS, Bradenton GCREC Res. Rept. BRA1988-15. 6 pp.
- Schuster, D. J. and J. F. Price. 1987. The western flower thrips and the sweetpotato whitefly: new pests threatening Florida tomato production. Univ. Fla., IFAS, Bradenton GCREC Res. Rept. BRA1987-16. 7 pp.
- Schuster, D. J. and J. B. Kring. 1988. Management of insects on tomato with UV-reflective mulches. Pages 5-19 In Report of tomato research supported by the Florida Tomato Committee 1987-1988. Univ. Fla., IFAS, Gainesville. 69 pp.

Table 1. Pesticides registered for use on tomatoes that produced $\geq 90\%$ mortality of at least one life stage of the sweetpotato whitefly in greenhouse and laboratory evaluations. GCREC, 1987-89.

Chemical class of compound	Product	Effective against indicated life stages ²					
		Unhatched eggs	Crawlers from treated eggs	Small nymphs	Large nymphs	Pupae	Adults
Pyrethroid	Ambush	+	++++	+++	+++	+	+++
	Asana	+	++++	++	++	+	-
	Pounce	+	+++	++++	+	+	++
	Pydrin	+	++++	-	-	-	-
Organophosphate	Guthion 2L	+	+	++++	+	+	-
Carbamate	Lannate	+	++	++	++	++	++++
	Vydate L	+	++++	++	++	+	-
Chlorinated hydrocarbon	Lindane	+	+	+	+	+	++++
	Thiodan	+	+	+	+	+	++++
Miscellaneous	Safer's Soap	+	+	++++	+++	++++	+
	Stylect Oil	+	+++	++++	+	+	+
Combinations	Monitor + Pounce	+	+++	++++	++++	+	++++
	Thiodan + Pyrenone	+	+	++	++	+	++++

²Percent mortality was rated by the following: ++++ = 90-100%; +++ = 70-89%; ++ = 50-69%; and + = less than 50%. A dash indicates that the life stage was not evaluated.

Table 2. Pesticides evaluated in the laboratory and greenhouse for control of specific lifestages of the sweetpotato whitefly. These pesticides either are not registered for use on tomato or did not produce at least 90% mortality against at least one lifestage. GCREC, 1987-89.

Chemical class of compound	Product	Registration status ²	Effective against indicated life stages ¹					
			Unhatched eggs	Crawlers from eggs	Small nymphs	Large nymphs	Pupae	Adults
Pyrethroid	Danitol	E	+	++	+++	+++	+	++++
	Mavrik	A	+	++++	++++	++	+	++
	Pyrenone	T	+	+	+	+	+	-
	Talstar	A	+	++++	++++	+	+	++++
Organophosphate	Cygon	T	+	+	+	+	+	-
	Diazinon	T	+	+	-	-	-	-
	Dibrom	T	+	+	+	+	+	+
	Disyston G	T	+	+	+	+	+	+
	Dursban 50W	A	+	++	++++	+	+	++++
	Dursban 20 MEC	A	+	+	+	+	+	+
	Malathion	T	+	+	-	-	-	-
	Monitor	t	+	+	++	+	+	+
	Orthene	v	+	++	++	++	+	++
	Plant Flume 103	A	+	+	++++	++++	+	++++
	Zolone	-	+	++++	++++	++++	+	++++
Carbamate	Dycarb	A	+	+	++++	+++	+	+
	Vydate G	T	-	-	+++	+++	+	+
	Sevin	T	+	+	+	+	+	+
	Temik	A	-	-	-	-	+	+
Chlorinated hydrocarbon	Kelthane	T	+	+	+	+	+	+
Microbial Derivative	Avid (Agri-Mek)	A	+	+	+++	+++	+	++
Botanical Derivative	Margosan-0	E	+	+	++	+	++	+

Table 2 (continued).

Chemical class of compound	Product	Registration status ²	Effective against indicated life stages ³				
			Unhatched eggs	Crawlers from eggs	Small nymphs	Large nymphs	Pupae Adults
Growth Regulator	Apex	A	+	++	++++	++++	+++
Miscellaneous	Amitraz	E	-	+	++++	++++	++
	Morestan	A	+	+	+	+	+++
	Natur'l Oil	T	+	+	+++	+	+
	Sulfur	T	+	+	+	+	+
	UBI k840	E	+	+++	++	+	+++
Combination	Ambush + Butacide ^x	T	+	+	+++	+++	+++
	Asana + Butacide ^x	T	-	-	++	++	-
	Danitol + Monitor	E	+	++++	++++	++++	++++
	Danitol + Orthene	E	+	++++	++++	++++	++++
	Mavrik + Apex	A	+	++	++++	++++	+++
	Talstar + Orthene	E	+	+	++++	++++	++++
	Safer Soap + Thiodan	T	-	-	+	+	-

²A = some agricultural registrations other than registrations for vegetables; E = experimental or no agricultural registrations; V = some vegetable registrations other than tomatoes; T = registered for use on tomatoes; t = registered for use on Florida tomatoes only.

³Percent mortality relative to an untreated check were rated by the following: ++++ = 90-100%; +++ = 70-89%; ++ = 50-69%; and + = less than 50%. A dash indicates that the lifestage was not evaluated.

^xButacide = activist or synergist.

Table 3. Influence of twice weekly applications of selected insecticides or insecticide combinations on the sweetpotato whitefly and irregular ripening (IRR) on commercially-grown tomatoes. Immokalee, Spring 1988.*

Treatment	Amount/ 100 gal	No. sweetpotato whitefly immatures /ten-20 mm leaf disks												x IRR		
		Unhatched eggs				Nymphs				Pupae					Emerged pupae	
		12 May	19 May	26 May	31 May	12 May	19 May	26 May	31 May	26 May	31 May	26 May	31 May		Adult rating ^y	Adult rating ^y
Agri-Mek 0.15 EC	8 oz	51.1bc ^x	83.4c	128.6d	294.3c	21.6ab	55.3cd	116.5c	147.5c	12.1b	16.8b	12.3b	28.3c	4.3bc	76.0	
Asana XL 0.66 EC	7 oz	40.7b	82.1c	56.3c	64.0b	19.0a	34.5bc	34.1b	30.0b	4.6a	2.8a	7.6ab	9.3ab	1.5a	-	
Asana XL 0.66 EC	7 oz															
+ Butacide 8 EC	6 oz	20.3a	13.6a	12.5a	15.0a	15.6a	14.3a	8.8a	5.3a	1.6a	2.5a	6.8ab	9.0ab	1.1a	67.1a	
Guthion 2L	2 pt	61.3bc	152.6d	228.4ed	352.3c	25.6ab	50.3cd	143.0c	243.8cd	13.7b	18.0b	9.9ab	20.3bc	3.6b	77.2a	
Thiodan 50 WP	1 lb															
+ Safers Soap	2 gal	15.5a	26.1b	27.5b	57.3a	14.5a	22.5ab	26.0b	29.8b	2.8a	7.0a	6.3a	5.8a	1.4a	81.2a	
Check		67.8c	141.1d	277.8e	378.8c	31.4b	63.7d	183.1c	322.8d	17.3b	39.0c	10.9ab	30.3c	4.5c	72.8a	

*Plots were three, 15 ft. long rows replicated four times. Treatments were applied with a hand-held CO₂ sprayer twice weekly for five weeks beginning Apr. 28. The sprayer delivered 125 gpa.

The number of adults present at harvest were rated 1-5 for increasing abundance.

³Means within columns followed by the same letter are not significantly different at the $P = 0.05$ level, Duncan's multiple range test.

Table 4. Evaluation of selected insecticides alternated at least weekly for management of the sweetpotato whitefly on commercially-grown tomatoes. Immokalee, Fall 1988.^z

Treatment alternation ^y	Amount/ 100 gal	No. sweetpotato whitefly immatures/10 leaflets											
		Crawlers						Sessile nymphs					
		16 Nov	23 Nov	30 Nov	7 Dec	14 Dec	16 Nov	23 Nov	30 Nov	7 Dec	14 Dec	16 Nov	23 Nov
Ambush 2EC & Thiodan 3EC	8 oz												
Ambush 2EC & Thiodan 3EC	2.5 pts	6.3a ^x	25.3a	16.7a	2.7a	44.3a	5.0a	2.3a	15.3a	9.3a	4.3a		
+ Safers Soap	8 oz												
+ Blendex	1.5 pts												
+ Blendex	1 gal	4.3a	20.7a	26.3a	15.0a	52.3a	2.0a	6.7a	25.7a	24.3ab	2.0a		
Asana 0.66EC	1 pt												
& Vydate 2L ^w	6 oz	11.3ab	29.3a	27.3a	27.0ab	50.3a	11.0a	10.3ab	16.3a	34.3ab	4.0a		
Control	2 pts	17.3b	33.7a	53.0b	64.0b	91.3b	12.0a	24.3b	44.0a	97.7b	12.7b		

^zTransplants were set Sept. 9 in six, 560 ft long plots replicated three times. Treatments were applied with a commercial, 6-row sprayer on Sept. 27; Oct. 4, 11, 18 and 25; Nov. 1, 8, 15, 22 and 30; Dec. 2, 6, 9, 13, 16, 20, 23, and 27. The sprayer delivered 40-100 gpa.

^yAn "&" indicates an alternation of treatments and a "+" indicates a tank mix combination.

^xMeans within columns followed by the same letter are not significantly different at the P = 0.05 level, Duncan's multiple range test.

^wThe rate of Vydate 2L was increased to 3 pts for the last six sprays.

Table 5. Evaluation of selected insecticides alternated at least weekly for management of the sweetpotato whitefly and irregular ripening (IRR) on commercially-grown tomatoes. Immokalee, Fall 1988 (continued from Table 4).²

Treatment alternation ¹	Amount/ 100 gal	No. sweetpotato whitefly pupae/10 leaflets	Average IRR rating ³						First harvest	Second harvest	Third harvest	Season average
			16 Nov	23 Nov	30 Nov	7 Dec	14 Dec					
Ambush 2EC & Thiodan 3EC	8 oz 2.5 pts	0.3a ⁴	1.3a	1.3a	0.3a	4.0a	9.3ab	1.1a	1.6a	2.0a	1.6a	
Ambush 2EC & Thiodan 3EC + Safers Soap + Blendex	8 oz 1.5 pts 1 gal 1 pt	0.7a	1.0a	1.0a	2.0a	3.7a	1.3a	1.1a	1.1a	2.0a	1.6a	
Asana 0.66EC & Vydate 2L ⁵	6 oz 2 pts	1.3a	2.0a	2.0a	0.7a	4.0a	7.7ab	1.0a	1.0a	2.3b	1.6a	
Control	-	8.3a	4.3a	4.3a	3.0a	7.7a	20.0b	1.4b	2.2b	2.6c	2.1a	

¹Transplants were set Sept. 9 in six, 560 ft long plots replicated three times. Treatments were applied with a commercial, 6-row sprayer on Sept. 27; Oct. 4, 11, 18 and 25; Nov. 1, 8, 15, 22 and 30; Dec. 2, 6, 9, 13, 16, 20, 23, and 27. The sprayer delivered 40-100 gpa.

²An "&" indicates an alternation of treatments and a "+" indicates a tank mix combination.

³Fruit were rated 1 to 4 for increasing severity of symptoms.

⁴Means within columns followed by the same letter are not significantly different at the P = 0.05 level, Duncan's multiple range test.

⁵The rate of Vydate 2L was increased to 3 pts for the last six sprays.

Table 6. Impact of insecticidal products on management of the sweetpotato whitefly and irregular ripening (IRR) on tomato. SWFREC, Immokalee, Fall 1988.^z

Insecticide	Amount/ 100 gal	No. sweetpotato whitefly immatures/10 leaflets										IRR ^y rating
		Crawlers			Sessile nymphs			Pupae				
		23 Nov	16 Dec	27 Dec	23 Nov	16 Dec	27 Dec	23 Nov	16 Dec	27 Dec		
Agri-Mek 0.15EC	8 oz	7.5ab ^x	4.2a	3.8a	4.0a	15.8a	7.8a	0.5a	3.0a	1.5ab	3.0a	
Endocide Plus EC (Endosulfan 2EC + Parathion 1EC)	1 qt	5.2ab	6.5ab	2.8a	1.8a	9.0a	3.5a	0.2a	0.2a	1.2ab	3.3a	
Rotacide 5EC + Butacide	5 pts 8 oz	12.5ab	16.2c	11.0a	2.5a	28.2a	13.2ab	1.0a	3.5a	2.0ab	3.4a	
Thiodan 3EC	2.5 pts	1.5a	3.5a	4.8a	0.8a	7.5a	4.8a	1.0a	0.8a	0.8a	3.1a	
Control	-	15.0b	11.0b	9.2a	9.5b	54.8b	24.8b	2.0a	3.0a	2.5b	3.4a	

^zTransplants were set Sept. 15 in three, 20 ft. long plots replicated three times. Treatments were applied with a 3-row, tractor-mounted plot sprayer on Sept. 30; Oct. 9, 18, and 25; Nov. 10, 16 and 25; Dec. 3, 7, 9, 15, 20 and 23. The sprayer delivered 50-100 gpa.

^yFruit were rated 1 to 4 for increasing severity of symptoms.

^xMeans within a column followed by the same letter are not significantly different at the P=0.5 level, Duncan's multiple range test.

Table 7. Management of the sweetpotato whitefly on commercially-grown tomatoes with twice weekly alternations of insecticides. Immokalee, Spring 1989.*

Treatment alternation ^y	Amount/ 100 gal	No. sweetpotato whitefly immatures/10 leaflets											
		Crawlers						Sessile nymphs					
		21 Feb	7 Mar	21 Mar	4 Apr	18 Apr	2 May	21 Feb	7 Mar	21 Mar	4 Apr	18 Apr	2 May
Agri-Mek 0.15 EC & Thiodan 3EC	8 oz 2.5 pts	10.7a ^x	12.3a	17.3a	14.0a	73.3a	232.0a	9.0a	0.3a	35.7a	25.0a	29.7a	139.3a
Agri-Mek 0.15 EC & Thiodan 3 EC	4 oz 2.5 pts	6.7a	7.0a	11.7a	18.3a	90.3a	159.3a	4.0a	1.3a	33.7a	22.7a	37.3a	137.3a
Ambush 2 EC & Thiodan 3 EC	8 oz 2.5 pts	15.7a	25.0ab	19.3a	11.3a	133.7a	125.0a	6.0a	5.0a	21.3a	22.3a	53.7a	116.7a
Asana XL 0.66 EC & Thiodan 3 EC	6 oz 2.5 pts	5.3a	7.0a	11.0a	14.3a	43.0a	67.0a	1.7a	0.0a	25.7a	15.7a	9.0a	40.3a
Asana XL 0.66 EC & Vydate 2 L	6 oz 3 pts	4.0a	18.3ab	24.3a	17.7a	94.7a	247.7a	1.3a	0.7a	51.3a	31.0a	30.3a	162.3a
Check		61.0b	39.0b	46.0b	45.7b	243.3b	1160.7b	53.7b	12.0a	195.0b	95.0b	127.7b	954.3b

*Transplants were set Jan. 24 in six, 560 ft. long plots replicated three times. Treatments were applied with a commercial, 6-row sprayer on Jan. 27 and 30; Feb. 3, 7, 10, 14, 17, 21 and 28; Mar. 3, 8, 11, 14, 17, 21, 24, 28 and 31; Apr. 4, 7, 11, 19, 25 and 28. The sprayer delivered 40-100 gpa. ^yInsecticides were alternated for each spray.

^xMeans within a column followed by the same letter are not significantly different at P = 0.05, Duncan's multiple range test.

Table 8. Management of the sweetpotato whitefly and irregular ripening (IRR) on commercially-grown tomatoes with twice weekly alternations of insecticides. Immokalee, Spring 1989 (continued from Table 7).^z

Treatment alternation ^y	Amount/ 100 gal	No. whitefly pupae/ 10 leaflets					External fruit IRR ^x					Internal fruit white tissue rating ^w			
		21 Mar	4 Apr	18 Apr	2 May	Rating		18 Apr	3 May	Total	% unmarketable fruit		18 Apr	3 May	Total
						18 Apr	3 May				18 Apr	3 May			
Agri-Mek 0.15 EC & Thiodan 3 EC	8 oz 2.5 pts	1.7a ^v	4.0a	3.0a	11.0a	2.0a	2.1ab	2.1a	0.6a	9.6ab	7.0b	3.1ab	3.8b	3.5a	
Agri-Mek 0.15 EC & Thiodan 3 EC	4 oz 2.5 pt	0.7a	9.0ab	6.7a	13.0a	2.0a	2.2b	2.1a	0.0a	13.1b	6.5b [*]	2.9a	3.8b	3.3a	
Ambush 2 EC & Thiodan 3 E	8 oz 2.5 pts	1.7a	9.3ab	8.0a	7.0a	2.0a	2.1ab	2.1a	0.0a	7.5ab	5.1ab	3.1ab	3.8b	3.5a	
Asana XL 0.66 EC [*] & Thiodan 3 EC	6 oz 2.5 pts	0.0a	5.3ab	1.3a	3.3a	2.0a	2.0a	2.0a	0.0a	4.2a	2.4a	3.0ab	3.4a	3.5a	
Asana XL 0.66 EC & Vydate 2 L	6 oz 3 pts	0.3a	5.3ab	3.7a	10.0a	2.0a	2.1ab	2.1a	0.3a	9.8ab	5.4ab	3.0ab	3.8b	3.5a	
Check		12.3b	26.7b	11.0a	95.3b	2.0a	2.8c	2.4b	2.7b	54.0c	31.2c	3.3b	4.3c	3.9b	

^xTransplants were set Jan. 24 in six, 560 ft. long plots replicated three times. Treatments were applied with a commercial, 6-row sprayer on Jan. 27 and 30; Feb. 3, 7, 10, 14, 17, 21 and 28; Mar. 3, 8, 11, 14, 17, 21, 24, 28 and 31; Apr. 4, 7, 11, 19, 25 and 28. The sprayer delivered 40-100 gpa. ^yInsecticides were alternated for each spray. ^zFruit were rated 1 to 4 for increasing severity of symptoms. Fruit rated 3 or 4 were considered unmarketable. Percent data were transformed arcsin of the square root of the proportion prior to analysis but are presented in the original scale. ^wFruit were cut transversely and rated 1 to 5 for increasing severity of white tissue. ^zMeans within a column followed by the same letter are not significantly different at P = 0.05, Duncan's multiple range test.

Table 9. Twice weekly alternations of insecticides for management of the sweetpotato whitefly, leafminers and irregular ripening (IRR) on tomato. SWFREC, Immokalee, Spring 1989.^a

Treatment alternation ^a	Amount/ 100 gal	No./10 leaflets												External fruit IRR ^c		Internal fruit white tissue rating ^d
		Sweetpotato whitefly immatures						Leafmines						unmarketable fruit	Rating	
		Crawlers		Sessile nymphs		Pupae		Large		Small						
		25 Apr	8 May	25 Apr	8 May	25 Apr	8 May	25 Apr	8 May	25 Apr	8 May					
		Ambush 2 EC & Thiodan 3 EC	8 oz 2.5 pts	16.8a ^v	59.5a	24.8a	59.2a	2.5a	11.8a	18.2b	12.0bc	5.5a	5.0a			
Monitor 4 EC + Ambush 2 EC & Thiodan 3 EC	1.5 pts 6.4 oz 2.5 pts	30.0ab	32.8a	43.8ab	24.2a	2.5a	5.5a	14.2b	13.0bc	9.5abc	8.5a	2.1a	7.9a	3.2a		
Monitor 4 EC & Agri-Mek. 0.15 EC	2.0 pts 8 oz	63.5ab	221.5b	114.2c	125.5a	9.8ab	28.5b	3.8a	2.0a	4.5a	2.2a	2.4bc	25.1bc	4.0cd		
Monitor 4 EC & Ambush 2 EC	2.0 pts 8 oz	31.2ab	47.2a	51.8ab	68.2a	5.5a	10.8a	21.0b	13.5bc	12.5bc	6.0a	2.1a	10.6a	3.4ab		
Monitor 4 EC & Thiodan 3 EC	2.0 pts 2.5 pts	62.8ab	85.0a	103.8bc	57.8a	5.8a	10.2a	14.8b	7.5ab	7.0ab	5.0a	2.1a	11.9ab	3.7bc		
Check		73.2b	360.5c	100.2bc	334.0b	16.8b	35.0b	22.0b	16.0c	14.8c	8.8a	2.5c	33.6c	4.2d		

^aTransplants were set Feb. 15 in three, 20 ft. long plots replicated four times. Treatments were applied with a 3-row, tractor-mounted plot sprayer on Mar. 13, 16, 20, 23, 27 and 31; Apr. 3, 6, 10, 13, 17, 20, 24 and 27; May 1, 4, 8, 11, 16 and 19. The sprayer delivered 40-80 gpa.

^bAn "g" refers to alternations of insecticides and a "+" refers to tank mixes.

^cFruit were rated 1 to 4 for increasing severity of symptoms. Fruit rated 3 or 4 were considered unmarketable. Percent data were transformed arcsine of the square root of the proportion prior to analysis but are presented in the original scale.

^dFruit were cut transversely and rated 1 to 5 for increasing severity of white tissue.

^eMeans within a column followed by the same letter are not significantly different at the P = 0.05 level, Duncan's multiple range test.

Table 10. Evaluation of pyrethroid insecticides for control of the sweetpotato whitefly and irregular ripening (IRR) on tomato. GCREC, Bradenton, Spring 1989.²

Treatment	Amount/ 100 gal	No. sweetpotato whitefly immatures/10 leaflets				External fruit IRR ^y	
		Crawlers	Sessile nymphs	Pupae	Rating	% unmarketable fruit	
Ammo 2.5 EC	3 oz	370.2b ^x	269.0a	36.5ab	3.1b		71.4b
Brigade 10 WP	9.6 oz	45.8a	29.5a	2.2a	2.6a		45.5a
Pounce 3.2 EC	6 oz	463.8b	210.3a	23.2ab	3.1b		75.9b
Check		668.2c	753.0b	56.5b	3.4c		87.3c

²Transplants were set Feb. 1 in three, 20 ft. long plots replicated four times. Treatments were applied with a 3-row, high-clearance sprayer on Mar. 27; Apr. 12, 19 and 26; May 3, 10, 17 and 24. The sprayer delivered 60-100 gpa.

^yFruit were rated 1 to 4 for increasing severity of symptoms. Fruit rated 3 or 4 were considered unmarketable. Percent data were transformed arcsine square root of the proportion prior to analysis but data are presented in the original scale.

^xMeans within a column followed by the same letter are not significantly different at the P_{0.05} level, Duncan's multiple range test.

Management of Weeds and Crop Residues

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Although weed control has always been an important component of tomato production, its importance has increased with the introduction of the sweet potato whitefly and development of the associated irregular ripening problem. Increased incidence of several viral disorders of tomatoes also reinforces the need for good weed control. Common weeds, such as the difficult to control nightshade, and volunteer tomatoes (considered a weed in this context) are hosts to many tomato pests, including sweet potato whitefly, bacterial spot, and viruses. Control of these pests is often tied, at least in part, to control of weed hosts. Most growers concentrate on weed control in row middles; however, peripheral areas of the farm may be neglected. Weed hosts and pests may flourish in these areas and serve as reservoirs for re-infestation of tomatoes by various pests. Thus, it is important for growers to think in terms of weed management on all of the farm, not just the actual crop area.

Total farm weed management is more complex than row middle weed control because several different sites, and possible herbicide label restrictions are involved. Often weed species in row middles differ from those on the rest of the farm, and this might dictate different approaches. Sites other than row middles include roadways, fallow fields, equipment parking areas, well and pump areas, fence rows and associated perimeter areas, and ditches.

The greatest row middle weed control problem confronting the tomato industry today is control of nightshade. Research and grower experience have demonstrated the low efficacy of Gramoxone Super for control of nightshade. Although several preemergence and postemergence herbicides have provided good control of nightshade in research, none of the currently labeled preemergence herbicides work that well and only Diquat and Enquik are labeled for postemergence control of nightshade in tomato row

middles. (Diquat's section 18 registration was due to expire August 31, 1989; however, renewal is expected.) A few isolated instances of nightshade resistance to Diquat have been reported; however, most growers are able to obtain satisfactory control with Diquat. Enquik (6 gal. or more per acre), when combined with Gramoxone Super (0.5 lb.a.i./acre), has provided good control of nightshade. Both Diquat and the combination of Enquik and Gramoxone Super frequently require two applications for best control. Where grass weeds are large and thick, Gramoxone will do a better job than Diquat. If the grass population is sparse or the grass weeds are small, Diquat will perform adequately. Enquik alone will control nightshade, but will not control grasses, thus the need to tank mix Gramoxone Super with it. Unocal, the manufacturer of Enquik, recommends application in approximately 40 gal. of water per acre with a minimum pressure of 40 psi at the nozzle. Growers who use Enquik at this pressure must minimize spray drift by assuring that the curtains/shields on their sprayers are properly adjusted. Research (Gilreath & Gilreath, unpublished data) indicates the greatest efficacy from Diquat is obtained with 2 applications of the label rate (0.50 lb.a.i./acre) applied in 50 to 75 gal. of spray preparation per acre to nightshade plants which are 4 to 6 inches tall. When applied to seedlings (less than 2 inches tall), Diquat provided poor control, thus the importance of the 4 to 6 inches size range. Application at volumes of 100 or more gal./acre reduced Diquat efficacy as did application at 25 gal./acre. Addition of a good surfactant is important with Diquat and Enquik. We found that increasing the rate of X-77 from 0.25% to 0.75% increased Diquat efficacy.

Disking is probably the least expensive weed control procedure for fallow fields. Where weed growth is mostly grasses, clean cultivation is not as important as in fields infested with nightshade and other disease and insect hosts. In the latter situation, weed growth should be kept to a minimum throughout the year. If cover crops are planted, they should be plants which do not serve as hosts for tomato diseases and insects. Some perimeter areas are easily disked, but berms are not and some form of chemical weed control may have to be used on these areas. We are not advocating bare ground on the farm as this can lead to other serious problems, such as soil erosion and sand blasting of plants; however, where undesirable plants exist, some control should be practiced, if practical, and replacement of undesirable species with less troublesome ones, such as bahiagrass, might be worthwhile.

Use of rye as a windbreak has become a common practice in the spring; however, in some cases, adverse effects have resulted. If undesirable insects buildup on the rye, contact herbicide can be applied to kill it and eliminate it as a host, yet the remaining stubble could continue serving as a windbreak.

Certainly fence rows and areas around buildings and pumps should be kept weed-free, if for no other reason than safety. Roundup can be applied in these situations, provided care is exercised to keep it from drifting onto the tomato crop.

Field ditches as well as canals are a special consideration because many herbicides are not labeled for use on aquatic sites. Where herbicidal spray may contact water and be in close proximity to tomato plants, for all practical purposes, growers probably would be wise to use Diquat only. On canals where drift onto the crop is not a problem and weeds are more woody, Rodeo, a systemic herbicide, could be used. Other herbicide possibilities exist. Growers are cautioned against using Arsenal on tomato farms as tomatoes are very sensitive to this herbicide. Particular caution should be exercised if Arsenal is used on seepage irrigated farms as it has been observed to move in some situations.

Eradication of weeds before they bloom is very important because many weeds are prolific seed producers. Each weed left to produce seed is adding considerably to the soil seed reservoir which represents a grower's weed control problem for years to come. Also, these weeds can be thought of as nurseries or reservoirs for tomato pests.

Additionally important is good field sanitation with regard to crop residue. Rapid and thorough destruction of tomato vines at the end of the season always has been promoted; however, this practice takes on new importance with the sweet potato whitefly. Good canopy penetration of pesticidal sprays is difficult with conventional hydraulic sprayers once the tomato plant develops a vigorous bush due to foliar interception of spray droplets. The sweet potato whitefly population on commercial farms was observed to begin a dramatic, rapid increase about the time of first harvest in the spring of 1989. This increase appears to continue until tomato vines are killed. It is believed this increase is due, in part, to coverage and penetration. Thus, it would be wise for growers to continue spraying for whiteflies until the crop is destroyed and to destroy the crop as soon as possible with the fastest means available.

The importance of rapid vine destruction can not be overstressed. Merely turning off the irrigation and allowing the crop to die will not do; application of a dessicant followed by burning is the prudent course. Presently, no herbicide is clearly interpreted as labeled for dessication of tomato plants. The most rapid and thorough kill of mature tomato plants in research on grower farms (Gilreath & Gilreath, unpublished data) was observed with Gramoxone Super (paraquat) and Diquat. Diquat was faster acting and provided more complete kill than Gramoxone Super at any rate from 0.25 to 1.0 lb. a.i./acre. Both products

were much more efficacious than Roundup or Ignite applied at rates as high as 2.5 lb.a.i./acre. Enquik killed tomato plants much slower than Diquat or Gramoxone Super and required 12 gal./acre to provide control similar to Gramoxone Super. Preliminary research (Schuster & Gilreath, unpublished data) indicates application of Diquat or Gramoxone Super reduces the number of adult whiteflies which emerge from treated foliage one or more days after application. Thus, rapid dessication with either of these herbicides reduces subsequent emergence of whiteflies and eliminates tomato plants as hosts.

Each situation is different, yet weed and crop residue management should be thought of in terms of the entire farm. Different areas of the farm require different approaches with many factors determining the best approach. Each grower should develop a program for his farm with consideration of the interrelationship between weed (and crop residue) and insect/disease pests. A good management program may not eliminate serious pests, such as sweet potato whitefly, but it could have an impact. The industry's current problems dictate that growers do all they can to keep the population of sweet potato whitefly and other pests in check.

NOTE: The use of trade names in this article is solely for the purpose of providing information and does not necessarily constitute a recommendation of the product.

BIOLOGY AND MANAGEMENT OF THRIPS AND
TOMATO SPOTTED WILT VIRUS

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Thrips in the genus Frankliniella are polyphagous insects that are pests of numerous crops worldwide. Economic damage can occur from feeding and ovipositional activities that result in injury to leaves, flowers, or fruit. Economically important species include F. occidentalis (western flower thrips), F. fusca (tobacco thrips), F. tritici (flower thrips), and F. bispinosa. Although originally confined to the western half of the U.S., the western flower thrips has moved into the southeastern U.S., being first recorded in Georgia in 1981 (Beshear 1983). The species is now present throughout most of the region, including Florida. Little is known about the pest status of western flower thrips and other thrips species inhabiting tomato. However, thrips were implicated as the cause for cosmetic fruit damage occurring on tomatoes grown in North Florida. This damage was severe during the spring growing seasons of 1985, 1986, 1988, and 1989. It also has been noted on tomatoes grown in Alabama, South Carolina, North Carolina, and South Florida.

Several species of thrips are known vectors of tomato spotted wilt virus. The disease has a wide host range and is worldwide in distribution (Sakimura 1962), but has only recently been found in the southeastern U.S. Tomato spotted wilt virus was reported extensively in the region during 1986 on tomato, pepper, and other crops (Reddick et al. 1987, Hagan et al. 1987) and was first noted in North Florida in 1986 (Olson and Funderburk 1986) and in South Florida in 1989.

The economic threat of Frankliniella spp. thrips and tomato spotted wilt virus to tomato in South Florida production areas is unknown. Thrips and tomato spotted wilt virus are the most economically important management problem for North Florida producers. A research effort is underway at the North Florida Research and Education Center to develop management strategies. The purpose of this paper is to review information on biology and management, including new research findings.

Wild Hosts. The western flower thrips has a wide host range. Bryan and Smith (1956) reported 139 plant species were hosts in California. Multiple wild host plant species inhabit areas in and around crop fields. Sakimura (1962) found western flower thrips were abundant on 18 plant hosts commonly found around tomato and

lettuce plantings in California. The pest was associated with 48 plant species around lettuce fields in Hawaii (Yudin et al. 1986). Stewart et al. (1989) noted that western flower thrips were common on 12 known host plants growing around peanut fields in Texas. The host ranges of tobacco thrips, flower thrips, and *F. bispinosa* also are great, but there is little published information on population dynamics of these species on wild hosts.

Tomato spotted wilt virus has a multitude of host plants. There are 236 plant species representing 34 families that are known hosts of the disease (Cho et al. 1986, Best 1969). Wild host plant species play an important role in the dissemination and spread of the disease (Yudin et al. 1986). Species of thrips known to vector tomato spotted wilt virus in North America include western flower thrips, tobacco thrips, and onion thrips (*Thrips tabaci* Lindeman). Bald and Samuel (1931) reported that only adult thrips transmit the virus after feeding on infected plants in the larval stage. Primary infections, following mass invasions of thrips from outside habitats of wild host plants, are important in introducing tomato spotted wilt virus into a crop field (Reddy et al. 1983). After primary infection occurs in a field, additional secondary spread occurs when immature thrips feed on infected plants, mature, and spread the virus to additional, uninfected plants.

Research is currently underway to determine population dynamics of *Frankliniella* spp. thrips on wild hosts around tomato fields in North Florida. This research has already revealed that numerous wild host plant species play important roles in the population dynamics of thrips around tomato fields. Additional research is planned to identify wild hosts of tomato spotted wilt virus in North Florida. Because of the great difference in the flora and fauna between North and South Florida tomato production areas, similar studies will be needed in South Florida if thrips and tomato spotted wilt virus become an economic problem.

Seasonal Abundance in Tomatoes. Thrips densities in tomato blooms were estimated weekly in two commercial tomato fields in North Florida during the spring cropping seasons of 1987, 1988, and 1989 and during the fall cropping seasons of 1987 and 1988. Blooms were placed in individual vials containing 70% ethyl alcohol and returned to the laboratory for processing, identification, and counting. Densities of adult thrips were greater in 1988 and 1989 than in 1987 (Figure 1). The peak densities occurred in May during each of the 3 years. Densities declined greatly during June. Very few thrips were noted during the 1987 and 1988 fall cropping seasons (Figure 2). Adults of western flower

thrips, tobacco thrips, and flower thrips accounted for over 96% of the adult thrips collected in the tomato blooms. F. bispinosa was infrequently collected, but accounted for most of the remainder. Very few immatures were collected on any sample date during the spring and fall cropping seasons.

A sampling program to estimate density of thrips in tomato blooms suitable for scouting programs is being developed from the seasonal abundance data collected in North Florida. Time of day when sampling and sampling location within a field had little or no influence on density estimates. However, estimates were greater for blooms on the upper half of tomato plants compared with blooms on the lower half of tomato plants.

Little information exists regarding the seasonal abundance of thrips inhabiting tomato fields in South Florida production areas. However, unpublished information from various sources indicated that F. bispinosa has been the most common species in tomato in South Florida. The possibility exists that the western flower thrips recently has established and increased in importance in South Florida production areas. Detailed studies are needed to evaluate the population dynamics of thrips in tomatoes in South Florida production areas.

Direct Injury to Tomato Fruit from Thrips. We reproduced the cosmetic fruit injury associated with thrips by confining western flower thrips adult females on tomato blooms and small fruit. The resulting injury was identical to that reported on young grapes (Yokoyama 1977). The injury is best described as a small indentation, with a light halo sometimes surrounding the indentation. As in grapes, this injury is apparently caused by ovipositional activities by the females. A single egg is visible within each indentation, and immature thrips hatch from young fruit within a few days of the sloughing of the corolla. It was not possible in these experiments to induce female tobacco thrips and flower thrips to oviposit on blooms or small fruit. Males of each species also were confined similarly, but no injury resulted. Female western flower thrips apparently are responsible for the cosmetic fruit damage occurring on tomatoes in North Florida. Additional studies are being conducted to determine the relationship between the number of female western flower thrips and the amount of cosmetic fruit injury.

Control Tactics. Several insecticides are labeled for thrips control in tomato or are labeled for tomato and have efficacy against thrips. No experimental trials have been conducted to compare efficacy of the available insecticides. Based on grower experiences in North

Florida, only methamidophos (Monitor, Chevron Chemical Co. and Mobay Chemical Corp.) has proven effective against adult and immature thrips in the tomato blooms. This insecticide gives residual efficacy of only a few days. The grower is limited by the label in the number of applications per season.

The only available control of tomato spotted wilt virus in tomato is through the use of insecticides to control the thrips vectors. Control of adult thrips moving into tomato fields is effective in reducing primary spread of the disease, while control of immature thrips is important in reducing secondary spread of the disease.

Cultural controls and resistant varieties may eventually prove useful in reducing economic losses from thrips and tomato spotted wilt virus, but are not currently available for growers. Certain colored mulches may be useful in disrupting colonization of tomato blooms by thrips. The elimination of certain wild hosts in and around fields has been proposed as a cultural control tactic (Yudin et al. 1986, Stewart et al. 1989).

Management Programs. Informational shortfalls have hampered efforts to develop management strategies. A lack of detection and control in North Florida has resulted in unacceptable economic losses from cosmetic fruit damage by western flower thrips and from tomato spotted wilt virus. Many growers have resorted to applying pesticides prophylactically which is an undesirable practice for integrated pest management programs. The practice is overly costly and frequently results in additional losses from secondary outbreaks of spider mites, leafminers, and other pests. Resistant thrips populations may also result from sole reliance on pesticides, especially considering that only one insecticide has good efficacy against both immature and adult thrips.

Although there are still important informational shortfalls, enough new research findings are available to develop a more acceptable integrated pest management approach. Our studies on seasonal abundance in North Florida have revealed that there are many times when economically important densities of thrips are not present in tomato fields (Figures 1 and 2). Consequently, we are generating research data to develop an efficient scouting program to estimate thrips density in tomato blooms and to determine economic thresholds for each thrips species. With these findings, a reliable treat-only-when-necessary management approach is being developed. The presence in tomato blooms of several thrips species complicates management, because scouts are

not able to reliably identify thrips to species directly while in the field.

During periods when thrips have migrated into tomato fields in massive numbers in North Florida, it has proved a practical impossibility to keep populations below economic threshold densities with the use of insecticides. Economic losses from cosmetic thrips damage and from primary infection of tomato spotted wilt virus have been very great under these circumstances. Undoubtedly, other control tactics (e.g., cultural control and host plant resistance) need to be developed and combined with chemical insecticides to reduce such economic losses. Insecticides alone have proven very effective in eliminating secondary spread of tomato spotted wilt virus.

Literature Cited

- Bald, J. G., and G. Samuel. 1931. Investigations on "spotted wilt" of tomatoes. II Australian Common. Coun. Sci. Ind. Res. Org. Bull. 54.
- Beshear, R. J. 1983. New records of thrips in Georgia (Thysanoptera, Terebrantia, Tubulifera). J. Ga. Entomol. Soc. 18:342-344.
- Best, R. J. 1968. Tomato spotted wilt virus. Advances in Virus Research. 13:65-145.
- Bryan, D. E., and R. F. Smith. 1956. The Frankliniella occidentalis (Pergande) complex in California (Thysanoptera: Thripidae) Univ. Calif. Publ. Entomol. 10:39-410.
- Cho, J. W., W. C. Mitchell, and R. Mau. 1986. Development of control procedures for tomato spotted wilt virus (TSWV) disease. Phytopathol. 76:1134.
- Hagan, A. K., J. R. Weeks, and J. C. French. 1987. Identification and control of tomato spotted wilt on peanut. Agriculture and Natural Resources Information, Ala. Coop. Ext. Serv., Auburn, Univ.
- Olson, S. M., and J. E. Funderburk. 1986. New threatening pest in Florida - western flower thrips. Proc. Fla. Tomato Inst. Veg. Crops Ext. Rep. VEC 86-1.
- Reddick, B. B., C. H. Hadden, S. C. Bost, and M. A. Newman. 1987. First report of tomato spotted virus in Tennessee. Plant Disease 71:376.
- Reddy, D. V. R., P. W. Amin, D. McDonald, A. M. Ghaneker, R. T. Plumb, and J. M. Thresh. 1983. Epidemiology and control of groundnut bud necrosis and other diseases of legume crops in India caused by tomato spotted wilt virus. ICRISAT Pub. 1983:93-102.
- Sakimura, K. 1962. The present status of thrips-borne virus, pp. 33-40. In K. Maramorosch [ed.] Biological transmission of disease agents. Academic Press, New York.

- Stewart, J. W., C. Cole, and P. Lummus. 1989. Winter survey of thrips (Thysanoptera: Thripidae) from certain suspected and confirmed hosts of tomato spotted wilt virus in South Texas. J. Entomol. Sci. 24:392-401.
- Yokoyama, V. Y. 1977. Frankliniella occidentalis and scars on table grapes. Environ. Entomol. 6:25-30.
- Yudin, L. S., J. J. Cho, and W. C. Mitchell. 1986. Host range of western flower thrips, Frankliniella occidentalis (Thysanoptera: Thripidae), with special reference to Leucaena glauca. Environ. Entomol. 15:1292-1295.

Number of Adults/Bloom

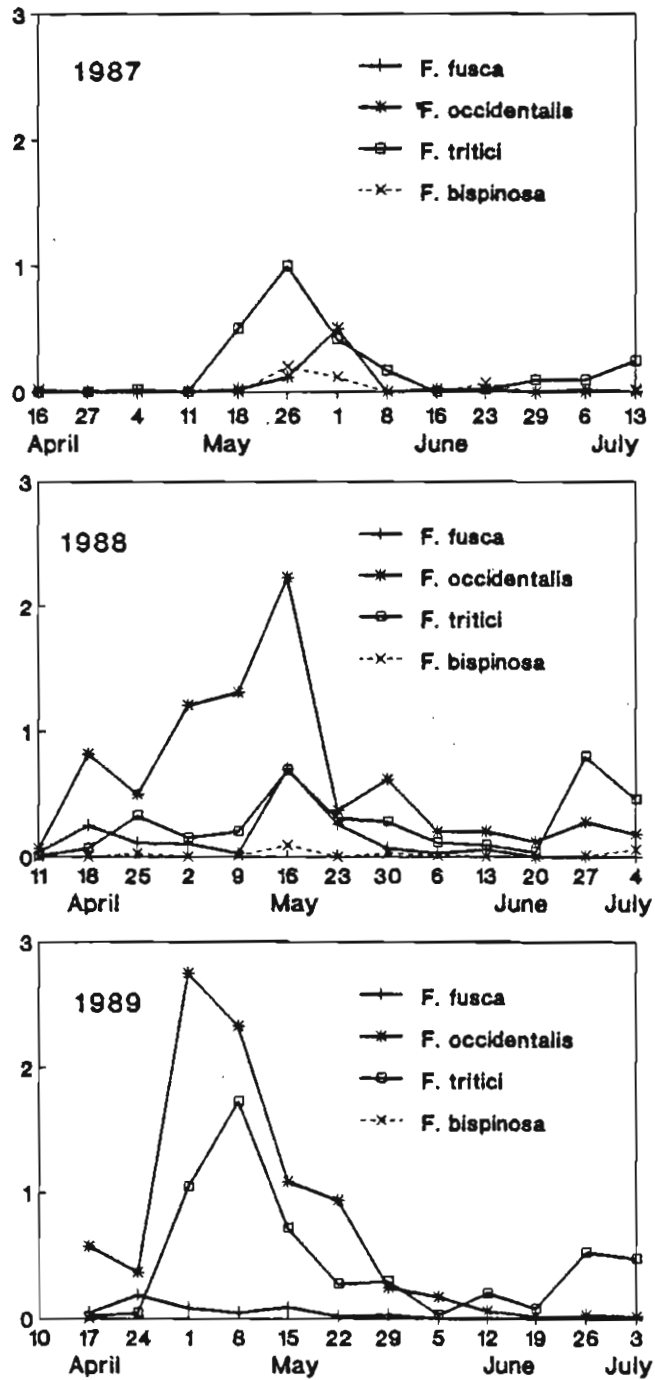


Fig. 1. Seasonal abundances of adult *Frankliniella* spp. thrips in tomato fields in Gadsden Co., Florida during the springs of 1987, 1988, and 1989.

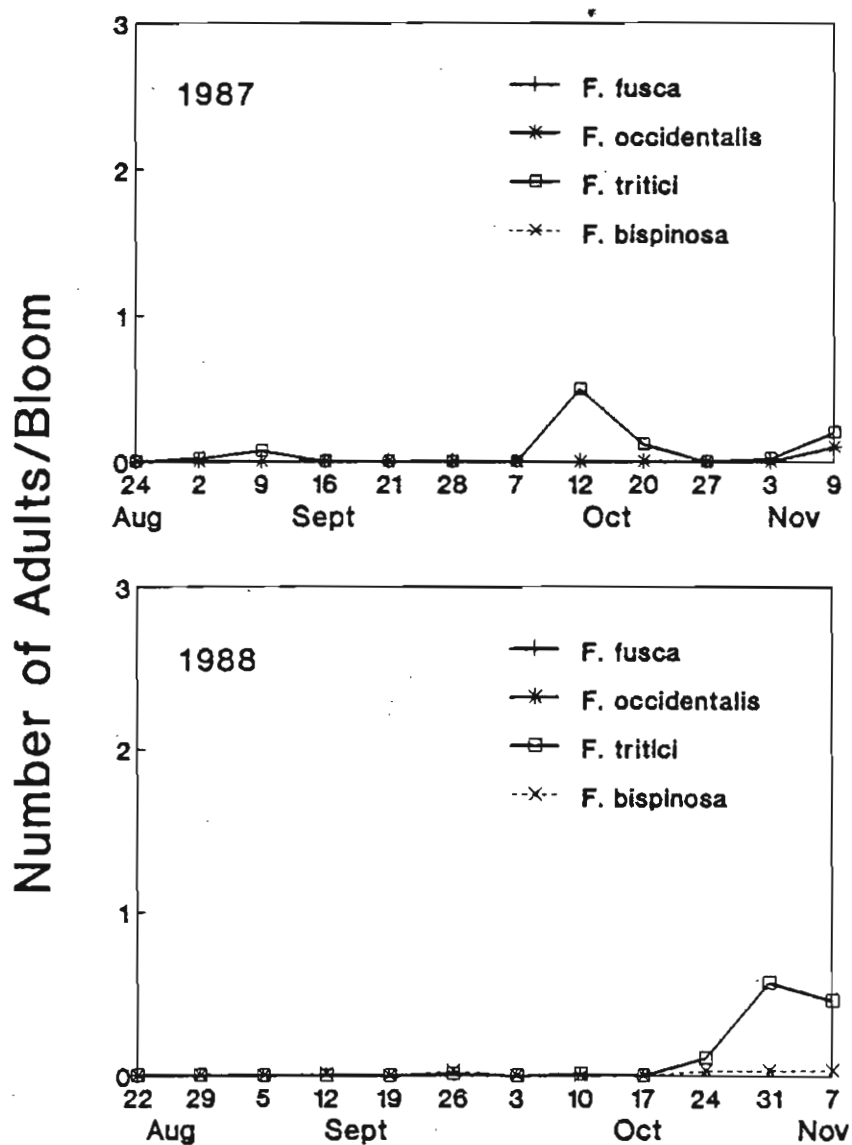


Fig. 2. Seasonal abundances of adult Frankliniella spp. thrips in tomato fields in Gadsden Co., Florida during the falls of 1987 and 1988.

TARGET SPOT, EARLY BLIGHT, BACTERIAL SPOT, AND BACTERIAL SPECK:
IDENTIFICATION AND CONTROL

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Target spot, caused by the fungus Corynespora cassiicola, was first reported on tomato in Florida in 1972 (Blazquez, C. H. 1972. Target spot of tomato. Plant Dis. Repr. 56:243-245). The disease thereafter occurred sporadically and remained relatively unimportant in Florida until the fall of 1987 when it resulted in severe foliage and fruit loss in the Manatee-Ruskin area. Target spot currently is serious in the north Florida, west central Florida, and southwest Florida tomato growing areas, often developing concomitantly with bacterial spot, caused by Xanthomonas campestris pv. vesicatoria and occasionally with bacterial speck, caused by Pseudomonas syringae pv. tomato. Because the chemical control strategies suggested for the bacterial-incited diseases will not adequately control target spot and the strategies for the chemical control of target spot will not control the bacterial-incited diseases, it is imperative to accurately diagnose the disease or diseases that are occurring to ensure maximum disease protection. This is very difficult because the symptoms of target spot, bacterial spot, and bacterial speck, as well as those of early blight (Alternaria solanii), are similar. Diagnostic characteristics and control chemicals are given in Table 1 to help in the identification and control of these four diseases. Nonetheless, field identification remains difficult and risky at best. It is strongly recommended, therefore, that a positive ID be made in a disease clinic or laboratory.

Table 1. Symptoms and chemical control of target spot, early blight, bacterial spot, and bacterial speck of tomato in Florida.

<u>TARGET SPOT</u>	<u>EARLY BLIGHT</u>	<u>BACTERIAL SPOT</u>	<u>BACTERIAL SPECK</u>
Even distribution of spots on leaf blade.	Even distribution.	Uneven distribution. Clustering of spots, especially near tip of blade.	Uneven distribution. Clustering of spots, especially near tip of blade.
Numerous leaf spots involving the entire leaf blade.	Widely scattered.	Numerous leaf spots. Will coalesce, killing large areas.	Numerous leaf spots. Will coalesce, killing large areas.
Entire plant affected from bottom to top at the same time.	Disease occurs first on the bottom of the plant and progresses upward.	Entire plant may be affected from bottom to top at the same time.	Entire plant may be affected from bottom to top at the same time.
Older leaf spots may develop faint concentric rings.	Leaf spots develop pronounced dark concentric rings, especially on the older leaves.	No concentric rings.	No concentric rings.
Bright yellow haloes around leaf spots, especially around the young lesions near the stem tip.	Dull yellow haloes.	Dull yellow haloes to none around mature lesions, none around young spots.	Bright yellow haloes around mature lesions, none around young spots.
Medium brown colored leaf spots, 8 mm in size when mature. May coalesce and involve entire leaf.	Dark brown, large spots 16 mm when mature.	Small dark, watersoaked spots, 3-5 mm in size.	Small, dark brown watersoaked spots, 3 mm in size.
Underside of a spot dark brown and slightly shiny.	Underside dark brown.	Underside dark brown and greasy.	Underside dark brown and greasy.

Elongate narrow streaks on stem, no concentric rings. May coalesce.	Elongate to round stem lesions with concentric rings.	Small specks on stem, may coalesce.	Oval to round lesions on stem.
Numerous small lesions causing blight of flowers, peduncles, and pedicels.	Large concentric lesions involving calyx, fruit, and peduncle.	Small lesions on petiole, pedicel and peduncle, may coalesce.	Small oval lesions on petiole, pedicel, and peduncle.
Fruit lesions variable depending on fruit maturity: <ul style="list-style-type: none"> a. specks, similar to spray damage b. crescent-shaped craters c. large lesions, with lens-shaped cracks. 	Large brown lesions with concentric rings at stem end often involving calyx.	Brown, raised, rough, scabby lesions, may have whitish to yellow haloes.	Small black specks with raised margins and sunken centers.
Chemicals that are efficacious in research plots: chlorothalonil, chlorothalonil + copper + maneb, chlorothalonil + copper + mancozeb, mancozeb + benomyl?	Chemicals that are efficacious in research plots: chlorothalonil, mancozeb, maneb + zinc.	Chemicals that are efficacious in research plots: (maneb + zinc) + copper, mancozeb + copper.	Chemicals that are efficacious in research plots: copper, (maneb + zinc) + copper, mancozeb + copper.

IFAS TOMATO BREEDING PROJECTIONS FOR THE 1990's

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The primary objective of the IFAS tomato breeding program is to release germplasm, either as finished cultivars or as breeding lines, which have novel genetic improvements. Emphasis in the 1980's has been on development of superior inbred lines and this will continue in the 1990's. However, it is difficult to fix all desirable traits in a single inbred (open-pollinated) line. Thus, when inbreds with many desirable traits are developed, they are tested in hybrid combinations for commercial acceptability. This was the procedure used for the 1988 release of the heat tolerant hybrid 'Solar Set'.

In past Tomato Institute talks, an overview of the IFAS breeding program was presented. The purpose of this presentation is to only report on a few projects. Some are near cultivar release, a status report will be given for some others and a few new projects will be introduced.

Projects With Cultivars Near Release. The next projected finished cultivar release will be a hybrid resistant to Fusarium wilt race 3. In spring 1989, about 100 F₁'s were evaluated. Of these, 7 were selected for yield evaluation in comparison with cultivars Sunny and Solar Set (Table 1). Results were promising, but further evaluation is needed to determine the real value of these experimental hybrids. All are jointed except Fla. 7308 which is jointless. With extensive testing, and barring problems, the best of these hybrids could be ready for release by fall 1990. However, new Fusarium race 3 resistant hybrids will be tested next spring using newer inbreds and one of the F₁'s could be released instead in 1991. All Fusarium wilt race 3 resistant hybrids are also resistant to Fusarium wilt races 1 and 2, Verticillium wilt, and gray leafspot. It is not anticipated that there will be any compromise of yield or quality with these or any future finished cultivar releases from this program. Thus the released cultivar should be of great benefit in Fusarium wilt race 3 infested fields, but also comparable or better than other cultivars in fields without Fusarium race 3. Parent lines will be made available to seed companies for their breeding programs.

Several cherry tomato breeding lines will likely be released in the fall of 1989 or spring 1990. Each has a disease resistance not yet commercially available and may be useful to seed companies in developing finished cherry cultivars. Several cherry lines were evaluated in a yield trial in spring 1989 (Table 2, data provided by T. K. Howe). Fla. 7221 and Fla. 7222 are resistant to bacterial spot, Fla. 7223 and Fla. 7224 are tolerant to Fusarium wilt race 3,

Fla. 7225 is resistant to Fusarium wilt race 3 and Fla. 7226 is resistant to Fusarium crown rot. In comparison to 'Cherry Grande', all the breeding lines are smaller fruited, which for the most part is considered desirable. Total yield of Fla. 7226 was not significantly different than 'Cherry Grande', whereas total season yields of other lines were less in part due to the reduced fruit size. A bacterial wilt resistant cherry line not tested with the above may also be released.

Old Projects, Present Status. The focus here will be on heat tolerance and bacterial spot resistance. New heat tolerant hybrids are being tested, but there are no plans to release any at present. A new array of heat tolerant inbreds is being evaluated for improved fruit size, horticultural type, and tolerance to bacterial spot. If one or more of these inbreds prove worthwhile, the efficiency of producing heat tolerant hybrids with other types of lines will be enhanced. The next anticipated release will combine heat tolerance with a high level of resistance to bacterial spot. It is not possible to accurately predict when such releases may be available. It depends on unknowns for both the heat tolerant and heat sensitive parents. Advanced testing could begin as early as next year or not for several years. The bacterial spot resistance work has been difficult due to complex genetic control, erratic selection environments, and possibly some unfavorable linkages which must be broken. This project will continue to receive an intensive effort.

New Projects. All present day nematode resistant cultivars have been derived from a single gene which was introgressed from a wild species in the 1940's. This resistance is not always effective in Florida as it breaks down when soil temperatures are greater than 28°C (82°F) which is often the case in our plastic mulched beds. Some recent work in California reported nematode resistance which was effective under high soil temperatures. This heat stable resistance is in Lycopersicon peruvianum, a wild species which requires two generations of embryo culture to obtain offspring when crossed to tomato. In 1988 and 1989, crossing and embryo culture of this material was done and 18 backcross plants were obtained. Self-pollinated seed was obtained on only 4 of these plants and sibling pollinations have been obtained on most of the others. At present, the lines are being field tested under high temperatures in cooperation with our "retired" nematologist, Mrs. A. J. Overman. It is hoped that resistance will be verified in some of the backcross lines. When seed of resistant backcrosses is available, it will be distributed to those seed companies with interest. Genetic analysis will be conducted to determine how to best incorporate the heat stable nematode resistance into improved breeding lines. A long term goal is to combine genes for resistance to numerous soil-borne pathogens into a single cultivar to avert problems which could occur if fumigants are lost.

There has been little breeding activity so far with regard to the irregular ripening caused by the sweetpotato whitefly. Once the cause of the problem is elucidated, a logical breeding approach can then be pursued. If it is a virus, then it may be easiest to breed

for resistance to the virus and not the whitefly. Alternatively if the disorder is caused by the whitefly itself, resistance to the whitefly might be the best approach. Thusfar several fruit color mutants have been assayed for irregular ripening in cooperation with Drs. D. J. Schuster and J. B. Kring in the field and all expressed the disorder. This indicates the disruption of ripening takes place early in the carotenoid development pathway. Preliminary assessment of genetic lines derived from L. hirsutum and L. pennellii for resistance to the sweetpotato whitefly are being made. Earlier work with vegetable leafminer resistance derived from L. hirsutum has proven quite difficult since resistance is generally lost when plants begin to resemble tomatoes. If resistant, L. pennellii derived lines might be easier to work with than L. hirsutum lines. An accession of L. pennellii was the source of resistance to Fusarium wilt race 3 so early generation lines are already available for testing if sweetpotato whitefly resistance is pursued. Once the cause of irregular ripening is elucidated, developing resistance or tolerance will become a major project for the 1990's.

Table 1. Yield and fruit size for seven Fusarium wilt race 3 resistant hybrids and two cultivars during Spring 1989 at Bradenton, Florida.

Genotype	Early Season				Total Season			
	Marketable Yield (25 lb box/ 1000 ft)	Culls (%)	Large Fruit (%)	Fruit Size (oz)	Marketable Yield (25 lb box/ 1000 ft)	Culls (%)	Large Fruit (%)	Fruit Size (oz)
Fla. 7308	155abc ²	14.8ab	93.6a	7.4a	321a	14.2bc	86.8ab	7.1a
Fla. 7302	207a	9.3cd	87.7ab	6.6ab	318a	11.7cdef	84.2ab	6.3abc
Fla. 7304	182ab	12.6bc	90.9a	6.9ab	297a	10.9def	88.8a	6.7ab
Fla. 7303	153abc	19.7a	90.3a	6.9ab	279ab	16.1ab	84.2ab	6.2abc
Solar Set	153abc	14.4abc	89.6ab	7.3a	274ab	13.1bcd	87.2ab	6.8ab
Fla. 7307	139bc	7.2d	88.5ab	6.6ab	265abc	8.9f	86.2ab	6.5abc
Fla. 7305	159bc	15.3ab	87.6ab	6.7ab	262abc	14.6bc	86.4ab	6.5abc
Sunny	112c	15.4ab	76.2bc	5.7b	260abc	12.5cde	73.6bc	5.6bc
Fla. 7306	138bc	16.6ab	88.6ab	7.2a	221bc	18.4a	8.70ab	7.0a

²Mean separation in columns by Duncan's multiple range test, 5% level.

Table 2. Early and total season yield and fruit size for disease resistant cherry inbreds and a cultivar during spring 1989 at Bradenton, Florida.

Genotype	Resistance ²	Early		Total	
		Yield (15 lb flat/A)	Size (oz)	Yield (15 lb flat/A)	Size (oz)
Cherry Grande	---				
Fla. 7226	FCR	245cd	0.88a	3634a	0.77a
Fla. 7221	BS	464bc	0.70cd	3097bac	0.59cd
Fla. 7225	F3R	140de	0.70cd	2939bc	0.61cb
Fla. 7222	BS	261dc	0.65d	2526bdc	0.61cb
Fla. 7223	F3T	92e	0.60e	2492dc	0.56ed
Fla. 7224	F3T	189de	0.50f	1944d	0.46f
		515a	0.54f	1901d	0.52e

²FCR = Fusarium crown rot; BS = bacterial spot; F3R = Fusarium wilt race 3 resistant; F3T = Fusarium wilt race 3 tolerant.

RESULTS OF NITROGEN AND POTASSIUM DEMONSTRATIONS FOR TOMATOES IN SOUTH FLORIDA

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INTRODUCTION

Optimum fertilizer management is a key to profitable production of high quality vegetables. Traditionally, large amounts of nitrogen (N) and potassium (K_2O) are used for tomato production (5). Commercial application rates of fertilizer are often two to three times the rates of 160 lb/A of N or K_2O recommended by IFAS for soils testing low in Mehlich-I K.

Research on N rates for tomato have been rather inconclusive. In general, tomato yields did not increase when N rate was raised above 200 lb/A (1,2,10). In some studies, yield did not increase above about 150 lb/A (3,5,10). Sometimes, a decrease in yield occurred as N rate increased above 225 lb/A (4).

Much less work has been done with K fertilization of tomatoes. In most studies, K_2O rates varied with N because researchers were using rates of a mixed fertilizer. In recent work, one cultivar of tomato responded to K_2O rates above 225 lb/A while another cultivar did not (4). It was interesting to note that the cultivar that did not respond was the higher yielding cultivar.

Early studies linked K to tomato-quality factors, such as gray wall and blotchy ripening. One study suggested that gray wall was related to the "ratio" of K to N in certain seasons. However ratios were confounded with N and K rates in that study and, in general, results were inconclusive (7). In a more recent study, blotchy ripening and graywall were reduced but not eliminated by increasing the K rate (11). Even rates above 700 lb K_2O did not eliminate the disorders.

The studies reported here were conducted for basically two purposes. One purpose was to field-test current IFAS recommendations for rates of N and K. The second objective was to obtain more information on tomato responses to N and K rates that would permit refinement of the overall commercial fertilizer program. One goal here was to evaluate K applications that were based on soil testing compared to those set by the "ratio" concept.

PROCEDURES

Three studies were conducted in the fall, winter, and spring during the 1988-1989 tomato season in Palm Beach and Manatee counties. Crops were grown on commercial tomato farms.

In Palm Beach, tomatoes were planted on mulched beds that were on 5.5-ft centers. Following the grower application of starter

fertilizer, the experimental fertilizer was applied to the bands on top of the beds. Soil tests showed that the soil was "very low" in K (Table 1) (6).

In Manatee County, studies were conducted on commercial tomato farm using the "single row" bed system, where bed centers were separated by 13 feet and an irrigation ditch. Fertilizer treatments in the fall were 160, 220, and 280 lb N/A and 80, 160, and 240 lb K_2O/A as KNO_3 , $Ca(NO_3)_2$, and NH_4NO_3 . For the Spring crop, the rates were 180, 240, and 300 lb N/A and 120, 200, and 280 lb K_2O/A . These rates of N and K_2O were combined in all possible combinations to make nine treatments. Commercial rates of fertilizer were 336 lb N/A and 530 lb K_2O/A in the Fall, and 400 lb N/A and 624 lb K_2O/A in the Spring. Soil tests showed that the Fall location was "very low" in K while the Spring location was "low" for K (Mehlich-I extractable values).

In all studies, tomatoes were harvested simultaneously with the commercial crop, often by the commercial harvesting crew. Fruits were hand graded in the Palm Beach and Manatee Fall studies, but were machine graded in the Manatee Spring experiment. Tomato leaves were collected through each season for laboratory N and K analyses. Fruit samples were collected from each plot for ripening and laboratory chemical analyses of quality components. This report will focus on the yield and size quality aspects of the study. Nitrogen and K effects did not interact so only the main effects of each will be presented.

RESULTS

Manatee, Fall 1988. Tomato yields did not respond to N rates (Table 2) or to K rates (Table 3). The treatment of 160 lb/A of each N and K_2O produced yields equal to those from 280 lb/A of N or K_2O . The Fall 1988 season at this site included over 15 inches of rain in a short period early in the season. Leaf-tissue results for N showed that leaf-N status was adequate, remaining near 4% even into October. Soil samples at the end of the season showed moderate amounts of fertilizer remaining in the beds from the plots that received high fertilizer rates, especially K. Total soluble salts were relatively low (800 ppm on a 1:2 S:W extract) at the end of the season except for the commercial-grower plots.

The Manatee Fall 1988 results show that considerable reductions in fertilizer rates are possible without a sacrifice in tomato yields (early or total) or a sacrifice in size. Even in a wet season, reductions in fertilizer rates were possible at this location. The data also show that "ratios" of N and K were not important because the 160 N/80 K_2O treatment (2:1) did as well as the 160 N/280 K_2O (1:1.75). Furthermore, the 160 N/80 K_2O treatment yielded statistically the same as the grower plots that received 336 lb N/530 lb K_2O/A (1:1.6), although the apparent trend was in favor of the lower (IFAS) fertilizer rate (Table 8). An interesting aspect of this study was the lack of response to K even on a soil testing very low in K. Even at these extractable-K levels, there

was adequate K in the soil for excellent tomato production.

Palm Beach, Winter 1988-1989. Nitrogen rates had no effect on yield or on fruit size of tomatoes (Table 4). Yields ranged from 1922 ctn/A with 160 lb N/A to 1670 ctn/A with 280 lb N/A (1 ctn=25 lb). These yields were statistically the same as those received by the grower using 336 lb N/A.

This soil tested extremely low for K (Table 1) and tomato yields responded positively to added K (Table 5). From the three K rates selected in the factorial treatment arrangement, response above 240 lb K₂O/A is suggested. However, the treatment of 160 lb N and 240 lb K₂O/A yielded the same as the grower treatment with 672 lb K₂O/A. Additional treatments were included in this study to test the K₂O aspect further. These treatments of 440 and 672 lb K₂O/A did not yield better than 240 lb K₂O/A.

Leaf-tissue analyses confirmed the yield results. Leaf-K concentration increased as K₂O rate increased. Leaf-K fell from about 2.2 % early in the season to less than 1.0 % for the low-K treatment. Plants receiving 240 lb K₂O/A had leaf-K concentrations of 2.5 % early in the season and about 2.0 % late in the season. Plants with higher K concentrations from higher fertilizer rates did not yield better than those receiving 240 lb K₂O/A.

Leaf-N was 4.0 % for all treatments early in the season and above 3.5 % for all treatments later in the season. Plants receiving more than 280 lb N/A had N concentrations of 4.0 % late in the season, but did not produce more fruit than plants receiving 160 to 220 lb N/A and having leaf-N levels of 3.8 %.

The results from Palm Beach indicate that rates of K₂O higher than 240 lb/A probably will not result in higher yields. The crop-nutrient requirement for K appears to be about 240 lb K₂O/A, slightly higher than the current IFAS value of 160 lb/A. This result is different from those from Manatee, Fall 1988, discussed above because the Manatee crop did not respond to K₂O rates, even on a soil testing very low in K.

As with the Manatee results above, the Palm Beach data indicate that tomatoes respond to rates of N and K₂O, not to ratios of N and K₂O. As long as about 240 lb K₂O/A were supplied, the rate of N did not matter and higher rates of K₂O did not result in better yields.

Manatee, Spring 1989. Like the Fall, 1988 crop, tomatoes in the Spring did not respond to N or K₂O rates (Tables 6 and 7). Yields are expressed on the basis of 3300 linear bed feet of crop in 43560 sq. feet. The yields of about 1300 ctn per 3300 linear bed feet would be roughly equivalent to 950 ctns per roll of plastic (2400 feet), an excellent yield. Furthermore, these yields were achieved in only two harvests.

Rates of N of 180 lb/A and rates of K₂O of 120 lb/A resulted

in the same yields and fruit size as N and K₂O rates of 300 and 280 lb/A, respectively. Leaf-N concentrations remained at about 3.75 % for most of the season, falling to only 3.5 % late in the season. Leaf-K concentration stayed above 2.5 %.

The Manatee, Spring 1989 data show that reductions in fertilizer are possible for this grower, especially for K₂O. This soil tested somewhat higher in K than the other two sites in these studies. Yield data and leaf tissue data show that the tomato could obtain all of its K requirement from the soil at this location. This was different from the result at Palm Beach where the soil-K was extremely low.

The Manatee data also refute the N/K ratio concept since the 180 N/120 K₂O treatments (1.5:1) yielded as well as the 180 N/280 K₂O (1:1.6) treatment. In addition, the lower fertilizer treatment produced the same yield as that of the grower (Table 8). A further interesting aspect from this study concerned a treatment of 240 lb N and 80 lb K₂O/A. This treatment yielded 1300 ctn/A compared to 1333 ctn/A for the 180 N/200 K₂O and 400 N/624 K₂O treatments. Again, this shows that the tomato plants could obtain a large amount of K from the unfertilized soil. It also implies that one should question the validity of the N/K fertilizer ratio concept.

SUMMARY

The results of the above studies indicate several important possibilities for tomato growers in Florida. They provide data that should assist commercial growers and IFAS to devise efficient fertilizer programs. Results can be summarized as follows:

1. Commercial growers can reduce rates of N without sacrificing yields or quality. Data presented in Table 8 show that rates of N in the range of 160 to 200 lb/A gave results equal to those with over 300 lb N/A. These results agree with those found for pepper (8,9).
2. Applications of K can be predicted upon soil testing (Mehlich-I extractant). Tomatoes in these studies responded to added K₂O only when the soil tested extremely low in K₂O (M-I K<20 ppm) and even then not always.
3. Fertilizer N and K applications should be based on crop nutrient requirement and soil testing concepts rather than on ratio concepts. Our data show that supplying K in amounts predicted by soil testing results in more efficient K fertilization without reductions in yield or quality. Depending on the soil test, K₂O rates may range from near 240 lb/A down to zero. Preliminary results from laboratory fruit-quality measurements show that reducing the K rate does not reduce fruit quality nor increase ripening disorders.

4. One recommendation would be for growers to try reducing N and K₂O rates in relatively small steps e.g. 20 to 25%. Try these reduced levels for one or two seasons, then try another reduction. Lowering fertilizer rates could improve profitability and also could reduce the soluble salt problem many growers are facing on their farms.

LITERATURE CITED

1. Bryan, H. H., J. W. Strobel, and J. D. Dalton. 1967. Effects of plant populations, fertilizer rates on tomato yields on rockdale soil. Proc. Fla. State Hort. Soc. 80:149-156.
2. Csizinszky, A. A. 1980. Response of tomatoes to fertilizer rates and within row plant spacing in two and four row production systems. Proc. Fla. State Hort. Soc. 93:241-243.
3. Csizinszky, A. A., and D. J. Schuster. 1982. Yield response of staked, fresh-market tomatoes to reduced use of fertilizers and insecticides. J. Amer. Soc. Hort. Sci. 107:648-652.
4. Csizinszky, A. A., and J. W. Scott. 1985. Response of tomato breeding line 7060 and 'Horizon' to nitrogen and potassium rates. Proc. Fla. State Hort. Soc. 98:240-244.
5. Everett, P. 1976. Effect of nitrogen and potassium rates on fruit yield and size of mulch-grown staked tomatoes. Proc. Fla. State Hort. Soc. 89:159-162.
6. Hanlon, E. A., G. Kidder, and B. L. McNeal, in press. Soil container media, and water testing interpretations and IFAS standardized fertilization recommendation. Fla. Coop. Extn. Ser., IFAS, Univ. of Fla. Circular 817.
7. Hayslip, N. C., and J. R. Iley. 1964. Tomato fertility trials on sandy soils. Proc. Fla. State Hort. Soc. 77:168-172.
8. Hochmuth, G. J., K. D. Shuler, P. R. Gilreath, and R. L. Mitchell. 1987. Field-testing of revised Mehlich-I-predicted fertilizer recommendations for pepper. Soil Crop Sci. Soc. Fla. Proc. 47:30-35.
9. Hochmuth, G. J., K. D. Shuler, R. L. Mitchell, and P. R. Gilreath. 1987. Nitrogen crop nutrient requirement demonstrations for mulched pepper in Florida. Proc. Fla. State Hort. Soc. 100:205-209.
10. Persaud, N., S. J. Locascio, and C. M. Geraldson. 1976. Effect of rate and placement of nitrogen and potassium on yield of mulched tomato using different irrigation methods. Proc. Fla. State Hort. Soc. 89:135-138.

11. Picha, D. H., and C. B. Hall. 1981. Influences of potassium, cultivar, and season on tomato graywall and blotchy ripening. J. Amer. Soc. Hort. Sci. 106:704-708.

Table 1. Pre-fertilization Mehlich-I soil-test indices for tomato nitrogen-potassium studies in southern Florida, winter-spring, 1988-89.

Location Season	Soil pH (1:2 S:W)	Index (Mehlich-I)							
		P	K	Ca	Mg	Zn	Cu	Mn	
					ppm				
Manatee Fall 1988	7.6	150 VH ²	14 VL	1382	220	17	14	14	
Palm Beach									
Winter 1988-89	7.7	300 VH	16 VL	1242	74	12	14	15	
Manatee Spring 1989	7.1	62 VH	26 L	1044	140	9	5	5	

²Mehlich-I interpretations are very low (VL), low (L), and very high (VH), respectively.

Table 2. Effects of nitrogen on yields of tomatoes, Manatee County, Fall, 1988.

N rate lb/A ^y	Early yield (first harvest)					
	Fruit grade					
	5x6	6x6	6x7	7x7	Cull	Tot. Mkt.
	----- 25-lb ctn/A -----					
160	55	23	7	1	9	85
220	44	24	6	1	8	74
280	48	24	7	1	8	79
Significance (P=.05)	NS ^z	NS	NS	NS	NS	NS

N rate lb/A ^y	Total yield					
	Fruit grade					
	5x6	6x6	6x7	7x7	Cull	Tot. Mkt.
	----- 25-lb ctn/A -----					
160	137	266	349	38	102	752
220	117	259	322	40	90	698
280	111	281	374	39	94	766
Significance (P=.05)	NS ^z	NS	NS	NS	NS	NS

^yRates of N calculated on basis of 7260 linear bed feet of crop per 43560 sq. feet. Yields expressed on a basis of 3300 linear bed feet of crop per 43560 sq. feet.

^zEffects of N rate are non significant (NS).

Table 3. Effects of potassium on early and total yields of tomatoes, Manatee County, Fall, 1988.

K ₂ O rate lb/A ^y	Early Yield (1st harvest)					
	Fruit grade					
	5x6	6x6	6x7	7x7	Cull	Tot. Mkt.
----- 25-lb ctn/A -----						
80	45	24	7	1	8	77
160	51	24	6	1	10	82
240	50	23	6	1	7	80
Significance (P=.05)	NS ^z	NS	NS	NS	NS	NS

K ₂ O rate lb/A ^y	Total yield					
	Fruit grade					
	5x6	6x6	6x7	7x7	Cull	Tot. Mkt.
----- 25-lb ctn/A -----						
80	120	270	346	41	92	736
160	125	279	344	41	99	748
240	120	256	354	35	95	730
Significance (P=.05)	NS ^z	NS	NS	NS	NS	NS

^yRates of K₂O calculated based on 7260 linear bed feet of crop per 43560 sq. feet. Yields expressed on basis of 3300 linear bed feet per of crop 43560 sq. feet.

^zEffects of K₂O are nonsignificant (NS).

Table 4. Effects of nitrogen rates on yield of tomatoes, Palm Beach County, Winter 1988-89.

N rate lb/A ^y	Early Yield				
	Fruit grade				
	5x6	6x6	6x7	Cull	Tot. Mkt.
----- 25-lb ctn/A -----					
160	211	436	40	36	687
220	182	404	38	33	624
280	196	406	38	36	640
Significance (P=.05)	NS ^z	NS	NS	NS	NS

N rate lb/A ^y	Total yield				
	Fruit grade				
	5x6	6x6	6x7	Cull	Tot. Mkt.
----- 25-lb ctn/A -----					
160	385	1252	285	167	1922
220	354	1128	248	181	1730
280	376	1113	178	175	1668
Significance (P=.05)	NS ^z	NS	NS	NS	NS

^yRates of N calculated on a basis of 7260 linear bed feet of crop per 43560 sq. feet. Yields expressed on a basis of 8000 linear bed feet of crop per 43560 sq. feet.

^zEffects of N rate are nonsignificant (NS).

Table 5. Effects of potassium rates on yield of tomatoes, Palm Beach County, Winter 1988-89.

K ₂ O rate lb/A ^y	Early Yield				
	Fruit grade				
	5x6	6x6	6x7	Cull	Tot. Mkt.
	----- 25-lb ctn/A -----				
80	200	404	42	37	646
160	190	425	31	35	646
240	199	418	43	33	660
Significance (P=.05)	NS ^z	NS	NS	NS	NS

K ₂ O rate lb/A ^y	Total Yield				
	Fruit grade				
	5x6	6x6	6x7	Cull	Tot. Mkt.
	----- 25-lb ctn/A -----				
80	313	909	190	170	1412
160	362	1177	209	164	1748
240	440	1406	313	190	2160
Significance (P=.05)	L ^z	L	L	NS	L

^yRates of K₂O calculated on a basis of 7260 linear bed feet of crop per 43560 sq. feet. Yields expressed on a basis of 8000 linear bed feet of crop per 43560 sq. feet.

^zEffects of K₂O rates are linear (L) or nonsignificant (NS).

Table 6. Effects of nitrogen rates on yield of tomatoes,
Manatee County, Spring, 1989.

N rate lb/A ^y	Early yield Fruit grade					
	5x6	6x6	6x7	7x7	Cull	Tot. Mkt.
----- 25-lb ctn/A -----						
180	442	258	107	17	49	807
240	459	275	103	17	50	837
300	457	274	113	22	53	843
Significance (P=.05)	NS ^z	NS	NS	NS	NS	NS

N rate lb/A ^y	Total Yield Fruit grade					
	5x6	6x6	6x7	7x7	Cull	Tot. Mkt.
----- 25-lb ctn/A -----						
180	795	378	135	21	74	1308
240	824	367	133	21	72	1325
300	771	373	138	27	76	1282
Significance (P=.05)	NS ^z	NS	NS	NS	NS	NS

^yRates of N calculated on a basis of 7260 linear bed feet of crop per 43560 sq. feet. Yields expressed on a basis a of 3300 linear bed feet of crop per 43560 sq. feet.

^zEffects of N rates are nonsignificant (NS).

Table 7. Effects of potassium rates on yield of tomatoes,
Manatee County, Spring, 1989.

K ₂ O rate lb/A ^y	Early yield Fruit grade					Tot. Mkt.
	5x6	6x6	6x7	7x7	Cull	
	----- 25-lb ctn/A -----					
120	471	261	108	20	57	841
200	441	279	114	19	48	833
280	446	266	102	17	47	814
Significance (P=.05)	NS ^z	NS	NS	NS	NS	NS

K ₂ O rate lb/A ^y	Total Yield Fruit grade					Tot. Mkt.
	5x6	6x6	6x7	7x7	Cull	
	----- 25-lb ctn/A -----					
120	784	358	134	23	82	1276
200	803	382	140	24	70	1326
280	804	378	132	22	70	1315
Significance (P=.05)	NS ^z	NS	NS	NS	NS	NS

^yRates of K₂O calculated on a basis of 7260 linear bed feet of crop per 43560 sq. feet. Yields expressed on a basis of 3300 bed feet of crop in 43560 sq. feet.

^zEffects of K₂O rates are nonsignificant (NS).

Table 8. Comparison of specific fertilizer treatments with grower practices.

Location	Grower	Fertilizer practice (N:K ₂ O)	Early yield ^{2,y}					Cull	Tot. Mkt.
			5x6	6x6	6x7	7x7	Fruit grade		
			----- 25-lb ctn/A -----						
Manatee (Fall 1988)	IFAS	160:80	57	25	8	1	9		88
	Grower	336:530	30	22	6	0	3		58
Palm Beach (Winter 1988)	IFAS	160:240	245	445	38	-	38		728
	Grower	336:672	171	365	30	-	35		566
Manatee (Spring 1989)	IFAS	180:200	417	266	129	17	44		814
	Grower	400:624	414	288	118	22	66		821

			----- 25-lb ctn/A -----						
Manatee (Fall 1988)	IFAS	160:80	155	272	360	33	97		787
	Grower	336:530	84	244	310	30	68		637
Palm Beach (Winter 1988)	IFAS	160:240	524	1545	381	-	215		2451
	Grower	336:672	393	1562	358	-	186		2313
Manatee (Spring 1989)	IFAS	180:200	790	385	158	22	67		1333
	Grower	400:624	785	401	145	26	98		1332

²Yields based on 3300 and 8000 linear bed feet of crop in 43560 sq. feet in Manatee and Palm Beach, respectively.

^yNo significant (P=.05) differences between IFAS and grower yields.

Effect of Pruning Methods on Yields, Fruit Weight
and Percent Marketable Fruit of
'Sunny' and 'Solar Set'

S. M. Olson

Tomatoes rank as the number one vegetable crop in Florida with farm value in 1987-88 season in excess of \$535 million on 56,800 acres. Production costs run about \$3000-4000/A depending upon the production area (3). The cost of pruning an acre ranges from about \$16-64 an acre depending upon how many times the crew goes through the field. This operation pruning comprises a very small part of production costs but can have a great effect on yields of the crop. Very little information is available on how to prune determinate type tomatoes or if determinate cultivars react differently to pruning methods (1,2). This study was undertaken with 'Sunny' the most widely used cultivar in Florida and 'Solar Set', a new cultivar for Florida production. The cultivars differ in the extent of vine production with 'Solar Set' producing less than 'Sunny'. 'Solar Set' would compare to 'Duke' in foliage production.

Materials and Methods

Pruning trials were conducted at the North Florida Research and Education Center. Planting dates were 3/23/83, 3/26/84, 3/21/88, and 3/21/89. Cultivars used were 'Sunny' and 'Solar Set'. 'Solar Set' is a new release from the University of Florida breeding program with very little cultural information available. 'Solar Set' was planted only in 1988 and 1989. 'Sunny' was not harvested in 1989 due to very poor plant stands.

Soil type was an Orangeburg loamy fine sand. Production was on full bed black plastic mulch with drip irrigation in 1988 and 1989 and overhead irrigation in 1983 and 1984. Total fertilizer applied in 1983 and 1984 was 216-120-295 lb/A of N-P₂O₅-K₂O. In 1988 and 1989 180-148-211 lbs/A of N-P₂O₅-K₂O were applied. Beds were fumigated with methyl-bromide before covering. Plants were staked and tied 4 times. Between-row spacing was 6 feet (7,260 linear feet/A). In-row spacing was 24 inches in 1983 and 1984 and 20 inches in 1988 and 1989. A randomized complete block design with 4 replications was used in all years except 1983 when 3 replications were used. Plot size was 20 feet.

Pruning treatments consisted of none, light (50% of the suckers removed from ground to first fork which is suckers below first bloom cluster) and heavy (all suckers removed from ground to first fork). Suckers were removed while small to prevent damage to plants.

Plants were harvested 4 times each year except 1989 where 3 harvests were made. Data collected included total yields, average fruit weight and percent marketable fruit.

Results

With 'Sunny' heavy pruning reduced yields over none or light pruning. (Table 1). Highest yield in all three years occurred with light pruning but was not significantly greater than no pruning. Pruning methods had no effect on fruit weight in 1984 but in 1983 and 1988 fruit size increased as degree of pruning decreased. (Table 2). Pruning methods did not significantly affect percent marketable fruit, but the highest percent marketable fruit occurred with light pruning. (Table 3).

Total yields of 'Solar Set' were reduced by heavy pruning over light or none. In both years highest yield was with no pruning but only in 1988 was it significantly higher than no pruning. (Table 4). Largest fruit size occurred with heavy pruning in both years and fruit size decreased as amount of pruning decreased. No pruning produced smallest fruit but was only significantly smaller than those produced by heavy pruning. Percent marketable fruit was lowest with heavy pruning in both years. No pruning produced significantly higher percent marketable fruit than heavy pruning in both years. In 1989 light pruning produced a significantly higher percent marketable fruit than heavy pruning but not in 1988.

Conclusion

'Sunny' produced highest total yields and percent marketable fruit with light pruning but never significantly greater than no pruning. Fruit size was smallest with no pruning and in 2 out of 3 years greatest with heavy pruning. Many growers prune 'Sunny' to first fork and may be reducing their total yields to increase fruit size. Even with heavy pruning there was adequate foliage to cover fruit and prevent sunburning.

With 'Solar Set' yields were highest with no pruning in both years but not significantly greater than light pruning in 1989. Heavy pruning resulted in largest fruit size but in lowest percent marketable fruit. With heavy pruning there was not enough foliage to protect fruit and many fruit were sunburned and unmarketable. At present additional trials are planned with 'Solar Set' to look at effect of removing only the ground suckers. With no pruning both cultivars present problems with excessive foliage at bottom of plant that are not caught in first or second strings.

New cultivars should be trialed on a limited basis to see how they react to pruning. Pruning a new cultivar heavy without knowing its vine characteristic could result in reduced yields and quality.

Literature Cited

Geisenbery, C. and K. Stewart. 1986. Field Crop Management. In The Tomato Crop, A Scientific Basis for Improvement, J. G. Atherton and J. Rudick, editors. p. 539.

Hochmuth, G. J., editor. 1988. Tomato Production Guide for Florida. Circular 98C.

Taylor, T. G. and S. A. Smith. 1988. Production Costs for Selected Florida Vegetables, 1987-88. Economic Information Report 245. pp. 18-20.

Table 1. Effect of Pruning Methods on Total Yields of 'Sunny' Tomatoes, Quincy.

Pruning Method	Total Yield (boxes/A)			Avg.
	1983	1984	1988	
None	2137 a ²	1831 a	2370 a	2113
Light	2459 a	1915 a	2634 a	2336
Heavy	1737 b	1348 b	1816 b	1634

²Mean separation by Duncan's multiple range test, 5% level.

Table 2. Effect of Pruning Methods on Fruit Weight of 'Sunny' Tomatoes, Quincy.

Pruning Method	Fruit Weight (oz)			Avg.
	1983	1984	1988	
None	6.95 c ²	7.01 a	6.78 c	6.91
Light	7.63 b	7.37 a	7.17 b	7.39
Heavy	8.49 a	7.21 a	8.39 a	8.03

²Mean separation by Duncan's multiple range test, 5% level.

Table 3. Effect of Pruning Methods on Percent Marketable Fruit of 'Sunny' Tomatoes, Quincy.

Pruning Method	Percent Marketable Fruit (%)			Avg.
	1983	1984	1988	
None	56.1 a ²	64.4 a	71.5 a	64.0
Light	62.1 a	67.5 a	80.9 a	70.2
Heavy	57.9 a	64.8 a	77.9 a	66.9

²Mean separation by Duncan's multiple range test, 5% level.

Table 4. Effect of Pruning Methods on Total Yield, Fruit Weight and Percent Marketable Fruit of 'Solar Set' Tomatoes, Quincy.

Pruning Method	Total yield (boxes/A)		Fruit weight (oz)		Percent marketable fruit (%)	
	1988	1989	1988	1989	1988	1989
None	2685 a ²	2065 a	7.06 b	7.41 b	77.6 a	62.6 a
Light	2243 b	1850 a	7.69 ab	8.16 ab	73.0 ab	61.8 a
Heavy	1482 c	1379 b	8.32 a	8.70 a	64.6 b	51.1 b

²Mean separation by Duncan's multiple range test, 5% level.

TREATMENT OF TOMATO WASTES USING ANAEROBIC DIGESTION by

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The disposal of tomato culls is becoming an increasingly more expensive cost item to the packers of fresh market tomatoes. The volumes are large, 30 percent of the incoming tomatoes, amounting to 150,000 tons annually for California. At present it is necessary to haul the culls away to pastures where cattle will eat them. The hauling costs are increasing such that it cost more to haul than the nutritional benefit to the cattleman. The net cost to the tomato packer is now \$1.35 per ton to dispose of the cull tomatoes. In addition, there was a concern for possible pesticide residues on these tomatoes, which may be magnified if the tomatoes are eaten by cattle thus concentrating the residues in the flesh of the cattle. For these reasons, the California Fresh Market Tomato Advisory Board has supported a research project at Cal Poly to investigate an alternative disposal method for these cull tomatoes, namely anaerobic digestion.

This report describes the results of the second year of this project, the design, construction and testing of a pilot scale anaerobic digester for these culled tomatoes (Babcock, et al, 1989). A 700 gallon up-flow plastic media-filled digester along with piping, pumps and the necessary controls was constructed at the Cal Poly Agricultural Engineering Department during the Spring, 1988.

Digester Operation

The digester underwent preliminary testing at Meyer Tomatoes, King City, during July, 1988 and was then returned to Cal Poly for modifications to the pumping and piping systems. The digester was then tested at Cal Poly over a 10 week period at two different organic loading rates. Cull tomatoes from Meyer Tomatoes were used as influent for the digester. Each batch of influent slurry was prepared by grinding the whole tomatoes and then using a finisher to separate the skins and seeds from the pulp. This pulp, which constituted about 85 percent by weight of the whole tomatoes, was then diluted with water, and its pH adjusted from 4.5 to 8 using sodium hydroxide. The resulting slurry, which contained about 1.6 to 2.1 percent total solids, was pumped slowly into the digester tank using a metering pump. Although the digestion system had heating provisions, difficulties with the heat exchange mechanism prevented the maintenance of an optimum temperature. Hot water was used for dilution, and this resulted in an average digestion temperature of about 70-75°F. As the slurry was metered into the system, an equal amount of effluent was expelled from the overflow line. This effluent was disposed of after sampling and testing.

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Digester Operation (cont)

The slurry recirculation system was run continuously during the test period. This was done to simulate a completely-mixed state and to partially offset the lack of heating. The quantity of generated biogas was measured with the gas meter and then piped into the flexible storage bag. From here the gas was tested for methane percentage using a Fyrite meter, and was occasionally used in a modified natural gas hot water heater.

The digester was operated continuously for a period of 13 weeks. The first three weeks were an acclimation period during which time effluent from the San Luis Obispo sewage treatment plant anaerobic digester was added to the Cal Poly digester to initiate start-up. This was followed by two five-week testing periods (Phase I and Phase II) during which time the hydraulic loading rate remained essentially constant at 30 gallons per day (23 day hydraulic retention time) while two different organic loading rates were utilized. During Phase I the slurry consisted of tomato pulp diluted with water for a 1.6 percent total solids content of which 91 percent were volatile solids; the organic loading rate was then 0.04 pounds of volatile solids per cubic foot of digester per day. In Phase II the dilution water was reduced such that the influent slurry total solids content was 2.1 percent, and the organic loading rate was 0.05 pounds of volatile solids per cubic foot per day.

Results

The anaerobic digester performed well during the test period, producing quantities of biogas while reducing the total solids, volatile solids and COD of the treated slurry. During Phase I, the average digester temperature was 77° F and the pH of the effluent was 6.9. Average biogas production was 30 cubic feet per day from the digester which had a volume of 93 cubic feet, resulting in a specific biogas rate of 0.32 cubic feet per cubic foot of digester per day. Based upon the organic loading rate of 0.04 pound of volatile solids per cubic foot per day, the biogas production rate for the Phase I period was 8.0 cubic feet per pound of volatile solids added per day. The total solids reduction was 78 percent as a result of anaerobic digestion.

The average temperature of the digester dropped during Phase II to 73°F, and the average pH was 7.0 indicating a stable digestion process. The biogas production did increase to an average of 43 cubic feet per day, or a specific biogas rate of 0.47 cubic feet per cubic foot of digester per day. At the higher loading rate of 0.05 pound of volatile solids per cubic foot per day, the biogas production rate increased to 9.4 cubic feet per pound of volatile solids added per day. The methane content of the gas during Phase II averaged 62.4 percent. The total solids reduction was measured to be 70 percent, or slightly less than during Phase II.

Page3

Results (cont)

However, the COD testing of the influent (20,000 parts per million) and of the effluent (145 parts per million) showed a reduction in COD of over 99 percent. This was a very impressive result, considering the digestion was carried out at less than optimum temperatures (95°F) for mesophilic anaerobic digestion.

Discussion

The operational parameters observed during the anaerobic digestion of tomato wastes included temperature, pH, total solids and COD reduction, hydraulic retention time, organic loading rate, and biogas production. The fact that rather complete anaerobic treatment of the tomato slurry (99 percent reduction in COD) occurred even though the temperature was somewhat low (73°F) can be attributed to the use of the plastic media which entrapped the bacteria for more efficient digestion, and the rather long hydraulic retention time, 23 days. Since the tomatoes were rather acidic (pH 4.0-4.2), addition of sodium hydroxide was necessary to neutralize the influent and maintain the digester pH at 7.0. The total solids reduction was found to be between 70 to 78 percent while the COD reduction was very high at 99 percent. This was due to inorganic material in the effluent, and the fact that the organic material in the tomato wastes was highly digestible. The high treatment efficiency was also due to organic loading rates that were fairly low, .04-.05 pounds of volatile solids per cubic foot of digester per day, and a fairly long hydraulic retention time, 23 days. Based upon previous work summarized by Babcock, et al (1989), upflow anaerobic filters can be operated at organic loading rates of 0.5 to 1.0 pounds of volatile solids per cubic foot per day, and retention times of only 2 to 3 days. The biogas production rate of 9.4 cubic feet per pound of volatile solids added per day would result in the following energy production if applied to a full scale tomato packer: Assuming 100 tons of culled tomatoes per day, a total of 64,000 cubic feet of biogas with an energy value of 40 million Btu would be produced daily. This gas could fuel an engine generator producing 110 kW continuously for 24 hours per day. This electricity could be used to offset that bought from the utility company at the rate of \$0.10 per kilowatt-hour; over the six month operating season a total savings of approximately \$40,000 would result. Furthermore, the waste heat of the engine-generator would substitute for the natural gas used for heating the washwater in the packing shed, resulting in about \$6,000 savings. Added to this would be the savings in hauling costs of the cull tomatoes, amounting to \$1.35 per ton, or over \$20,000 per year. Thus, an annual total of \$66,000 in benefits from energy and disposal savings could result from a full-scale digester at a typical fresh market tomato packing operation.

1. Babcock, R., D. W. Williams, P. Stepanek, J. Montecalvo. 1989. "Pilot-Scale Methane Production from Culled Tomatoes". ASAE Paper No. 89-6085, St. Joseph, Michigan.

ESTIMATING MECHANICAL INJURY DURING TOMATO HANDLING USING THE INSTRUMENTED SPHERE

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INTRODUCTION

Minimizing mechanical injury during handling is one of the primary goals of Florida tomato packer/shippers. Tomatoes experience a number of transfers during typical harvest, handling and packing operations, and each of these transfer points has potential to reduce quality by inflicting bruises, cuts, punctures and abrasions.

Many studies have documented the extent of external and internal mechanical injury incurred during tomato handling (Halsey, 1955; Hatton and Reeder, 1963; MacLeod et al., 1976). Recently a prototype instrument became available which is capable of measuring impact accelerations experienced during handling operations (Zapp, et al, 1989). This Instrumented Sphere (IS) is a battery operated data logger which is 3.5 inches in diameter and has a density similar to that of a tomato. It can be placed on a packing line in order to record impact times and intensities at each of the transfer points. The IS was originally developed for analyzing apple handling systems at the USDA/ARS laboratory at Michigan State University in East Lansing, Michigan. We purchased an IS to develop a database for vegetable handling systems as part of a cooperative research project involving several research institutions and a variety of horticultural crops.

As part of a continuing effort to optimize the handling of Florida tomatoes, we began a program this past spring season: 1) to develop a database of impacts at transfer points during tomato handling using the IS; 2) to document actual mechanical injury for a range of tomato handling and packing situations in Florida; and 3) to correlate IS data with actual injury data in order to allow prediction of potential injury for packing line transfer points using impact values measured by the IS. This report will describe results regarding Objectives 1 and 2.

PROCEDURES

Instrumented Sphere Tests

The IS was run over three tomato packing lines during the spring of 1989. The following procedure was employed during the tests. While the line was running at typical capacity, the IS was activated and placed in the line, beginning in the bulk bin prior to dumping into the float tank. It was allowed to flow over several transfer points while the elapsed time was recorded at each point.

The IS was then removed and the data was transferred to a portable computer. This procedure was repeated ten times for each segment of the packing line until the entire line was documented. Averages were later taken for the ten runs at each transfer point.

Tomato Samples

In May and June, 1989, samples were taken from two of the packinghouses at four points during handling: in the bulk bin at filling in the field; in the float tank after dumping; after final grading (but prior to sizing); and after the carton was stacked on the pallet. 'Sunny' was the cultivar sampled for these two packinghouses. At each sample point 80 tomatoes of 6x6 size and at two ripeness stages (mature green and breaker) were randomly selected. These were placed in polystyrene cell pack trays to avoid further damage.

The samples were transported the same day to the laboratory in Gainesville and were held at about 70°F (21°C). Mature green tomatoes were treated with 100 ppm ethylene to initiate ripening. When the samples reached firm, red ripe stage (7 to 14 days postharvest) they were evaluated for external damage (bruises, cuts/punctures, abrasions, decay) based on federal grade standards (USDA, 1976). Damage which was obviously attributable to preharvest factors was not scored. The tomatoes were also sliced through the equator and rated for incidence of internal bruising, and the number of locules was recorded. Internal bruising is described as a failure of the locular gel to ripen after the tomato receives an impact above a certain threshold level. The shock is transmitted through the locular wall to the underlying gel, causing a disruption of the ripening process in the gel. As a result the gel appears yellowish, shrunken and stringy after the fruit has reached the red ripe stage.

RESULTS AND DISCUSSION

Packing line transfer points

Every point at which a fruit or vegetable is transferred from one type of equipment to another is a potential site for increased mechanical injury. Therefore the packing lines which cause the least injury are straight, with no major turns during handling, and level, with minimal drops at transfer points. Transfer points should also be clean, smooth and padded at surface protrusions. Brush rolls should be set at sufficient speed so as to provide adequate washing without causing excessive fruit movement and increased fruit to fruit contact.

The impact averages as measured by the IS showed that the highest impacts generally occurred where there was a roll or drop onto a metal plate at the transfer point or a roll down a steep incline onto a roller conveyor (Table 1). Other transfers were usually lower than 60 g's, which probably caused minimal mechanical injury. The drop to the wash brushes for the lines at Packinghouses

1 and 3 (PH-1, PH-3) was quite severe. At this point tomatoes on these two lines dropped onto metal prior to bouncing to the brushes, resulting in average impacts of 110 and 147 g's, respectively. This same transfer point at Packinghouse 2 (PH-2) caused an average impact of 68 g's due to a lower drop height.

The maximum g's measured at the drop to the washer ranged from 149 to 207 g's for the three houses, illustrating the extent of severe shocks which can be experienced by tomatoes during typical handling. The variability in shocks measured for several runs over a particular point is due to the volume of tomatoes being run across the line at a certain moment; the lower the volume, the less fruit to fruit contact which allows the IS to directly strike plates and rollers.

The average impact measured on the Green Lines for the three packing lines was 67.4 g's, while the average impact measured on the Pink Lines was 82.2 g's. Tomatoes showing color are less firm than those which are at the mature green stage and therefore are more sensitive to impacts. Packing lines should be designed and managed to handle the most injury sensitive crop, in this case, tomatoes which are showing color. For existing lines drop heights and transfer plate angles at transfer points can be lowered. Curtains or power brushes can also facilitate transfer while reducing mechanical injury.

Mechanical Injury

Scores for external injuries at firm, red ripe stage confirmed that MG tomatoes were less susceptible to injury than BR tomatoes (Tables 2, 3). The only exception was PH-2, which had significantly more abrasions on MG than BR. Analysis by sample location showed that the amount of damage-free tomatoes decreased to 72.5% and 73.1% during harvest and transfer to the bulk bin for PH-2 and PH-3, respectively. Bruises, cuts/punctures and abrasions increased substantially during harvest.

After transport to the packinghouses and dumping into the float tanks the amount of damage-free tomatoes decreased to 48.1% and 57.5% for PH-2 and PH-3, respectively. Cuts/punctures increased significantly for both houses, and abrasions increased significantly for PH-2; bruises did not increase significantly during transport and dumping.

The grading operation significantly reduced the amount of damaged tomatoes in both houses, with the averages after grading similar to those in the bin prior to transport. This reveals the effective management of the grading operations for these packinghouses. There was no significant increase in damage during sizing, carton filling and palletizing operations for either house. The extent of injury inflicted from the float tank and prior to grading was not determined, since the sample was taken after grading.

Internal bruising (IB) was rated as Moderate (very noticeable discoloration at the locular gel margin) and Severe (desiccation of the gel in addition to discoloration). Both of these ratings were deemed to be potentially quite objectionable to the consumer. The analysis revealed that MG tomatoes were significantly more resistant to this type of injury than BR tomatoes for both packinghouses (Tables 2,3). Overall, PH-2 had 79.7% and 60.0% IB-free for MG and BR tomatoes, respectively; PH-3 had 99.7% and 55.0% for these ripeness stages.

Incidence of IB increased significantly with handling. Samples for PH-3 taken in the field bin, in the float tank and after final grading had progressively more IB. However, sizing, filling and palletizing did not cause additional IB in this house. It can be seen from the interactions that there was virtually no IB in MG tomatoes during handling, while incidence of IB in BR tomatoes increased to 63.7% after palletizing. Samples for PH-2 had higher amounts of IB than PH-3 in both MG and BR tomatoes, though following the same trend as PH-3. The apparent reduction in IB for BR tomatoes sampled in the float tank was related to difficulty in scoring IB due to a high proportion of severely puffy tomatoes in that particular lot of tomatoes.

IB is not associated with puffiness; this was confirmed by a separate laboratory test in which undamaged tomatoes from this same lot of 'Sunny' (PH-2) were dropped from several heights onto a hard surface. In that test, IB only occurred at drop sites on the tomatoes, regardless of extent of puffiness. In fact, puffy tomatoes may actually have less incidence of IB by providing an air barrier between the locular wall and the locular gel during impacts. An analysis of the extent of external injury and internal bruising for 'Sunny', 'Solar Set', and NK-4459 was reported earlier (Sargent, et al., 1989).

SUMMARY

The instrumented sphere was demonstrated to provide a means of quantifying impacts which occurred during tomato handling on three packing lines. Tomato samples taken at four points during handling showed that external mechanical injury and internal bruising increased with increased handling; however, a significant amount of externally injured tomatoes were removed during sorting and grading operations. Further tests in the laboratory and in packinghouses will attempt to correlate IS impact threshold measurements with actual damage incurred during handling.

REFERENCES

- Ahrens, M.J. and D.J. Huber. 1987. Firmness and mealiness of selected Florida-grown tomato cultivars. Proc. Florida State Horticultural Society. 100:39-41.
- Halsey, L.H. 1955. Preliminary studies of bruising of "turning" and

"pink" tomatoes caused by handling practices. Proc. Florida State Horticultural Society. 68:240-243.

Hatton, T.T. 1963. Effect of field and packinghouse handling on bruising of Florida tomatoes. Proc. Florida State Horticultural Society. 76:301-304.

MacLeod, R.F., A.A. Kader and L.L. Morris. 1976. Stimulation of ethylene and CO₂ production of mature⁺green tomatoes by impact bruising. HortScience 11(6)604-606.

Sargent, S.A., J.K. Brecht, J.J. Zoellner. 1989. Assessment of mechanical damage in tomato packing lines. ASAE Paper No. 89-6060. American Society of Agricultural Engineers. St. Joseph MI 49085.

U.S.D.A. 1976. United States Standards for Grades of Fresh Tomatoes. USDA/AMS, Washington DC. 11 pp.

Zapp, H.R., S.H. Ehlert, G.K. Brown, P.R. Armstrong and S.S. Sober. Advanced instrumentation sphere (IS) for impact measurement. ASAE Paper No. 89-6046. American Society of Agricultural Engineers. St. Joseph MI 49085.

Table 1.

Peak accelerations recorded by the Instrumented Sphere for several tomato packing lines.

		PEAK ACCELERATION (g's)* Packinghouse Number		
	<u>Transfer Point</u>	<u>1</u>	<u>2</u>	<u>3</u>
FLOAT TANK	Dump to float tank	35/83	41/70	**
	Drop to prewash brushes	**	60/170	**
	Drop to tank	29/47	47/95	**
MAIN LINE	Drop to wash brushes	110/149	68/160	147/207
	Drop to eliminator belt	30/43	67/88	**
	Drop to sort table	56/79	109/131	77/88
GREEN LINE (#1)	Drop to sponge/waxer	35/59	85/131	47/71
	Drop to grade table	46/92	63/84	79/93
	Drop to sizing belts	48/53	61/80	43/60
	Sizing belts***			
	Drop to takeaway belt	86/139	79/112	69/121
	Drop to accumulation table	101/136	**	102/164
PINK LINE	Drop to conveyor	103/170	76/200	97/133
	Drop to waxer	**	103/164	**
	Drop to breaker grade table	61/90	**	107/146
	Drop to breaker sizing belts	62/87	78/146	64/71
	Sizing belts***			
	Drop to takeaway belt	83/145	52/78	95/142
	Drop to pink sizer	**	104/132	**
	Sizing belts***	**	**	**
	Drop to takeaway belt	**	65/93	**
	Drop to filler conveyor	59/79	**	**
	Drop into carton	93/130	82/158	48/67
	Stack on pallet	51/55	**	**

*Mean and maximum accelerations, respectively (g's).

**Transfer point location may vary between packing lines. Not all points present or measured in all lines.

***Several drops and impacts over 100 g's occur during sizing.

Table 2. External and internal mechanical damage to 'Sunny' tomatoes during packing.

Packinghouse 2 'SUNNY'	n	EXTERNAL MECHANICAL DAMAGE (z)						INTERNAL BRUISING (z)					
		Damage		Bruises		Cuts/Punctures		Abrasions		Tomatoes		Locules with	
		Free	z	Slight ^y	Mod/Sev.	Slight	Mod/Sev.	Slight	Mod/Sev.	Free	z	Internal Bruising ^x	Puffy Tomatoes
Ripeness Stage													
Mature Green	320	67.8		1.6	5.3	2.5	5.0	14.4	25.3	79.7		4.8	0.8
Breaker	320	60.0	z	8.1	22.2	9.7	9.1	4.7	14.4	60.0	z	9.9	4.8
				***	***	***	*	***	**	***		***	***
Sample Location													
Field Bin	160	68.7a		8.1	17.5a	3.8b	4.3b	7.5	12.5b	75.9a		2.5b	0.9c
Float Tank	160	48.1b		5.6	20.0a	2.5b	13.1a	7.5	28.7a	84.4a		3.5b	1.5bc
Grade Table	160	68.1a		2.5	10.0b	6.8ab	4.4b	11.3	18.1b	60.6b		11.3a	3.7ab
Carton	160	70.6a		3.1	7.5b	11.3a	6.3b	11.9	20.0b	56.9b		12.0a	5.2a
		***		n.s.	**	**	**	n.s.	**	***		***	**
Interactions													
Stage X Location													
Mature Green	80	72.5			8.7	0.0	2.5	12.5	18.7	90.0		0.0	5.5
Field Bin	80	51.3			8.7	2.5	10.0	7.5	38.7	86.3		1.3	5.0
Float Tank	80	71.3			2.5	3.7	3.7	21.3	23.7	66.3		1.3	22.5
Grade Table	80	76.3			1.3	3.7	3.7	16.3	20.0	76.3		0.7	23.7
Carton	80												
Breaker	80	65.0			26.3	7.5	6.3	2.5	6.3	63.8		1.8	25.0
Field Bin	80	45.0			31.2	2.5	16.2	7.5	18.7	82.5		1.7	56.3
Float Tank	80	65.0			17.5	10.0	5.0	1.3	12.5	55.0		6.1	65.0
Grade Table	80	65.0			13.7	18.7	8.7	7.5	20.0	37.5		9.7	87.5
Carton	80			n.s.	n.s.	*	n.s.	*	n.s.	***		n.s.	***

z ** *** n.s Significant at P = 0.05, 0.01, 0.001, respectively. Column means with significant differences are followed by different letters as determined by Duncan's Multiple Range Test.

^ySeverity ratings for damage: Sl. = slight, Mod. = moderate, Sev. = Severe.

^xPercent Internal Bruising based on number of damaged locules per total number of locules with seeds.

Table 3. External and internal mechanical damage to 'Sunny' tomatoes during packing.

Packinghouse 3 'SUNNY'	n	EXTERNAL MECHANICAL DAMAGE (X)										INTERNAL BRUISING (Z)			
		Damage		Bruises		Cuts/Punctures		Abrasions		Decay	Tomatoes Damage Free	Locules with Internal Bruising ^x		Puffy Tomatoes	(Y)
		Free	Slight ^y	Mod/Sev.	Slight	Mod/Sev.	Slight	Mod/Sev.	Mod/Sev.			Mod.	Sev.		
Ripeness Stage															
Mature Green	320	72.5	0.0	1.8	10.6	14.4	10.3	13.7	1.9	1.9	99.7	0.0	0.0	0.0	19.7
Breaker	320	61.3	3.4	12.8	8.7	13.1	15.0	21.9	2.8	2.8	55.0	14.8	11.4	44.7	44.7
			***	***	n.s.	n.s.	n.s.	**	n.s.	n.s.	***	***	***	***	***
Sample Location															
Field Bin	160	73.1a	1.9	7.5	1.3c	7.5b	8.4	14.4	1.3	1.3	92.5a	1.5b	0.1b	8.1	8.1
Float Tank	160	57.5b	0.6	10.6	12.5ab	18.1a	13.7	21.3	3.7	3.7	82.2b	3.8b	1.2ab	20.3	20.3
Grade Table	160	68.1a	1.2	5.6	8.7b	13.7ab	13.7	18.7	2.5	2.5	66.7c	13.9a	2.3a	47.8	47.8
Carton	160	68.7a	3.1	5.6	16.3a	15.6a	13.7	16.9	1.9	1.9	68.1c	10.7a	2.5a	47.5	47.5
		*	n.s.	n.s.	***	*	n.s.	n.s.	n.s.	n.s.	***	***	*	***	***
Interactions															
Stage X Location															
Mature Green															
Field Bin	80	80.0		1.3		6.3		12.5			100.0	0.0	0.0	0.0	3.7
Float Tank	80	66.3		1.3		16.2		17.5			100.0	0.0	0.0	0.0	20.3
Grade Table	80	71.3		3.7		15.0		13.7			98.7	0.2	0.0	0.0	30.0
Carton	80	72.5		1.3		20.0		11.3			100.0	0.0	0.0	0.0	25.0
Breaker															
Field Bin	80	66.3		13.7		8.7		16.3			85.0	3.0	2.8	12.5	12.5
Float Tank	80	48.7		20.0		20.0		25.0			64.5	7.6	8.3	30.4	30.4
Grade Table	80	65.0		7.5		12.5		23.7			34.2	27.8	13.9	65.8	65.8
Carton	80	65.0		10.0		11.3		22.5			36.3	21.5	15.0	70.0	70.0
		n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	***	***	*	**	**

z* ** *** n.s Significant at P = 0.05, 0.01, 0.001, respectively. Column means with significant differences are followed by different letters as determined by Duncan's Multiple Range Test.

ySeverity ratings for damage: Sl. = slight, Mod. = moderate, Sev. = Severe.

xPercent Internal Bruising based on number of damaged locules per total number of locules with seeds.

THE 1988-89 TOMATO SEASON
WAYNE HAWKINS
FLORIDA TOMATO COMMITTEE
ORLANDO, FLORIDA

The Organizational Meeting of the Florida Tomato Committee was held on September 8, 1988, at the Ritz Carlton Hotel, Naples, Florida. Recommendations were made to the Secretary of Agriculture calling for an assessment rate of 2-1/2¢ (\$.025) per 25-lb. equivalent which was an increase of 1¢ per package over the previous season. A budget of \$1,537,000 including \$115,000 for research and \$1,140,500 for education and promotion was approved and recommended to the Secretary of Agriculture for his approval. The regulations recommended were the same as those in effect at the end of the 1987-88 season which eliminated the shipment of 7x7 tomatoes, eliminated 6x7 No. 3 grade tomatoes and extended the regulatory period to June 30th. Only 5x6 and larger tomatoes were allowed to be commingled.

Marketing Agreement No. 125 and Order No. 966 for Fresh Florida Tomatoes were amended in 1986 to provide for paid advertising and promotion and production research projects. The production research projects and the education and promotion programs recommended to the Secretary of Agriculture by the Florida Tomato Committee were approved as presented. Both projects were amended later in the season providing more funds for both.

The Committee met again on December 14, 1988, at LaBelle, Florida, with the primary reason being to discuss discharging tomato packinghouse dump tank waste water with representatives of the Florida Department of Environmental Regulations. A law on the books since 1983 requires permitting of this discharge and it appears that DER is going to start enforcing the law. Beth Mahaffey, the new Director of Education and Promotion, was introduced and she gave an update on the promotion activities.

The Committee met again on February 2, 1989, in Homestead, Florida. The packinghouse dump tank waste water research project was discussed and it was reported that samples will finally be taken in March or April. The Director of Education and Promotion reported that she had met with the Education and Promotion Subcommittee in January and presented plans for the balance of the season. The subcommittee recommended that these plans be presented to the full Committee for their consideration. The Committee unanimously recommended that the Secretary of Agriculture approve the expenditure of an additional \$309,675 for promotion and education activities for the balance of the season. The Committee also instructed management to conduct an agency review this spring. The Committee also approved an additional \$10,000 for research to cover the costs of a study to determine the effect of eliminating all No. 3 grade tomatoes and the feasibility of defining and packing a 5x5 and larger tomato.

Nomination meetings were held in each of the four districts during April to select members and alternates to serve on the Florida Tomato Committee during the 1989-90 season. A list of nominees was forwarded to the Secretary

of Agriculture for his consideration in appointing the new Committee. Current issues and problems were also discussed at these meetings with management following through on recommended solutions.

The Committee met again on June 23, 1989, in Orlando, Florida. The main purpose of this meeting was to hear presentations from seven advertising organizations wanting to represent the Florida Tomato Committee for the 1989-90 season. After nearly six hours of presentations, the Committee voted unanimously to retain Lewis/Neale of New York City and Anson-Stoner of Winter Park, Florida, to represent them during the 1989-90 season. It was also reported that ripening problems associated with the sweet potato whitefly are the greatest problem facing the Industry today. An all-out effort is still underway to get \$500,000 for the U.S.D.A. lab in Orlando to hire two full-time scientists to work on this problem.

Total acres planted in Mexico were reportedly up; however, Mexico had very poor quality during most of their season and crossings reported by the Florida Department of Agriculture and Consumer Services were down 150 carlots from the previous year. Prices at Nogales, Arizona, were constantly cheaper than Florida prices which tended to depress the market, particularly in the west. In early February, March and part of April, Mexico covered the United States with cheap tomatoes even offering delivered prices in Florida that were half of the going F.O.B. market in Florida. The same tactics were employed by the Mexicans last season, but efforts to get any relief from Washington failed.

Total harvested acres in Florida were 57,663, compared to 53,939 the previous season and 50,908 in the 1986-87 season. Districts 2, 3 and 4 had increases of 47, 1,709 and 3,088 acres, respectively. District 1 was down 1,120 acres, giving a net increase of 3,724 acres. Only 45,530 acres were harvested in 1985-86; therefore, Florida has had an increase of 12,122 acres harvested in only three years. This is nearly a 27 percent increase. There were less than 1,000 acres of ground tomatoes planted this season representing only about one and one-half percent. The major contributing factor was that practically all Dade County acreage was grown on metal stakes this season. Total shipments were 64,868,916 25-lb. equivalents compared to 64,746,068 the previous year.

Total shipments were up 122,848 25-lb. equivalents from the previous season. Weather conditions that prevailed throughout most of the winter season and three days of below freezing temperatures along with irregular ripening problems in the spring prevented the shipments from being much higher. Poor crops were produced in the fall due to excessive rain fall and the winter season was plagued with cold, windy weather causing bloom drop, scarring and a lot of misshapen fruit. Cold, wet conditions enhanced disease problems, making it nearly uncontrollable in some fields. A freeze in late February and irregular ripening problems caused very unusual circumstances throughout the spring months.

Harvesting of the fall crop began in District 4 in mid-October with all districts shipping two weeks later. It is becoming increasingly more difficult to separate production areas and shipping areas since more and more crops are transported to other districts to be packed. Total shipments from all districts exceeded one million packages by the week ending November 12 and remained above one million per week until June 6th. There were 17 weeks with shipments exceeding two million 25-lb. equivalents and four with over three million.

District 2 started harvesting the last week of October and continued shipping good volume through the first week of May with lighter shipments into early June. Acreage planted for harvest was up by only 47 acres over the previous season but total shipments were up about 3.9 percent. Weekly shipments from this district exceeded 200,000 25-lb. equivalents for 20 weeks during the season with 15 of these weeks exceeding 300,000 25-lb. equivalents and four exceeding 400,000.

District 1 started shipping the last week of October, but most of the early tomatoes were trucked in from District 3. Weekly volume increased steadily to mid-February and then remained constant through mid-April, and for all practical purposes, ended the second week of May. Total acres planted for harvest was down approximately 12 percent but shipments were almost identical to last season with an increase of 39,810 25-lb. equivalents over the previous season. The contributing factor to this increase was almost the entire crop being planted on stakes this season, much better size than normal, and the amount of tomatoes grown in District 3 but packed in District 1.

District 3 started shipping the last of October and by November 12 weekly shipments totalled more than 500,000 packages per week. The volume increased rapidly, and remained well above one-half million packages per week for 23 of the remaining 30 weeks. Cold, windy, rainy weather caused grade outs to be high and reduced average yields on most farms, but the major problem was irregular ripening, particularly in later plantings. Total shipments were up about 4.8 percent over the previous season, and acreage harvested was up about nine percent. Some of the shipments reported for District 3 were actually grown in District 4 and vice versa. The completion of Interstate 75 makes it easy to haul tomatoes from the field in one district to the packinghouse in another district.

District 4 started harvesting in mid-October and reached shipments totalling more than 500,000 25-lb. equivalents by the fifth week. Fall acreage was up about 14 percent but shipments were down by 13.5 percent. About 5.9 million 25-lb. equivalents were shipped from District 4 during the fall season compared to 6.9 million the previous season. This points out the extremely wet conditions that produced 12 to 20 inches of rain in District 4 during the first week of September and Tropical Storm Keith in November that dumped another four to six inches accompanied by heavy winds.

Harvest of the spring crop in District 4 started in mid-April on crops that survived the late February freeze. Nearly 6,000 acres were replanted in late February and early March making the crop a little later than normal.

About 1,950 more acres were harvested this spring, but shipments were down nearly six percent. During the last 11 weeks of the season, District 4 shipped more than 13.5 million 25-lb. equivalents, but slightly more than 12.5 million of these were shipped in a seven-week period. Basic quality and size were good during most of this period. Problems with irregular ripening plagued the Industry in April, May and June. Ideal weather conditions allowed picking to continue well into June when the rains finally started; however, it rapidly curtailed harvest leaving a lot of tomatoes in the field.

The total 64,868,916 25-lb. equivalents were shipped over a 37-week period. Thirty-one of these weeks had shipments exceeding one million packages with 17 weeks showing more than two million and four weeks with more than three million. The total shipments were up 122,848 25-lb. equivalents from the previous season.

The total value of the crop was about 602.9 million dollars, compared to 465 million the previous season. The average price was \$9.29 per 25-lb. equivalent for the entire season and \$7.28 for 1986-87. Evenly spaced supplies during the winter season and the lack of overlapping between districts helped stabilize the season's average price. Tables Two, Three, Four and Five show the variations in average price between the different districts.

During the 1988-89 season, there were about 21 different commercial varieties planted, which was six more than last season. Sunny, Duke, F.T.E. No. 12, BHN 26, and Solar Set accounted for nearly 96 percent of the total acreage. Some of the other varieties planted were Freedom, Castle 1035, Floradade, Floratom, All Star, 6,000, 8412, Hayslip and Summit. The Florida Tomato Exchange is continuing research efforts to find a new super variety for Florida and several seed companies are working toward the same objective.

The continuing regulations allowing commingling of only 5x6 and larger tomatoes, requiring all tomatoes shipped out of state to be in new boxes, requiring the tomatoes to be run over sizing equipment and be packed at the registered handler's facility, requiring the name and address of the registered handler on the carton, coupled with washing and positive lot identification, went a long way toward solving the problems of theft and the shipment of cull tomatoes all over the United States.

The Committee's activities in controlling container weights and designated diameters of tomato sizes have been profitable for the Florida Tomato Industry. It is also doubtful that Mexican producers would impose restrictions on themselves voluntarily if the Florida Tomato Marketing Order was not in effect. The need for continued use of these controls plus consideration of additional regulations on domestic shipments during periods of market glut are essential if profitable returns are to be expected by the Florida Tomato Industry.

The producers of Florida tomatoes must continue to work together to provide the ultimate consumer with a more palatable product. New varieties will be developed and the consumer must be educated in the proper methods of ripening and preparation. Additional spending on promotion and education should be considered in future years since increased per capita consumption of fresh Florida tomatoes could cure many of the problems of overproduction. Joint efforts of the Florida Tomato Committee and the Florida Tomato Exchange are channeled in this direction.

TOMATO VARIETIES FOR FLORIDA

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Variety selection, often made several months before planting, is one of the most important management decisions made by the grower. Failure to select the most suitable variety or varieties may lead to loss of yield or market acceptability.

The following characteristics should be considered in selection of tomato varieties for use in Florida:

* Yield - The variety selected should have the potential to produce crops at least equivalent to varieties already grown. The average yield in Florida is currently about 1300 25-pound cartons per acre. The potential yield of varieties in use should be much higher than average.

* Disease Resistance - Varieties selected for use in Florida must have resistance to Fusarium wilt, Race I and Race II; Verticillium wilt; gray leaf spot; and some tolerance to bacterial soft rot. Available resistance to other diseases may be important in certain situations.

* Horticultural Quality - Plant habit, jointlessness and fruit size, shape, color, smoothness and resistance to defects should all be considered in variety selection.

* Adaptability - Successful tomato varieties must perform well under the range of environmental conditions usually encountered in the district or on the individual farm.

* Market Acceptability - The tomato produced must have characteristics acceptable to the packer, shipper, wholesaler, retailer and consumer. Included among these qualities are pack out, fruit shape, ripening ability, firmness and flavor.

Current Variety Situation

Many tomato varieties are grown commercially in Florida but only a few represent most of the acreage.

'Sunny' is the leading variety, accounting for over 70% of the state's acreage. The proportion of acreage in which Sunny is planted gradually increased in each of the previous five years, however, the 1988-89 acreage was virtually the same as the 1987-88 acreage. Sunny accounts for almost all of the acreage in southwest Florida and the east coast, and almost 70% of the Palmetto-Ruskin acreage. Most of the north Florida acreage is in 'Sunny'.

'Duke' is the most important variety in Dade County, accounting for about 65% of the acreage there. 'Duke' is not grown to any extent in the other production areas, and acreage is declining in Dade County. Overall, the acreage in 'Duke' is about 9% of the statewide total.

'Pacific' is the third most important variety in Florida based on acreage, representing about 12% of the Palmetto-Ruskin and 5% of the statewide acreage.

'BHN 26', 'FTC 12' and 'Solar Set' are each grown on about 3% of the state acreage. Most of the 'BHN 26' and 'Solar Set' acreage is planted in the Palmetto-Ruskin area, whereas, most of the FTC 12 acreage is in Dade County representing about 20% of the acreage there. 'All Star' represents about 1% of the statewide acreage and 3% of the Palmetto-Ruskin acreage.

Small (less than 1% of the state total) acreages of 'Summer Flavor 6000', 'Hayslip', 'Bonita', 'Floridade', 'Floratom II', 'Castleby 1041', 'Freedom', 'Summit', 'Roma', and various experimental hybrids were grown in the 1988-89 season.

Tomato Variety Trial Results

Summary results from the Gulf Coast Research & Education Center, Bradenton; Ft. Pierce Agricultural Research & Education Center; Southwest Florida Research & Education Center, Immokalee; and North Florida Research & Education Center, Quincy for the fall 1988 season are shown in Table 1. High total yields and large fruit size were produced by 'Bingo' at Bradenton; 'Sunny', 'IFAS 7209', 'IFAS 7193', 'Duke', and 'IFAS 7182' at Ft. Pierce; 'Solar Set' and 'Bingo' at Immokalee; and 'PSR 39686' at Quincy.

Varieties having high total yields and large fruit size at these locations for the spring 1989 season are shown in Table 2. At Bradenton, 'Pacific', 'Solar Set', and 'NVH 4459' had both high total yields and large fruit size.

In several of these trials, there was little or no statistical difference between the highest and lowest yielding varieties suggesting that there are many outstanding varieties that growers can select for planting. Complete reports of IFAS tomato variety trials are available from those cited in the References.

Table 1. Summary of IFAS tomato variety trial results. Fall 1988.

Location	Total yield	Fruit size
<u>Bradenton (2)</u>		
	Bingo	Bingo
	IFAS 7211	Olympic
	IFAS 7209	Gator
	X 3883	Duke
	Solar Set	
<u>Ft. Pierce (5)</u>		
	Sunny	Duke
	IFAS 7209	IFAS 7193
	IFAS 7193	IFAS 7182
	Duke	Sunny
	IFAS 7182	IFAS 7209
<u>Immokalee (1)</u>		
	IFAS 7182	Bingo
	Pacific	IFAS 7193
	IFAS 7211	PSX 77684
	Solar Set	Solar Set
	Bingo	NVH 4461
		IFAS 7193
<u>Quincy (4)</u>		
	PSR 39686	88E313U
	PSR 58786	NVH 4461
	PSR 43586	PSR 39686
	Solar Set	
	NKH-494	

Sources: Asgrow - Gator, Pacific, Solar Set, Sunny
 Campbell - X 3883
 Ferry-Morse - Bingo
 Gulf Coast Research & Education Center - IFAS 7182, IFAS 7193,
 IFAS 7209, IFAS 7211, 88E313U
 Northrup King - NKH-494, NVH 4461
 Petoseed - Duke, PSR 39686, PSR 43586, PSR 58786, PSX 77684

Table 2. Summary of IFAS variety trial results. Spring 1989.

Location	Total yield	Fruit size
<u>Bradenton (3)</u>		
	FTE 24	Bingo
	Pacific	Olympic
	Solar Set	PSR 9586
	IFAS 7209	NVH 4459
	NVH 4459	Pacific
	Sunny	Solar Set
<u>Ft. Pierce (5)</u>		
	Sunny	Duke
	IFAS 7209	Solar Set
	Duke	Sunny
	Solar Set	FTE 12
	FTE 12	IFAS 7209
<u>Immokalee (6)</u>		
	Sunny	Bingo
	Summer Flavor 6000	Olympic
	FTE 24	Pacific
	Solar Set	PSR 9586
	IFAS 7209	NVH 4459
<u>Quincy (4)</u>		
	Colonial	NC 87345
	Agrisat 761	Olympic
	NC 87345	PSR 9586
	Bonita	Bingo
	Solar Set	NS 268

Sources: Abbott & Cobb - Summer Flavor 6000
 Asgrow - Pacific, Solar Set, Sunny
 Ferry-Morse - Bingo
 Gulf Coast Research & Education Center - IFAS 7209
 Neuman - NS 268
 North Carolina State University - NC 83745
 Northrup King - Bonita, NVH 4459
 Petoseed - Agriset 761, Colonial, Duke, FTE 12, FTE 24, Olympic,
 PSR 9586

RECOMMENDED VARIETIES

The varieties listed have performed well in IFAS trials conducted in various locations. Those varieties designated as FOR TRIAL should be evaluated in trial plantings before large-scale production is attempted.

All Star (Petoseed). A midseason, jointed, determinate hybrid. Fruit are large, globe-shaped, and green shouldered. Resistant: Verticillium Wilt, Fusarium Wilt (Race 1 and 2), Gray Leaf Spot, Alternaria Stem Canker. FOR TRIAL.

Bingo (Ferry-Morse). A medium-early, jointed, determinate hybrid. Fruit are large, globe-shaped, and green shouldered. Resistant: Verticillium Wilt, Fusarium Wilt (Race 1 and 2), Gray Leaf Spot, Alternaria Stem Canker. FOR TRIAL.

Duke (Petoseed). An early, determinate, jointless hybrid. Fruit are large, green shouldered, and moderately flat-round shaped. Resistant: Verticillium Wilt, Fusarium Wilt (Race 1 and 2), Gray Leaf Spot, Alternaria Stem Canker.

Floratum II (Petoseed). A jointless, determinate mid-season, large fruited hybrid available from Agrisales, Inc. and S&M Farm Supply. Resistant: Verticillium Wilt, Fusarium Wilt (Race 1 and 2), Gray Leaf Spot, Alternaria Stem Canker. FOR TRIAL.

FTC 12 (Petoseed). An early to mid-season, jointless, determinate hybrid developed for members of the Florida Tomato Committee. Moderately large fruit have green shoulders and are flat-round shaped. Resistant: Verticillium Wilt, Fusarium Wilt (Race 1 and 2), Gray Leaf Spot, Alternaria Stem Canker.

Pacific (Asgrow). Large, smooth-globe, green shouldered fruit are produced on determinate plants. Jointed. Hybrid. Resistant: Alternaria, Fusarium Wilt (Race 1 and 2), Verticillium Wilt (Race 1), Gray Leaf Spot.

Solar Set (IFAS-Asgrow). An early, large-fruited, jointed hybrid. Determinate. Fruit set under high temperatures (92°F day/72° night) is superior to other commercial varieties. Resistant: Fusarium Wilt (Race 1 and 2), Verticillium Wilt (Race 1) and Gray Leaf Spot.

Summer Flavor 6000 (Abbott & Cobb). A mid-season, jointless, determinate hybrid. Large, deep globe fruit. Resistant: Verticillium Wilt, Fusarium Wilt (Race 1 and 2). FOR TRIAL.

Sunny (Asgrow). A mid-season, jointed, determinate hybrid. Fruit are large, flat-globular in shape, and are green shouldered. Resistant: Verticillium Wilt, Fusarium Wilt (Race 1 and 2), Alternaria Stem Canker, Gray Leaf Spot.

CHERRY TYPE

Cherry Grande (Petoseed). A jointed, determinate hybrid. Fruit are deep red, green shouldered, globe shaped, and have an average diameter of 1 1/4 to 1 1/2 in. Resistant: Verticillium Wilt, Fusarium Wilt (Race 1), Alternaria Stem Canker, Gray Leaf Spot.

Castlette 1067 (Sunseeds). A jointless, medium-vine determinate hybrid. Bright-red fruit are green shouldered, deep-globe shaped, and about 1 1/4 in. in diameter. Resistant: Verticillium Wilt, Fusarium Wilt (Race 1).

Red Cherry Large (Petoseed). A jointed, indeterminate, open-pollinated variety. Green shouldered, deep-globe fruit are about 1 1/4 in. diameter. Resistant: Alternaria Stem Canker.

REFERENCES

1. Arnold, C. E. and K. A. Ambrester. 1989. Staked tomato variety trial results - fall 1988. Southwest Florida Research & Education Center Research Report IMM 89-1.
2. Howe, T. K., J. W. Scott and W. E. Waters. 1989. Tomato variety trial results for fall 1988. Gulf Coast Research & Education Center Research Report BRA 1989-6.
3. Howe, T. K. 1989. Personal communication.
4. Olson, S. M. 1989. Personal communication.
5. Stoffella, P. J. 1989. Personal communication.
6. Vavrina, C. S. 1989. Personal communication.

TOMATO PLANT DISEASE
CHEMICAL CONTROL GUIDE

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Crop	Chemical	Rate/A	Minimum days to harvest	Pertinent Diseases		Special Remarks
				on label	not on label but controlled	

Tomato

FOR BACTERIAL SPOT CONTROL IN TOMATOES, A MANEB OR MANCOZEB FUNGICIDE MUST BE TANK MIXED WITH A COPPER FUNGICIDE.

Benlate WP or DG	1/2 - 1 lb.	NTL	Gray mold Leaf mold White mold (Sclerotinia) Phoma leaf spot	Target spot Rhizoctonia Fruit rot	Field & Greenhouse
Botran 75 W	1 lb/100 gal. water	NTL	Botrytis stem canker		Seedlings or newly set transplants may be injured by drenching. Greenhouse use only.
Bravo 720	1 1/2 - 3 pts.	1	Early blight Late blight	Phoma leaf spot Target spot	Do not use with Copper Count-N in concentrated spray mixtures.
Bravo DG	1 3/4 - 2 1/4 lbs.	1	Gray leaf spot Leaf mold		
or			Septoria leaf spot		
Bravo W-75	1 1/2 - 3 lbs.	1	Gray mold Black mold Rhizoctonia fruit rot		

Crop	Chemical	Rate/A	Minimum days to harvest	Pertinent Diseases		Special Remarks
				on label	not on label but controlled	
Tomatoes (cont'd)	Manex II	1.3-2.5 qts.	5	Leaf mold Early blight Late blight Gray leaf spot Septoria leaf spot Bacterial spot (use in combination with Tri-Basic copper sulfate.		
	Dithane M-45	1 1/2 - 3 lbs.	5	Anthrachnose Late blight Early blight Leaf mold Septoria leaf spot	Phoma leaf spot Phoma leaf spot Bacterial spot & Bacterial speck	
	Penncozeb	1 1/2 - 3 lbs.	5	Early blight Late blight Gray leaf mold Leaf mold	See Dithane M-45 Bacterial spot	Field or greenhouse. Do not use on young tender plants under glass.
	Maneb & Zinc F4	1.6 qts.	5	Anthrachnose Leaf mold Early blight Late blight Grey Leaf spot Septoria leaf spot		

Crop	Chemical	Rate/A	Minimum days to harvest	Pertinent Diseases		Special Remarks
				on label	not on label but controlled	
Tomatoes	Dithane F-45	1.2-2.4 qts.	5	Early blight Gray leaf spot Late blight Leaf mold Septoria leaf spot Anthracnose		
	Maneb 80	2 lbs.	5	Early blight Late blight Septoria leaf spot Gray leaf spot	Bacterial spot	Do not use on young plant in greenhouse as injury may occur.
	Ridomil-Bravo 81W	1 1/2 - 2 lbs.	NTL	Early blight Late blight Gray leaf spot		
	Manzate 200 WP or DF	1 1/2 - 3 lbs.	NTL	Early blight Late blight Gray leaf spot Gray leaf mold Bacterial spot		
	Bravo C/M	2-3 lbs. (4-6 lbs. if sprayed weekly)	5	Bacterial spot Late blight Early blight Target spot		

Crop	Chemical	Rate/A	Minimum days to harvest	Pertinent Diseases		Special Remarks
				on label	not on label but controlled	
Tomatoes (cont'd)	Dyrene (not for use in greenhouse)	2-5 lbs.	NTL	Botrytis Early blight Late blight Septoria leaf spot		If temperatures exceed 85°F do not use more than 1 lb. if tank mixed with a copper fungicide.
	Kocide 101, Blue Shield or Champion WP	2-4 lbs.	NTL	Early blight Bacterial speck Bacterial spot		Minimum days to harvest is 5 if used with a Dithane or Manzate fungicide.
	Kocide 606 or Champion FL	2 2/3 - 5 1/3 pts.	NTL	Early blight Bacterial speck Bacterial spot		Same as Kocide 101.
	Tri-basic Copper Sulfate	2-4 lbs.	NTL	Bacterial spot Bacterial canker Early blight Late blight Leaf mold Septoria Stemphylium leaf spot		Same as Kocide 101.
	Basicop	2-4 lbs.	NTL	Bacterial spot Bacterial canker Early blight Late blight Leaf mold Septoria		
	CP-Basic Copper TS-53 WP	2-4 lbs.	NTL	Same as Tri-basic Copper sulfate		Same as Kocide 101.
	JMS Stylet Oil	3 qts.	NTL	Potato virus Y Tobacco etch virus	Tomato yellows	Must be applied with ground rig at 400 psi using Tee Jet TX5 SS nozzles. <u>READ LABEL.</u>

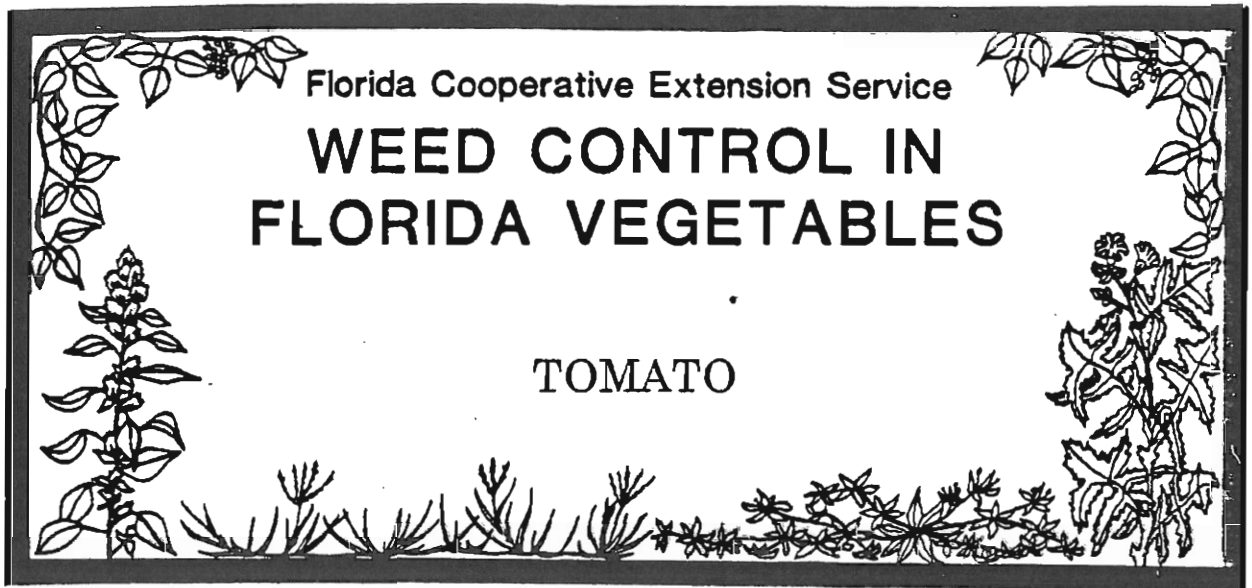
Crop	Chemical	Rate/A	Minimum days to harvest	Pertinent Diseases		Special Remarks
				on label	not on label but controlled	
Tomatoes (cont'd)	Ridomil 2E ¹ (Soil application)	2-4 pts. (Broadcast only)	PPI treatment for plant beds.	Pythium damping off in plant beds Late blight Phytophthora stem canker		May not be a necessary treatment for Pythium if beds are fumigated prior to seedling and recontamination of fumigated soil is avoided. Not for use in greenhouses.
	Ridomil 2E ¹ (Soil application)	4-8 pts. ² (Broadcast rate)		Pythium damping off for field	Phytophthora stem canker Late blight	Same as Ridomil 2E above.
	Ridomil 2E ¹ (Soil application)	4 pts. ³		Phytophthora or Pythium fruit rots.	Late blight	Same as Ridomil 2E above.
	Copper-Count-N	1/3 - 3/4 gal.	NTL	Bacterial spot		Mix with a Maneb fungicide.

¹ Do not apply more than 12 pints Ridomil 2E/season.

² PPI (via mechanical device) or POPI (via irrigation) broadcast or banded.

³ Soil surface 4-8 weeks before harvest followed by irrigation. If plastic used on beds, apply as a band next to bed in middle if roots have developed beyond plastic. Ridomil translocates upward in plant from roots. If plastic is not used, band on soil below drip line.

Crop	Chemical	Rate/A	Minimum days to harvest	Pertinent Diseases		Special Remarks
				on label	not on label but controlled	
Tomatoes (cont'd)	Ridomil MZ-58, (Foliar spray)	1 1/2 - 2 lbs.	5	Late blight	Phytophthora stem canker Pythium fruit rot	2



Florida Cooperative Extension Service
**WEED CONTROL IN
FLORIDA VEGETABLES**

TOMATO

Institute of Food and Agricultural Sciences • University of Florida

SS-VEC 919

W. M. Stall
Vegetable Crops Department

Weeds are a major problem in tomato production in Florida. Weeds can reduce yields through direct competition for light, moisture and nutrients as well as harbor insects such as white fly and thrips among others as well as diseases that attack tomatoes.

Tomatoes are present in the field in some area of Florida every month of the year. Over this period, the variable climatic conditions influence the diversity of weed species present and their severity. Growers should plan a total weed control program that integrates mechanical and cultural methods of weed control along with chemical means to fit their weed problems and production practices.

Herbicide performance depends on weather, irrigation, soil as well as proper selection for weed species to be controlled and accurate application and timing.

Weeds such as nightshade have developed resistance to some post-emergent herbicides such as paraquat in some areas. Control of this weed and some others can only be accomplished with tank mix combinations. Several studies have shown that gallonage above 60 GPA can dilute some tank mix combinations and reduce efficacy.

Obtain consistent results by reading the herbicide label and other information about proper application and timing of each herbicide. To avoid confusion between formulations, suggested rates listed are stated in pounds active ingredient per acre (lbs ai/acre). On soils with low organic matter use the lower rates.

When applying a herbicide for the first time or in a new area, use in a small trial basis first.

Before application of a herbicide, CAREFULLY READ AND FOLLOW THE LABEL.

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TOMATOES

Herbicide	Labelled Crops	Time of Application to Crop	Rate (lbs. ai./acre)
Chloramben (Amiben)	Tomatoes (established)	Postemergence or posttransplant	3.0

REMARKS: Granular formulation may be applied to cultivated non-mulched transplanted or established direct seeded tomatoes. Plants should be at the 5-6 leaf stage. Apply only when foliage is dry. Will not control established weeds.

Chloramben (Amiben)	Tomatoes (established)	Post planting or post trans- planting	3.0
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REMARKS: A special Local needs 24 (c) Label for Florida. Apply once per crop season after existing weeds in row middles have been removed. Label states control of many annual grasses and broadleaf weeds. Among these are crabgrass, goosegrass, lambsquarter, wild mustard, black nightshade, pigweed, purslane, common ragweed and Florida beggarweed.

DCPA (Dacthal)	Established tomatoes	Posttrans- planting after crop establishment (non-mulched)	6.0 - 8.0
		Mulched row middles after crop establishment	6.0 - 8.0

REMARKS: Controls germinating annuals. Apply to weed-free soil 6-8 weeks after crop is established and growing rapidly or to moist soil in row middles after crop establishment. Note label precautions of replanting non registered crops within 8 months.

Diphenamid (Enide)	Tomatoes	Pretransplant Preemergence Postemergence Posttransplant incorporated	3.0 - 4.0
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REMARKS: Controls germinating annuals. Apply to moist soil 1 week before or within 4 weeks after transplanting crop. Incorporate 0.5 to 2 inches. May be applied as directed band over "plug" planting or to mulched row middles. Label states control of many grasses and broadleaf weeds including spiny amaranth, bermudagrass, goosegrass, seedling johnsongrass, lambsquarter, pigweed, purslane, Fla. pusley and others.

(cont'd)

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Tomatoes - cont'd

Herbicide	Labelled Crops	Time of Application to Crop	Rate (lbs. ai./acre)
Metribuzin (Sencor)	Tomatoes	Postemergence Posttransplanting after establishment	0.25 - 0.5

REMARKS: Controls small emerged weeds after transplants are established direct seeded plants reach 5-6 true leaf stage. Apply in single or multiple applications with minimum of 14 days between treatments and a maximum of 1.0 lb. ai/acre within a crop season. Avoid applications for 3 days following cool, wet or cloudy weather to reduce possible crop injury.

Metribuzin (Sencor, Lexone)	Tomatoes	Directed spray in row middles	0.25 - 1.0
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REMARKS: Apply in single or multiple applications with a minimum of 14 days between treatments and maximum of 1.0 lb. ai acre within crop season. Avoid applications for 3 days following cool, wet or cloudy weather to reduce possible crop injury. Label states control of many annual grasses and broadleaf weeds including, lambsquarter, fall panicum, amaranthus sp., Florida pusley, common ragweed, sicklepod, and spotted spurge.

Napropamid (Devrinol)	Tomatoes	Preplant incorporated	1.0 - 2.0
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REMARKS: Apply to well worked soil that is dry enough to permit thorough incorporation to a depth of 1-2 inches. Incorporate same day as applied. For direct seeded or transplanted tomatoes.

Napropamid (Devrinol)	Tomatoes	Surface treatment	2.0
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REMARKS: Controls germinating annuals. Apply to bed tops after bedding but before plastic application. Rainfall or overhead irrigate sufficient to wet soil 1 inch in depth should follow treatment within 24 hours. May be applied to row middles between mulched beds. A special Local Needs 24(c) Label for Florida. Label states control of weeds including Texas panicum, pigweed, purslane, Florida pusley, and signalgrass.

Paraquat (Gramoxone Super)	Tomatoes	Premergence Pretransplant	0.5 - 1.0
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REMARKS: Controls emerged weeds. Use a non-ionic spreader and thoroughly wet weed foliage.

(cont'd)

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Tomatoes - cont'd

Herbicide	Labelled Crops	Time of Application to Crop	Rate (lbs. ai./acre)
Paraquat (Gramoxone Super)	Tomatoes	Post directed spray in row middle	0.47

REMARKS: Controls emerged weeds. Direct spray over emerged weeds 1 to 6 inches tall in row middles between mulched beds. Use a non-ionic spreader. Use low pressure and shields to control drift. Do not apply more than 3 times per season.

Paraquat (Gramoxone Super) +	Tomatoes	Post directed spray in row middle	0.47 +
Enquick			3 - 5 gal

REMARKS: Controls emerged weeds only. Apply 3-5 gal Enquick and 2 1/2 pt Gramoxone Super in 20 - 50 gal of spray mix per acre. A non-ionic surfactant must be added at 1 - 2 pt per 100 gal spray mix. Enquick is severely corrosive to nylon. Non-nylon plastic and 316-L stainless steel are recommended for application equipment. Read the precautionary statements on Enquick before use. Follow all restrictions on both labels.

Sethoxydim (Poast)	Tomatoes	Postemergence	0.188 - 0.28
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REMARKS: Controls actively growing grass weeds. A total of 4 1/2 pt product per acre may be applied in one season. Do not apply within 20 days of harvest. Apply in 5 to 20 gallons of water adding 2 pt of oil concentrate per acre. Unsatisfactory results may occur if applied to grasses under stress. Use 0.188 lb a.i. (1 pt) to seedling grasses and up to 0.28 lb a.i. (1 1/2 pt) to perennial grasses emerging from rhizomes etc. Consult label for grass species and growth stage for best control.

Trifluralin (Treflan)	Tomatoes (except Dade County)	Pretransplant incorporated	0.75 - 1.0
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REMARKS: Controls germinating annuals. Incorporate 4 inches or less within 8 hours of application. Results in Florida are erratic on soils with low organic matter and clay contents. Note label precautions of planting non-registered crops within 5 months. Do not apply after transplanting.

Trifluralin (Treflan)	Seeded tomatoes (except Dade County)	Post directed	0.75 - 1.0
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REMARKS: For direct seeded tomatoes, apply at blocking or thinning as a directed spray to the soil between the rows and incorporate.

NEMATODE CONTROL IN TOMATOES,
PEPPERS, & EGGPLANTS

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January 1989

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Nematode Pests of Vegetable Crops in Florida

The following is a list of nematodes which may affect vegetable crops in Florida; many may cause drastic yield reductions.

Common Names	Scientific Names
Root-knot nematodes	Meloidogyne spp.
Sting nematodes	Belonolaimus spp.
Stubby-root nematodes	Trichodorus spp.
Root-lesion nematodes	Pratylenchus spp.
Cyst nematodes	Heterodera spp.
Awl nematodes	Dolichodorus spp.
Stunt nematodes	Tylenchorhynchus spp.
Lance nematodes	Hoplolaimus spp.
Spiral nematodes	Helicotylenchus spp.
	Scutellonema spp.
Ring nematodes	Criconeoides spp.
Dagger nematodes	Xiphinema spp.
Bud and leaf nematodes	Aphelenchoides spp.
Reniform nematodes	Rotylenchulus spp.

Multiple-Pest Interactions:

A Basis for Crop Loss Assessment and Nematode Management

It is frequently not possible to confidently predict crop losses due to nematodes based solely on soil and root sample information of nematode population density, because of the uncertainty of the interactions between plant parasitic nematodes and their environment, and with other pest species. Much is known about the impact of specific pests, agronomic inputs, and environmental factors on plant growth when they are manipulated and studied separately. Less is known about the combined action of various pests and the effects interacting plant stresses have on pest populations or the rates at which these populations develop. In particular, prediction of crop loss for advisory purposes must be able to partition and account for the interaction of multiple pests under varying agronomic practices and conditions. Crop loss information from the total pest complex forms the basis for rational or optimal farm, crop and pest management decisions. In this way pesticide use can be most efficiently and prudently prescribed.

During development, plants are exposed to different levels and complexes of competing pests. For example, many kinds of nematodes and fungi are generally present in the soil and their populations may be assessed prior to planting. Other pests, including insects, weeds and certain fungi and bacteria arrive and are assessed much later in the growth of the crop. The timing of pest attacks, whether they occur simultaneously, sequentially, or any combination of the two during the development of the plant can profoundly alter final crop yield.

Individual species of nematodes (root-knot, sting, lesion, etc.) seldom occur alone but rather in a community with many other species of plant parasitic nematodes. The presence of one species may enhance, retard or have no obvious effect on the population dynamics of another competing nematode species when present on a particular host plant. For other host plants, soil types,

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cultural, edaphic, and environmental conditions, the effects of such competitive interactions between nematode species may be very different. Therefore one cannot extrapolate interaction predictions from one host plant to another. The interactions between nematodes or with other pests may be physical, such as simple competition for food or space, or may be functionally mediated through the plant and represented by a change in food quantity or quality, or in production of antibiotic chemicals.

Types of Interactions:

Changes caused in the plant by one stress factor may indirectly influence the subsequent impact of a second stress factor. Alteration of host plant physiology in response to nematode parasitism may increase, decrease, or have no apparent effect on the susceptibility of the plant to additional pests. When two or more pests attack a plant, the interaction may be synergistic where the combined effects of the pests are greater than the sum of the effects of each pest acting alone. Multiple-pest associations that cause synergistic increases in yield losses are particularly well documented for nematodes and fungi. The best documented example is the root-knot nematode, *Meloidogyne* spp., and *Fusarium* wilt disease on old tomato production land. The root-knot nematode, by causing the development of root galls, provides a nutrient-rich food source which the fungi colonize rapidly. Root-knot nematodes can thus significantly enhance disease development and yield loss, elevating primary or secondary pathogens to major pest status even though population levels or pathogenic potential of the fungi were initially very low and yield losses would have been minimal in the absence of the nematode.

In other multiple pest associations different pests may interact negatively, so that the combined effects are less than the sum of the effects of each pest acting alone. Direct competition for feeding sites or substrates or effects on host physiology may serve to lessen the full expression of each pest's damage potential. In other cases, the presence of the two or more pests do not appear to increase or decrease yield in relation the sum of the individual pest effects. The effects are simply the pathogenic potential of each species and the levels to which they are suppressed or enhanced. Ultimately, multiple-pest effects are dependent on a myriad of complex factors, many of which are not well understood or studied.

Periodic measurement of pest population density may also be needed to detect seasonal population changes, since affected tissues and prediction of yield as a function of pest population varies seasonally when different pests and disease-causing organisms are present. For example, highest nutsedge populations frequently occur in the field when moderate to high *Meloidogyne* populations have reduced crop growth and allowed weed development. This further reduces crop yields and increases pest control expenses. The interaction in this case is sequential and illustrates the importance of nematode management programs. Failure to account for co-variation of weed and nematode populations misrepresents the true impact of the nematode on crop productivity even though the weeds, through competition for water, light, and nutrients, caused the additional loss in yield.

Quantifying Nematode Stress:

Many factors serve to isolate and maintain certain nematodes within particular locations of the field. As the environment of a particular field changes, so

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does the relative involvement and pathogenicity of the nematode and pest complex present. For example, as the coarse-particle size content of soils increase, the synergistic interaction between root-knot nematode and certain fungi generally increases. Increasing soil particle size also increases damage from the nematode and fungus alone. Preliminary sampling, which is accomplished prior to harvest or after destruction of the previous crop, is necessary to identify infested areas and ranges in nematode population levels within the field. Sampling procedures are described in sampling kits available from the Nematode Assay laboratory or local County Extension Offices

Typically many different species of nematodes are recovered from a soil sample submitted for nematode diagnostic and advisory purposes. To formulate a control recommendation, the damage anticipated from the most pathogenic species is first considered. Other less pathogenic species of nematodes present are then ranked and their expected effects related to the damage expected from the most pathogenic species. Their relative pathogenic ratings in terms of the most pathogenic species are then summed across species and population densities to provide a cumulative total of pathogenic equivalents. Since anticipated damage from the most pathogenic species is the benchmark, plant damage is assessed in terms of standardized units of pathogenicity for all nematode species involved.

Distributional Aspects:

The ability to predict crop losses attributable to nematodes and other pests at a field level is based on accurate description of pest density, distribution, and areas where different nematode or pest species occur together. The areas of overlap are important since they form the critical areas for pest interaction. Development of nematode crop loss predictions uniquely determined for individual fields and pest species will undoubtedly await further refinements in many different areas of nematology, including sampling methods, and descriptions of nematode field distribution patterns.

If nematode field distribution were known, field estimates of crop loss including the relative involvement of the species present and recommendations for 'spot' treatment could be estimated. For example, in all areas of the field where no species overlap occurs, it would be possible to apply a single damage relationship accounting for each pest by summing over the frequency and density of each pest occurring within each unit area of the field. For areas in which pests overlap, the resultant damage relationship would have to include the individual affects of each pest as well as the interaction term summed over the number of overlapping areas to arrive at an estimate of crop loss. The total loss would then be the simple addition of expected loss for each area of the field with respect to pest density and distribution. For man pest-crop systems, incorporation of the interaction term could significantly improve crop loss prediction by considering synergistic or antagonistic relationships among nematodes and with other pathogenic organisms.

Nematode control strategies may influence other pest species, which in turn can alter the incidence and severity of the disease complex or alter the susceptibility of the plant to other stress factors. In fact, much of the evidence for the involvement of nematodes in disease complexes is based on lower disease severity when nematode were controlled. Most soil fumigant

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nematicides, applied at specific rates and formulations, can differentially affect nematode and other soil borne pests as well as soil nutrient relations through their effects on non-target soil microorganisms. Justification for use of specific formulations and dosage levels of fumigant nematicides could well be based on the diversity and levels of pests within the field, since many fumigants differentially effect the soil-borne pest complex. Similarly, selection of non-fumigant insecticide/nematicides could be based on consideration of their expected effects or levels of injury for all pests that are present.

Prescriptive Approaches to Soil Pest Control With Methyl Bromide & Chloropicrin

During development, plants are frequently exposed to different levels and complexes of competing pests. A combination of pest stressors on plant growth may interact such that the combined effects of the pest complex are greater than the added effects of each pest. Nematode parasitism frequently increases plant susceptibility to plant pathogenic fungi and bacteria. The interaction among pests is well documented in tomatoes on old production land when Fusarium wilt disease and Root-knot nematode (*Meloidogyne* spp.) are both present. Young plants are very susceptible to the combination of pests, collapsing prior to harvest. The nematode, by impairing water and nutrient availability, disrupts root function and plant growth processes. These effects combined with the vascular blocking due to the wilt fungi can be particularly severe, and if widespread, result in total crop failure.

This interaction between pests seriously limits the use of economic thresholds developed for individual pests and justification for specific, individual pest-oriented control strategies. The severity and re-occurring nature of multiple-pest problems, as in tomato production on old land, underscores the need for control strategies which consider population density of all members of the pest complex and their combined ion crop yield.

Methyl bromide (MB) and chloropicrin (CP) are marketed as broad spectrum soil fumigants to control such soil-borne pests as insects, weeds, nematodes, and fungi. They are currently registered within Florida under various different labels and formulations as preplant treatments for tomatoes, peppers, eggplant, broccoli, cauliflower, melons, strawberry, and seedbeds for transplants (Table 1). MB is commonly mixed in various proportions with CP. In low concentrations, CP is used primarily as a field marker for detection of escaping MB fumes.

Since the discovery of CP in 1848 and MB in 1932, considerable research has been done to evaluate their dispersion and dissipation characteristics and efficacy of each against a myriad of urban, storage, and soil-borne pests. Even with this extensive research base, some uncertainty exists concerning the broad spectrum activities of MB, CP, and their mixtures.

Lethal levels required to control individual pests are determined from study of dose-response relationships of individual pests with each pesticide product. Pest control practices are then generally based on pesticide levels required to kill the most tolerant or resistant economically important pest species. In general, the degree of nematode or general soil pest control

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increases non-linearly as fumigation rate increases. In the case of MB-CP mixtures, product selection becomes more complex since each compound is known to possess greater toxicity than the other to specific pests. This differential toxicity of the two components of MB-CP mixtures should allow a more prescriptive approach to pest control for fields with differing pest complexes.

Weeds:

In the case of different weeds, the relative susceptibility of different weeds to MB and CP formulations and dosage levels have not been adequately assessed. MB is the primary herbicidal agent for the MB-CP mixture and the weed control properties decrease as the rate per acre of the MB decreases. This is especially pertinent to weed species with hard seed coats or large corms or tubers. Many weeds, including mallow, morning glory, vetch, dodder and some species of clover are difficult to control at recommended rates and methods of application and marked growth stimulation, especially of grasses and hard seeded legumes can also occur in response to inadequate rates of fumigation. At a broadcast rate of 400 lbs/a, nutsedge control can be marginal with formulations of 67-33% (268 lb MB/a); this has therefore promoted the use of 98-2% methyl bromide-chloropicrin formulation (392 lb MB/a) for more effective nutsedge control.

Failure to control tolerant weeds such as nutsedge and pigweed with MB is most frequently related to inadequate soil preparation and dry soil conditions prior to fumigation. Pretreatment irrigation 1-2 weeks prior to fumigation is recommended to encourage seed/tuber germination and susceptibility to diffusing gases. Weed control at the bed surface may also be incomplete midpoint between injection points and permit weeds to compete with transplants set off-center of the injection path.

Nematodes:

In general, nematodes are much more sensitive to the multipurpose fumigants than are fungi, bacteria, weeds, or most forms of soil dwelling insects. Although sensitive, many nematodes still survive the fumigant treatment even at application rates sufficient to affect other more tolerant pests. The survival of nematodes is influenced by many factors. The presence of large, undecayed roots prior to treatment can shelter endoparasitic nematodes from lethal gases. It has been shown that undecayed roots can be 8-16 times more resistant to fumigants than the pests or pathogens living in them and this resistance increases markedly with root size. Inconsistent control of root-knot nematodes has occurred with CP when complete decay of infested roots was not achieved prior to fumigation. Conversely, excellent control of root-knot nematode-infested roots has been obtained with MB, which penetrates intact root tissues more readily.

The vertical migration of nematodes within the soil, especially prior to cool and/or dry fallow periods is now being considered as another important factor which maintains populations below treated zones following fumigation. In very dry soils, many nematodes which can survive in a dehydrated state can tolerate 10 times the dose lethal to active forms in moist soils. The rapid escape of volatilizing gases near the soil surface only compounds the problem. Another commonly overlooked factor is dosage level, the quantity of chemical per unit

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area of soil required to achieve control. Dosage levels required for effective control vary not only with soil type, soil moisture, and temperature but also nematode infestation level. Higher dosages are generally required to reduce higher populations to desired sub-economic levels.

Other Plant Pathogens:

MB and CP are also used to reduce the incidence of soil borne fungal pathogens such as *Fusarium* and *Verticillium*. In field and laboratory studies, MB has generally failed to control *Verticillium*, even at rates in excess of 200 lbs/a. In other tests, MB was ineffective for control of *Fusarium* and *Corynebacterium*. Microsclerotia of *Verticillium* are difficult to kill and control of the microsclerotial-forming fungi decreases rapidly with MB dosage, especially in soils with high organic content. In contrast to MB, CP is an excellent fungicide, active against many plant pathogenic fungi of economic importance. Toxicological studies relating the level of control of soil borne plant pathogens to increasing levels of CP in MB mixtures have not been performed or are not readily available. In some cases it has been shown that percent control of *Verticillium*, *Fusarium*, *Rhizoctonia*, *Pythium*, and *Thielaviopsis*, all economically important fungal pathogens, increased when chloropicrin was added to MB. This increased level of control in relation to MB or CP alone is apparently due to the additive toxicity of the two compounds together.

Formulation Assessment:

Based solely on the above toxicological information, some general guidelines for MB-CP formulation decisions can be inferred. In fields where the primary objective is weed control, formulations emphasizing MB should be used as in formulations with 98% MB and 2% CP. Formulations with 67% MB and 33% are generally regarded as borderline for nutsedge control. In fields where plant pathogenic fungi are the primary problem, formulations emphasizing CP should be used, as in 67% MB and 33% CP. For nematode control, MB has certain advantages over CP. MB is cheaper, easier to handle, less corrosive to equipment and permits field replanting sooner than CP. If chloropicrin is used at high levels in the formulation, then treatment and consequently replanting should be sufficiently delayed to allow for root decay and to prevent any undesirable phytotoxic effects to the following crop.

The higher price of chloropicrin relative to methyl bromide is, in addition to differential toxicity, an important economic factor influencing fumigant use, rate, and formulation decisions. The difference in price allows the use of greater field dosage rates of MB than other formulations when equivalent material costs are considered.

The real cost to the grower is not solely determined by comparison of the difference in product price. The comparative efficacies of the different rates and formulations of methyl bromide and chloropicrin are important considerations, especially pertinent when equivalent costs are evaluated. Formulation decisions based entirely on material costs can result in production losses due to marginal or incomplete control of MB tolerant or resistant pests. In this case the philosophy that 'more is always better' can have serious economic consequences and should be avoided. At the same time it underscores the need for further study and economic analysis comparing returns over costs for different rates and formulations of fumigant nematicides.

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The environmental and nutritional consequences of pesticide use is becoming of primary concern to many public and governmental agencies. Agricultural chemical are more closely scrutinized, especially as they relates to environmental fate, toxicity, worker safety, and pesticide misuse. Development of more prudent and efficient pest management strategies is therefore essential.

Chemigation

Chemigation refers to the injection and delivery of agrichemicals through an irrigation system. Drip irrigation systems are being increasingly used to deliver nematicides, as well as broad spectrum fumigant materials to control soil insects, nematodes, fungi, and weeds. In general chemigation of nematicides (Nemagation) has been shown to be both feasible and effective when the drip irrigation and chemical injection systems are properly installed, calibrated and operated, and when the proper chemicals are utilized and applied uniformly. In this regard chemigation is no different from conventional pesticide application systems in that effective nematode control will always be contingent upon the care and precautions taken to insure proper soil conditions and accurate calibration and delivery of nematicides.

Both federal (EPA) and state agricultural agencies (DACS) currently permit application of nematicides and insecticides through irrigation systems (including drip) provided: 1) necessary backflow, anti-siphon irrigation equipment is installed, 2) the treated crop is contained on the pesticide label, and 3) the label does not prohibit irrigation injection.

The use of a drip irrigation system for the delivery of nematicides appears to be a promising approach for precision application to the root zone of plants to control nematodes prior to planting and for postplant applications to infested crops to salvage yield. For many high value vegetable crops, the future of nemagation appears to lie in its use for multiple cropping systems, enhancing yields of the 2nd crop, and in conjunction with soil fumigation and film mulch with the primary crop. Chemigated pesticides are delivered to the plants rooting zone within a limited wetted area near the drip emitters. For a single emitter a small, circular wetted area may only be visible at the soil surface in many of the coarse sands characteristic of crop production in Florida. With depth the cross-sectional area of the wetted zone generally increases, typically forming the general shape and appearance of an 'onion bulb'. The vertical and horizontal movement of water in the plant bed following irrigation is dependent on many factors, the most important of which is soil type (hydraulic conductivity & water holding capacity), initial soil moisture conditions, soil compaction, presence of shallow subsurface impermeable layers and water table, and rate and volume of water delivery.

For water introduced at uniform points on the soil surface a wetted strip usually develops parallel to the drip line. For mulched crops with drip emitter spacings of 12 inches and bed widths of 36 inches, the entire plant bed may be wetted during an irrigation cycle. However, in dry seasons with little or no rainfall and declining water tables, limited movement of water into the shoulder of the plant bed has been observed even when two drip lines

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per bed have been used to supply irrigation water. On Rockdale soils, with similar bed design and drip emitter spacings, the wetted zone may be a semicircle no greater than 9 inches in radius for individual emitters. The shape of the wetted zone tends to be hemispherical, with a dry zone perpendicular to the drip tube and at depth, midway between emitters.

On sandy soils, nematode control may be limited by the width and depth of the wetting pattern and the distribution of pesticide within the wetted zone. Factors which affect water infiltration and radial movement will also affect the location of the chemical in the soil. For example, overlapping patterns of coverage for adjacent emitters do not concentrate soil applied nematicides when water fronts meet midway between emitters. As water fronts collide, water and the chemicals contained in them, move outward and downward, forming irregularly shaped wetted bands, rather than individual circles. Many other factors also affect nematicide transport through soil including chemical solubility, organic matter adsorption, and microbial degradation.

Nematicides applied with irrigation water are carried by water into the soil but are generally not moved throughout the entire wetted zone but only a proportion of the distance moved by the water itself. Limited horizontal movement of irrigation water in many coarse textured Florida sands have inhibited the efficacious use of nematicides. In general, nematode control has increased as the tube placement in the soil increased from the soil surface to a depth of 4 inches and as the broadcast application rate increased.

Drip irrigation systems have also been successfully used to deliver soil fumigant nematicides such as Methyl Bromide and Chloropicrin into mulched beds through bi-wall tubing prior to planting using a hot gas method. Excellent weed and nematode control have been obtained and crop yields significantly increased. Application of fumigant nematicides through micropore tape has been ineffective for controlling nematodes or improving yields due to a rapid loss and poor linear distribution of the fumigant along the tape.

Calibration and Injection:

For proper calibration growers must have field specific information regarding the size and shape of the wetted area, particularly as they relate to the quantity and duration of a single application of irrigation water. The amount of chemical injected into the drip irrigation system would then be calculated according to the surface area of each acre actually wetted by emitters. Calculation of pesticide rates are frequently based entirely on bed width and assumptions of uniform movement and distribution of the pesticide throughout the wetted zone which, in fact, seldom occurs. When pesticide rates are calibrated based solely on bed width and not wetted zone, then pesticides may be applied at phytotoxic levels in the volume of the plant bed in which the pesticide is distributed. Poor root growth may occur in areas where nematodes are controlled due to phytotoxic effects as well as in areas where nematodes are not exposed to the chemical.

When the entire bed is wetted during an irrigation cycle, the amount of chemical injected per acre is a simple proportion (bed width/row spacing) of the maximum broadcast rate of application. When the entire bed is not wetted, then the calculation becomes more complex since the maximum cross sectional

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area of the wetted zone or the average width of the wetted band must be determined. The average width of the wetted band is then related to row width to determine what proportion of the broadcast rate to apply.

Once the overall pesticide rate has been calculated (based on surface wetted acre), the next step is determining when and for what duration the chemical will be injected into the irrigation cycle. Chemicals injected too early in the irrigation cycle may be effectively pushed out of the rooting zone with continued application of water. If injected over a short period, the chemical may form only a narrow semicircular band of effective control around each emitter. The injection time must also reflect the time required to flush the chemical from the irrigation lines. Ideally, the chemigation operation will disperse and maintain the chemical throughout the entire rooting zone of the plant, at toxic concentrations, for sufficient time to be effective.

Different injection periods have been evaluated to determine whether better results would be obtained by applying chemicals in higher concentrations in a single application at the beginning of the crop or by spreading the application of lower concentrations over a longer time period. In general, nematicides applied over an extended period have been found to be more effective than over a single day period in improving crop yields. However, it is unlikely that the introduction of nematicides into the root zone for the entire crop season will prove to be necessary to achieve maximum yield increase. Preplant nematode control practices have repeatedly been shown to be more effective than postplant applications for nematode control and increasing yield, since nematodes that become established within root tissues, may be shielded from the pesticide in the soil and survive the treatment.

A waiting period for subsequent irrigations is another important factor which is frequently overlooked and strongly influences nematode control. A five day waiting period is generally considered to be essential for adequate nematode control. An irrigation delay is required because the effects of many nematicides are cumulative such that nematode mortality increases as exposure time to the chemical increases. And more importantly, the effects can be reversible once the pesticide has been flushed from the environment which surrounds the nematode. In this case the objective may be to maintain lower concentrations over an extended time through repeated applications. However, in Florida soils with low organic matter and water holding capacity, water availability to the plant may be compromised to retain chemicals within the plant rooting zone. An irrigation delay may be particularly severe for plants when weather conditions are hot and dry and plant water demand is high.

The level of pest control that is achieved is related primarily to pesticide concentration, outward radial movement which determines total treated soil volume, and residence time of the chemical in the soil. Very little information is available at present regarding optimal strategies for injection of pesticides to maximize nematode control and yield. Considerably more information is needed regarding pesticide movement and longevity in the soil in order to determine optimal irrigation frequency and number of pesticide applications.

Once in the soil, nematicides may be transported by water through the various soil strata down to groundwater. The risks associated with nematode control, such as the downward transport of nematicides to groundwater, should therefore be of primary concern. Highly permeable sandy soils with low organic matter, and

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shallow groundwater are typical of Florida crop production and those usually associated with high risk of groundwater contamination. In this regard irrigation scheduling programs using moisture depletion as a basis for determining the timing and quantity of water application may become critical for maintaining pesticides within the rooting zone of crops and avoidance of groundwater contamination problems. Managing pesticides within the soil profile may go along ways in providing more effective nematode control, providing consistent economic returns to the grower, and resolution of environmental and human health concerns.

Nematicides: Explanation of Rates Listed in the Following Tables

Chemicals used to control nematodes include non-fumigant nematicides, fumigant nematicides, and multipurpose fumigants. Refer to Section III of this Guide for discussion of the characteristics of each of these groups.

"Overall" soil fumigation is done by injecting fumigant from outlets equally spaced across the entire field. Outlets (behind chisels or coulters) are spaced:

- a. All fumigants except Vapam and Vorlex: 12 inches; if less than 12 inches, the rate per outlet should be reduced proportionally. The rate of fumigant within the area actually treated should never exceed the maximum overall rate (broadcast rate).
- b. Vapam: 5 inches.
- c. Vorlex: 6-8 inches (8 inches was used for calculation of row rates for this Guide).

"Row" application of fumigants refers to treatment of a relatively narrow band of soil with one or more outlets centered on the planting row. This generally provides adequate protection for annual crops with much less fumigant per acre of field. If two or more outlets are used per row, they should be spaced and the rate per outlet should be the same as for overall treatment. "Row" fumigant rates in the tables assume use of one outlet per row, with rows 36 inches apart, unless otherwise noted. Wider spacing of rows will require less total fumigant per acre, and closer spacing will require more, than the "Gal/Acre" estimate based on 36-inch row spacing.

The dosage listed for some fumigants should be increased for organic soils (peat and muck); others should not be applied to such soils; see labels.

Rates of non-fumigant materials are given in weight or volume units of formulation. The maximum rate per 1000 ft of row should not be exceeded; wider row spacing will use less total chemical per acre, but closer row spacing must not result in more total material used per acre than the maximum permitted on a broadcast basis.

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TOMATOES, PEPPERS, & EGGPLANTS

These crops share similar nematode problems and nematicide registrations, and are grown and handled similarly. Their most important nematode pests are root-knot (in sand, muck and Dade Co. rock-based soils), stubby-root (in sand and muck soils), and sting (in sands) nematodes. Fumigants (Table 1) are much more consistently effective against root-knot nematodes than the non-fumigants (Table 2); under some circumstances, non-fumigants are more effective against stubby-root nematodes than are fumigants; most nematicides can be effective against sting nematodes if applied properly.

Tomatoes, peppers and, to some extent eggplant are produced on plastic-mulched beds in many areas of Florida. These beds are routinely fumigated with a multi-purpose fumigant at the time they are covered for broad spectrum soil pest control. Several brands of the fumigants used most widely for tomatoes, including many different methyl bromide/chloropicrin mixtures, have also been registered for peppers and/or eggplant. There is evidence to suggest that some formulations may be better suited for control of specific pest complexes (i.e., combinations of nematodes, weeds, and/or fungi). However, the GROWER must check the label of the product he is actually using to be sure that it is registered for the crops to be grown in the soil being treated. Most multi-purpose fumigants which do not contain methyl bromide may be legally used to treat production fields for nearly any vegetable crop.

TABLE 1. FUMIGANT NEMATICIDES FOR TOMATOES, PEPPERS AND EGGPLANTS IN FLORIDA. (Rates are believed to be correct for products named, and similar products of other brand names, when applied to mineral soils. Higher rates are required for muck (organic) soils. However, the GROWER has the final responsibility to see that each product is used legally; READ THE LABEL of the product to be sure that you are using it properly.)

Nematicide	Broadcast (overall) application		Row Application (single chisel/row)	
	Gallons/ acre	Fl oz/1000 ft/chisel spaced 12"	Gal/acre 36" row*	Fl oz/1000 ft/chisel, any spacing
Telone II**	12-15	35-44	5.3-6.7	46-62

*Gal/acre estimated for row treatments to help determine the approximate amounts of chemical needed per acre of field. If rows are closer, more chemical will be needed per acre; if wider, less. If using more than one chisel/row, space chisels and apply the same flow rate of fumigant/chisel as for broadcast application.

**The manufacturer of Telone II and Telone C-17 has suspended their sale and distribution in all of Florida south of and including Dixie, Gilchrist, Marion, Volusia, and Flagler counties. A result of this action is that there is no fumigant nematicide, except multi-purpose fumigants, which are available for use on this crop in much of Florida. Information about use of Telone II is provided to guide final use of existing supplies.

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TABLE 2. NON-FUMIGANT NEMATOCIDES FOR TOMATOES AND PEPPERS IN FLORIDA.
(These products are not as consistently effective against root-knot nematodes as the fumigants, but are registered as indicated.)

Product	Broadcast or Overall Rates		Row Rates	
	Per Acre	Per 1000 sq ft	Per Acre, 36 Inch Row Spacing	Per 1000 ft of Row, Any Row Spacing
Dasanit 15G*	66.7-134 lb	1.5-3.0 lb	22-43 lb	1.5-3.0 lb
Furadan 15G**	---	---	13.3-20 lb	14-22 oz

Vydate L - Tomatoes and peppers: treat soil before or at planting with any other appropriate nematocide or a Vydate transplant water drench followed by Vydate foliar sprays at 7-14 day intervals through the season; do not apply within 7 days of harvest; refer to directions in appropriate "state labels," which must be in the hand of the user when applying pesticides under state registrations.

*Tomatoes only: early season suppression of nematodes.

**Peppers only: one preplant application of Furadan granules in a 12 to 14 inch band per growing season, incorporated in top 3" of soil for sting nematodes only.

IMPORTANT WARNING! Carbofuran is a chemical which can travel (seep or leach) through soil and can contaminate ground water as a result of agricultural use. Carbofuran has been found in ground water as a result of agricultural use. Users are advised not to apply carbofuran where the water table (ground water) is close to the surface and where the soils are very permeable i.e., well-drained soils such as loamy sands. Your local agricultural agencies can provide further information on the type of soil in your area and the location of ground water. In addition, some product label statements include as a further qualification of risky soils, soils containing sinkholes over limestone bedrock, severely fractured surfaces, and substrates which would allow direct introduction into an aquifer. A more complete discussion of this risk of groundwater contamination appears at the beginning of this Guide, immediately following the Table of Contents.

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Dr. Freddie Johnson, Extension Entomologist

INSECT CONTROL IN TOMATOES

Ants

Insecticide	Formulation	Rate/Acre	Min. Days to Harvest
allethrin (Pyrellin SCS)	1% liquid (EC)	1 - 1 1/2 pt	see label
carbaryl (Sevin)	5 B	20 - 40 lb	0

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Aphids

Insecticide	Formulation	Rate/Acre	Min. Days to Harvest
allethrin (Pyrellin SCS)	1% liquid (EC)	1 - 1 1/2 pt	see label
aliphatic petroleum (JMS Stylet Oil)	97.6% EC	see label	see label
azinphosmethyl (Guthion)	2S, 2L (EC)	2 - 3 pt	0
demeton (Systox)	2 EC	1 - 1 1/2 pt per 100 gal	3
diazinon	4 EC	1/2 pt	1
dimethoate (Cygon, Defend)	4 EC	1/2 - 1 pt	7
disulfoton (Di-Syston)	8 EC	1.2 - 3.5 fl oz per 1000 ft row	30
endosulfan (Thiodan) (green peach aphid)	3 EC	2/3 qt	1
esfenvalerate (Asana) (potato aphid)	0.66 EC	4.8 - 9.6 fl oz	1
fenvalerate (Pydrin) (potato aphid)	2.4 EC	5 1/3 - 10 2/3 oz	1
lindane (Isotox-lindane) (fresh market)	25 WP	1/2 - 1 lb	Do not apply after fruits start to form.
malathion	5 EC	1 pt per 100 gal	1
methamidophos (Monitor)	4 EC	1 1/2 - 2 pt	7
methomyl (Lannate, Nudrin)	1.8 L	2 - 4 pt	1
mevinphos (Phosdrin)	4 EC	1/4 - 1/2 pt	1
methyl parathion	4 EC	1 - 3 pt	15
parathion	4 EC	1 - 2 pt	10
phosphamidon	8 EC	1/2 pt	10
pyrethrins + piperonyl butoxide (Pyrenone) (green peach aphid)	66% liquid (EC)	2 - 6 oz per 100 gal	0

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Armyworms

See also: Beet, Fall, Southern, and Yellow-Striped Armyworm

Insecticide	Formulation	Rate/Acre	Min. Days to Harvest
allethrin (Pyrellin SCS)	1% liquid (EC)	1 - 1 1/2 pt	see label
Bacillus thuringiensis (Javelin)	See label for rates and instructions		
carbaryl (Sevin)	5 B	20 - 40 lb	0
diazinon	4 EC	3/4 - 1 pt	6
esfenvalerate (Asana) (sugarbeet, Western yellow-striped)	0.66 EC	4.8 - 9.6 fl oz	1
fenvalerate (Pydrin) (Southern, Sugarbeet, Western Yellow-Striped)	2.4 EC	5 1/3 - 10 2/3 oz	1
methomyl (Lannate, Nudrin)	1.8 L	1 - 2 pt	1
methyl parathion	4 EC	1 - 3 pt	15
parathion (up to 3rd instar)	4 EC	1 - 2 pt	10
trichlorfon (Dylox, Proxol)	5 B	20 lb	28

Fall Armyworms

Insecticide	Formulation	Rate/Acre	Min. Days to Harvest
carbaryl (Sevin)	80S (WP)	1 1/2 - 2 1/2 lb	0
diazinon	4 EC	3/4 - 1 pt	1
methomyl (Lannate, Nudrin)	1.8 L	2 pt	1
methoxychlor	2 EC	2 - 6 qt	1 for 3 1/2 qt 7 for 3 1/2+ q

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Southern Armyworms

Insecticide	Formulation	Rate/Acre	Min. Days to Harvest
diazinon	4 EC	3/4 - 1 pt	1
esfenvalerate (Asana)	0.66 EC	4.8 - 9.6 fl oz	1
fenvalerate (Pydrin)	2.4 EC	5 1/3 - 10 2/3 oz	1
methomyl (Lannate)	1.8 L	2 - 4 pt	1
permethrin* (Ambush)	2 EC	3.2 - 12.8 oz	up to day of
(Pounce)	3.2 EC	2 - 8 oz	harvest

* Permethrin (Ambush, Pounce) only for Florida use where final market is for fresh tomatoes. Do not use on cherry tomatoes or any variety used to produce fruit less than 1" (one inch) in diameter. Permethrin can be applied by air or ground. Use sufficient water to obtain uniform coverage. Do not apply more than 1.2 lbs. active ingredient per acre per season which is equivalent to 76.8 ozs. of Ambush 2 EC or 48 ozs. of Pounce 3.2 EC.

Beet Armyworms

Insecticide	Formulation	Rate/Acre	Min. Days to Harvest
fenvalerate (Pydrin) (Sugarbeet armyworm)	2.4 EC	5 1/3 - 10 2/3 oz	1
methomyl (Lannate, Nudrin)	1.8 L	2 - 4 pt	1
permethrin* (Ambush)	2 EC	3.2 - 12.8 oz	up to day of
(Pounce)	3.2 EC	2 - 8 oz	harvest

* Permethrin (Ambush, Pounce) only for Florida use where final market is for fresh tomatoes. Do not use on cherry tomatoes or any variety used to produce fruit less than 1" (one inch) in diameter. Permethrin can be applied by air or ground. Use sufficient water to obtain uniform coverage. Do not apply more than 1.2 lbs. active ingredient per acre per season which is equivalent to 76.8 ozs. of Ambush 2 EC or 48 ozs. of Pounce 3.2 EC.

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Yellow-Striped Armyworms

Insecticide	Formulation	Rate/Acre	Min. Days to Harvest
azinphosmethyl (Guthion)	2L, 2S (EC)	.3 - 6 pt	14
fenvalerate (Pydrin) (Western Yellow Striped)	2.4 EC	5 1/3 - 10 2/3 oz	1

Banded Cucumber Beetles

Insecticide	Formulation	Rate/Acre	Min. Days to Harvest
azinphosmethyl (Guthion)	2S, 2L (EC)	1 1/2 - 2 pt	0
diazinon	4 EC	3/4 - 1 pt	1

Beetles

See also: Banded Cucumber, Blister, Colorado Potato, Darkling Ground, Flea, and Potato Flea Beetle

Insecticide	Formulation	Rate/Acre	Min. Days to Harvest
allethrin (Pyrellin SCS)	1% liquid (EC)	1 - 1 1/2 pt	see label

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Blister Beetles

Insecticide	Formulation	Rate/Acre	Min. Days to Harvest
cryolite (Kryocide)	96 WP	15 - 30 lb	wash fruit
endosulfan (Thiodan)	3 EC	2/3 qt	1
methoxychlor	2 EC	2 - 6 qt	1 for 3 1/2 qt 7 for 3 1/2+ qt
parathion	4 EC	1 - 2 pt	10

Cabbage Loopers

Insecticide	Formulation	Rate/Acre	Min. Days to Harvest
Bacillus thuringiensis (Bactur, Bactospeine, Dipel, Sok, Stan-Guard, Thuricide)	See individual labels.		0
cryolite (Kryocide)	96 WP	15 - 30 lb	wash fruit
endosulfan (Thiodan)	3 EC	1 qt	1
esfenvalerate (Asana)	0.66 EC	4.8 - 9.6 fl oz	1
fenvalerate (Pydrin)	2.4 EC	5 1/3 - 10 2/3 oz	1
methomyl (Lannate, Nudrin)	1.8 L	2 - 4 pt	1
methyl parathion	4 EC	2 - 3 pt	15
permethrin* (Ambush)	2 EC	3.2 - 12.8 oz	up to day of
(Pounce)	3.2 EC	2 - 8 oz	harvest

* Permethrin (Ambush, Pounce) only for Florida use where final market is for fresh tomatoes. Do not use on cherry tomatoes or any variety used to produce fruit less than 1" (one inch) in diameter. Permethrin can be applied by air or ground. Use sufficient water to obtain uniform coverage. Do not apply more than 1.2 lbs. active ingredient per acre per season which is equivalent to 76.8 ozs. of Ambush 2 EC or 48 ozs. of Pounce 3.2 EC.

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Colorado Potato Beetles

Insecticide	Formulation	Rate/Acre	Min. Days to Harvest
azinthosmethy1 (Guthion)	2S, 2L (EC)	1 1/2 pt	0
carbaryl (Sevin)	80S (WP)	2/3 - 1 1/4 lb	0
disulfoton (Di-Syston)	8 EC	1.2 - 3.5 fl oz per 1000 ft row (any row spacing) or 1 - 3 pt per acre (38" row spacing)	30
endosulfan (Thiodan)	3 EC	2/3 qt	1
esfenvalerate (Asana)	0.66 EC	4.8 - 9.6 fl oz	1
fenvalerate (Pydrin)	2.4 EC	5 1/3 - 10 2/3 oz	1
methoxychlor	2 EC	2 - 6 qt	1 for 3 1/2 qt 7 for 3 1/2+ qt
parathion	4 EC	1 - 2 pt	10
Pennacap-M	2 EC	4 pt	15
permethrin* (Ambush) (Pounce)	2 EC 3.2 EC	3.2 - 12.8 oz 2 - 8 oz	up to day of harvest
phosphamidon	8 EC	1/2 pt	10
pyrethrins + piperonyl butoxide (Pyrenone)	66% liquid (EC)	2 - 6 oz per 100 gal	0
rotenone (Rotenox)	5% liquid	2/3 gal	0

* Permethrin (Ambush, Pounce) only for Florida use where final market is for fresh tomatoes. Do not use on cherry tomatoes or any variety used to produce fruit less than 1" (one inch) in diameter. Permethrin can be applied by air or ground. Use sufficient water to obtain uniform coverage. Do not apply more than 1.2 lbs. active ingredient per acre per season which is equivalent to 76.8 ozs. of Ambush 2 EC or 48 ozs. of Pounce 3.2 EC.

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Corn Earworms

Insecticide	Formulation	Rate/Acre	Min. Days to Harvest
azinphosmethyl (Guthion)	2S, 2L (EC)	3 - 6 pt	14

Crickets

Insecticide	Formulation	Rate/Acre	Min. Days to Harvest
carbaryl (Sevin)	5 B	20 - 40 lb	0
trichlorfon (Dylox, Proxol)	5 B	20 lb	28

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Cutworms

Insecticide	Formulation	Rate/Acre	Min. Days to Harvest
allethrin (Pyrellin SCS)	1% liquid (EC)	1 - 1 1/2 pt	see label
carbaryl (Sevin)	80S (WP)	2 1/2 lb	0
carbaryl (Sevin)	5 B	20 - 40 lb	0
diazinon	14 G	14 - 28 lb	preplant
diazinon	4 EC	2 - 4 qt	preplant
esfenvalerate (Asana)	0.66 EC	4.8 - 9.6 fl oz	1
fenvalerate (Pydrin)	2.4 EC	5 1/3 - 10 2/3 oz	1
methomyl (Lannate) (variegated cutworm)	1.8 L	2 pt	1
permethrin* (Ambush) (Pounce) (granulate cutworm)	2 EC 3.2 EC	3.2 - 12.8 oz 2 - 8 oz	up to day of harvest
trichlorfon (Dylox, Proxol) (surface-feeding cutworms)	5 B	20 lb.	28

* Permethrin (Ambush, Pounce) only for Florida use where final market is for fresh tomatoes. Do not use on cherry tomatoes or any variety used to produce fruit less than 1" (one inch) in diameter. Permethrin can be applied by air or ground. Use sufficient water to obtain uniform coverage. Do not apply more than 1.2 lbs. active ingredient per acre per season which is equivalent to 76.8 ozs. of Ambush 2 EC or 48 ozs. of Pounce 3.2 EC.

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Darkling Beetles

Insecticide	Formulation	Rate/Acre	Min. Days to Harvest
carbaryl (Sevin)	5 B	20 - 40 lb	0

Drosophilas (fruit flies)

Insecticide	Formulation	Rate/Acre	Min. Days to Harvest
azinphosmethyl (Guthion)	2S, 2L (EC)	1 1/2 - 2 pt	0
diazinon	4 EC	1/2 - 1 1/2 pt	1
malathion	5 EC	2 1/2 pt	1
naled (Dibrom)	8 EC	1 pt	1

European Corn Borers

Insecticide	Formulation	Rate/Acre	Min. Days to Harvest
azinphosmethyl (Guthion)	2S, 2L (EC)	2 - 3 pt	0
carbaryl (Sevin)	80S (WP)	1 1/2 - 2 1/2 lb	0

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Flea Beetles

Insecticide	Formulation	Rate/Acre	Min. Days to Harvest
azinphosmethyl (Guthion)	2S, 2L (EC) •	2 - 3 pt	0
carbaryl (Sevin)	80S (WP)	2/3 - 1 1/4 lb	0
carbophenothion (Trithion) (potato flea beetle)	8 EC	1/2 - 1 pt	7
cryolite (Kryocide)	96 WP	15 - 30 lb	wash fruit
disulfoton (Di-Syston)	8 EC	1.2 - 3.5 fl. oz per 1000 ft row (any row spacing) or 1 - 3 pt per acre (38" row spacing)	30
endosulfan (Thiodan)	3 EC	2/3 qt	1
esfenvalerate (Asana)	0.66 EC	4.8 - 9.6 fl oz	1
fenvalerate (Pydrin)	2.4 EC	5 1/3 - 10 2/3 oz	1
methyl parathion	4 EC	1 - 3 pt	10 for 1 pt 15 for 1+ pt
methoxychlor	2 EC	2 - 6 qt	1 for 3 1/2 q 7 for 3 1/2+ q
naled (Dibrom)	8 EC	1 pt	1
parathion	4 EC	1 - 2 pt	10
Pennacap-M	2 EC	2 - 4 pt	15
phosphamidon	8 EC	1/2 pt	10
pyrethrins + piperonyl butoxide (Pyrenone)	66% liquid (EC)	2 - 6 oz per 100 gal	0

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Garden Symphylans

Insecticide	Formulation	Rate/Acre	Min. Days to Harvest
fonofos (Dyfonate)	10 G	20 lb	preplant, broadcast
diazinon (D.z.n.) (D.z.n. 500)	14 G 4 EC	70 lb 10 qt	preplant broadcast

Grasshoppers

Insecticide	Formulation	Rate/Acre	Min. Days to Harvest
azinphosmethyl (Guthion)	2S, 2L (EC)	2 - 3 pt	0
carbaryl (Sevin)	5 B	20 - 40 lb	0
esfenvalerate (Asana)	0.66 EC	4.8 - 9.6 fl oz	1
fenvalerate (Pydrin)	2.4 EC	5 1/3 - 10 2/3 oz	1
mevinphos (Phosdrin)	4 EC	1/2 - 1 pt	1
parathion	4 EC	1 - 2 pt	10

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Hornworms (tomato hornworm)

Insecticide	Formulation	Rate/Acre	Min. Days to Harvest
azinphosmethyl (Guthion)	2S, 2L (EC)	3 - 6 pt	14
Bacillus thuringiensis (Bactospeine, Bactur, Dipel, Sok, Stan-Guard, Thuricide)	See individual labels.		0
carbaryl (Sevin)	80S (WP)	1 1/2 - 2 1/2 lb	0
cryolite (Kryocide)	96 WP	15 - 30 lb	wash fruit
esfenvalerate (Asana) (tomato hornworm, tobacco hornworm)	0.66 EC	2.4 - 4.8 fl oz	1
fenvalerate (Pydrin)	2.4 EC	2 2/3 - 5 1/3 oz	1
methomyl (Lannate)	1.8 L	2 - 4 pt	1
naled (Dibrom)	8 EC	1 pt	1
PennCap-M	2 EC	4 pt	15
permethrin* (Ambush) (Pounce)	2 EC 3.2 EC	3.2 - 12.8 oz 2 - 8 oz	up to day of harvest
trichlorfon (Dylox, Proxol)	80 SP	20 oz	21

* Permethrin (Ambush, Pounce) only for Florida use where final market is for fresh tomatoes. Do not use on cherry tomatoes or any variety used to produce fruit less than 1" (one inch) in diameter. Permethrin can be applied by air or ground. Use sufficient water to obtain uniform coverage. Do not apply more than 1.2 lbs. active ingredient per acre per season which is equivalent to 76.8 ozs. of Ambush 2 EC or 48 ozs. of Pounce 3.2 EC.

Lace Bugs

Insecticide	Formulation	Rate/Acre	Min. Days to Harvest
carbaryl (Sevin)	80S (WP)	1 1/2 - 2 1/2 lb	0

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Leafhoppers

Insecticide	Formulation	Rate/Acre	Min. Days to Harvest
allethrin (Pyrellin SCS)	1% liquid (EC)	1 - 1 1/2 pt	see label
azinphosmethyl (Guthion)	2S, 2L (EC)	2 - 3 pt	0
carbaryl (Sevin)	80S (WP)	2/3 - 1 1/4 lb	0
carbophenothion (Trithion) (potato leafhopper)	8 EC	1/2 - 1 pt	7
dimethoate (Cygon, Defend)	4 EC	1/2 - 1 pt	7
disulfoton (Di-Syston)	8 EC	1.2 - 3.5 fl oz per 1000 ft row (any row spacing) or 1 - 3 pt per acre (38" row spacing)	30
methoxychlor	2 EC	2 - 6 qt	1 for 3 1/2 qt 7 for 3 1/2+ qt
methyl parathion	4 EC	1 - 2 pt	15
mevinphos (Phosdrin)	4 EC	1/2 - 1 pt	1

Leafminers

Insecticide	Formulation	Rate/Acre	Min. Days to Harvest
allethrin (Pyrellin SCS)	1% liquid (EC)	1 - 1 1/2 pt	see label
azinphosmethyl (Guthion)	2S, 2L (EC)	1 1/2 - 2 pt	0
carbophenothion (Trithion)	8 EC	1/2 - 1 pt	7
diazinon	4 EC	1/2 pt	1

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Leafminers - cont'd

Insecticide	Formulation	Rate/Acre	Min. Days to Harvest
diazinon	50 WP	1/2 lb	1
dimethoate (Cygon, Defend)	4 EC	1/2 - 1 pt	7
disulfoton (Di-Syston)	8 EC	1.2 - 3.5 fl oz per 1000 ft row (any row spacing) or 1 - 3 pt per acre (38" row spacing)	30
fenvalerate (Pydrin)	2.4 EC	10 2/3 oz	1
lindane (Isotox-lindane)	25 WP	3/4 - 1 1/2 lb	Do not apply after fruit starts to form
methamidophos (Monitor) adults	4 EC	1 1/2 - 2 pt	7
naled (Dibrom)	8 EC	1 pt	1
oxamyl (Vydate L)	2 EC	2 - 4 pt per 100 gal	1
parathion	4 EC	1 - 2 pt	10
Pennacap-M	2 EC	2 - 4 pt	15
permethrin* (Ambush)	2 EC	3.2 - 12.8 oz	up to day of
(Pounce)	3.2 EC	2 - 8 oz	harvest
phosphamidon	8 EC	1/2 pt	10
trichlorfon (Dylox, Proxol)	80 SP	20 oz	21

* Permethrin (Ambush, Pounce) only for Florida use where final market is for fresh tomatoes. Do not use on cherry tomatoes or any variety used to produce fruit less than 1" (one inch) in diameter. Permethrin can be applied by air or ground. Use sufficient water to obtain uniform coverage. Do not apply more than 1.2 lbs. active ingredient per acre per season which is equivalent to 76.8 ozs. of Ambush 2 EC or 48 ozs. of Pounce 3.2 EC.

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Loopers

See also: Cabbage Looper

Insecticide	Formulation	Rate/Acre	Min. Days to Harvest
allethrin (Pyrellin SCS)	1% liquid (EC)	1 - 1 1/2 pt	see label
Bacillus thuringiensis (Javelin)	See label for rates and instructions		
methomyl (Lannate, Nudrin)	1.8 L	2 - 4 pt	1

Mites

Insecticide	Formulation	Rate/Acre	Min. Days to Harvest
MITES (GENERAL):			
allethrin (Pyrellin SCS)	1% liquid (EC)	1 - 1 1/2 pt	see label
carbophenothion (Trithion) (russet, tropical and two-spotted mites)	4 EC	1 - 2 pt	7
demeton (Systox)	2 EC	1 - 1 1/2 pt per 100 gal	3
dicofol (Kelthane)	1.6 EC	1 - 2 qt	2
disulfoton (Di-Syston)	8 EC	1.2 - 3.5 fl oz per 1000 ft row (any row spacing) or 1.3 pt (38" row spacing)	30
methyl parathion	4 EC	1 - 2 pt	15
mevinphos (Phosdrin)	4 EC	1/2 - 1 pt	1
naled (Dibrom)	8 EC	1 pt	1

(cont'd)

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Mites - cont'd

Insecticide	Formulation	Rate/Acre	Min. Days to Harvest
TOMATO RUSSET MITE:			
malathion	25 WP	2 - 4 lb	1
methyl parathion	4 EC	1 - 3 pt	15
parathion	4 EC	1 - 2 pt	10
sulfur (Kolospay)	81½ WP	7 lb	0
sulfur (Magneticide)	6 F	1/2 - 1 gal	0
SPIDER MITE:			
malathion	5 EC	1 1/2 pt per 100 gal	1

Mole Crickets

Insecticide	Formulation	Rate/Acre	Min. Days to Harvest
diazinon	14 G	7 lb	preplant
diazinon	4 EC	1 qt	preplant, broadcast

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IX AA-18

Pinworms (tomato pinworm)

Insecticide	Formulation	Rate/Acre	Min. Days to Harvest
allethrin (Pyrellin SCS)	1% liquid (EC)	1 - 1 1/2 pt	see label
azinphosmethyl (Guthion)	2S, 2L (EC)	3 - 6 pt	14
carbaryl (Sevin)	80S (WP)	1 1/2 - 2 1/2 lb	0
cryolite (Kryocide)	96 WP	15 - 30 lb	wash fruit
esfenvalerate (Asana)	0.66 EC	4.8 - 9.6 fl oz	1
fenvalerate (Pydrin)	2.4 EC	5 1/3 - 10 2/3 oz	1
methamidophos (Monitor) (fresh fruit only)	4 EC	1 1/2 - 2 pt	7
methomyl (Lannate, Nudrin)	1.8 L	2 - 4 pt	1
PennCap-M	2 EC	4 pt	15
permethrin* (Ambush) (Pounce)	2 EC 3.2 EC	3.2 - 12.8 oz 2 - 8 oz	up to day of harvest

* Permethrin (Ambush, Pounce) only for Florida use where final market is for fresh tomatoes. Do not use on cherry tomatoes or any variety used to produce fruit less than 1" (one inch) in diameter. Permethrin can be applied by air or ground. Use sufficient water to obtain uniform coverage. Do not apply more than 1.2 lbs. active ingredient per acre per season which is equivalent to 76.8 ozs. of Ambush 2 EC or 48 ozs. of Pounce 3.2 EC.

Plant Bugs

Insecticide	Formulation	Rate/Acre	Min. Days to Harvest
allethrin (Pyrellin SCS)	1% liquid (EC)	1 - 1 1/2 pt	see label
carbaryl (Sevin)	80S (WP)	1 1/2 - 2 1/2 lb	0
methyl parathion	4 EC	2 pt	15
parathion	4 EC	1 - 2 pt	10

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IX AA-19

Potato Flea Beetles

Insecticide	Formulation	Rate/Acre	Min. Days to Harvest
carbophenothion (Trithion)	8 EC	1/2 - 1 pt	7

Potato Psyllids

Insecticide	Formulation	Rate/Acre	Min. Days to Harvest
carbophenothion (Trithion)	4 EC	1 - 2 pt	7
methyl parathion	4 EC	1 - 3 pt	15
parathion	4 EC	1 - 2 pt	10

Saltmarsh Caterpillars

Insecticide	Formulation	Rate/Acre	Min. Days to Harvest
trichlorfon (Dylox, Proxol)	5 B	20 lb	28

Sowbugs

Insecticide	Formulation	Rate/Acre	Min. Days to Harvest
carbaryl (Sevin)	5 B	20 - 40 lb	0

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IX AA-20

Stinkbugs

Insecticide	Formulation	Rate/Acre	Min. Days to Harvest
azinphosmethyl (Guthion) (green stinkbugs)	2S, 2L (EC)	1 1/2 - 2 pt	0
carbaryl (Sevin)	80S (WP)	1 1/2 - 2 1/2 lb	0
parathion	4 EC	1 - 2 pt	10
phosphamidon	8 EC	1/2 pt	10
pyrethrins + piperonyl butoxide (Pyrenone)	66% liquid (EC)	2 - 6 oz per 100 gal	0

Thrips

Insecticide	Formulation	Rate/Acre	Min. Days to Harvest
azinphosmethyl (Guthion)	2S, 2L (EC)	2 - 3 pt	0
lindane (Isotox-lindane)	25 WP	1/2 - 1 lb	Do not apply after fruit starts to form
parathion	4 EC	1 - 2 qt	10

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IX AA-21

Tomato Fruitworms (corn earworm)

Insecticide	Formulation	Rate/Acre	Min. Days to Harvest
azinphosmethyl (Guthion)	2S, 2L (EC)	3 - 6 pt	14
carbaryl (Sevin)	80S (WP)	1 1/2 - 2 1/2 lb	0
cryolite (Krocide)	96 WP	15 - 30 lb	wash fruit
esfenvalerate (Asana)	0.66 EC	4.8 - 9.6 fl oz	1
fenvalerate (Pydrin)	2.4 EC	5 1/3 - 10 2/3 oz	1
methamidophos (Monitor)	4 EC	1 1/2 - 2 pt	7
methomyl (Lannate, Nudrin)	1.8 L	2 - 4 pt	1
naled (Dibrom)	8 EC	1 pt	1
PennCap-M	2 EC	4 pt	15
permethrin* (Ambush)	2 EC	3.2 - 12.8 oz	up to day of
(Pounce)	3.2 EC	2 - 8 oz	harvest

* Permethrin (Ambush, Pounce) only for Florida use where final market is for fresh tomatoes. Do not use on cherry tomatoes or any variety used to produce fruit less than 1" (one inch) in diameter. Permethrin can be applied by air or ground. Use sufficient water to obtain uniform coverage. Do not apply more than 1.2 lbs. active ingredient per acre per season which is equivalent to 76.8 ozs. of Ambush 2 EC or 48 ozs. of Pounce 3.2 EC.

Tuberworms

Insecticide	Formulation	Rate/Acre	Min. Days to Harvest
azinphosmethyl (Guthion)	2S, 2L (EC)	2 1/4 - 3 pt	0

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IX AA-22

Weevils

Insecticide	Formulation	Rate/Acre	Min. Days to Harvest
allethrin (Pyrellin SCS)	1% liquid (EC)	1 - 1 1/2 pt	see label

Whiteflies

Insecticide	Formulation	Rate/Acre	Min. Days to Harvest
azinphosmethyl (Guthion)	2S, 2L (EC)	1 1/2 - 2 pt	0
esfenvalerate (Asana)	0.66 EC	4.8 - 9.6 fl oz	1
fenvalerate (Pydrin)	2.4 EC	5 1/3 - 10 2/3 oz	1
parathion	4 EC	1 - 2 pt	10
phosphamidon	8 EC	1/2 pt	10

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IX AA-23

Wireworms

Insecticide	Formulation	Rate/Acre	Min. Days to Harvest
diazinon	14 G	21 - 28 lb	preplant
diazinon	2 B	50 lb	none listed
diazinon	14 G	21 - 28 lb	preplant, broadcast
diazinon	4 EC	3 - 4 qt	preplant, broadcast
parathion	10 G	30 - 40 lb	preplant, broadcast & disc 3 wks preplanting
parathion	4 EC	5 qt	apply to soil surface preplanting & work 6-9" int soil

