The Florida TOMATO PROCEEDINGS 2016

COVER PHOTO CREDIT: Monica Ozores-Hampton, UF/IFAS, SWFREC, Immokalee

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The Ritz-Carlton, Naples, Florida | September 7, 2016/PRO 532

9:00 **Welcome** – Monica Ozores-Hampton, UF/IFAS, SWFREC, Immokalee.

9:00 **Opening remarks** – Saqib Mukhtar, Associate Dean & Ag. Program Leader, UF/IFAS, Gainesville.

MODERATOR: Crystal Snodgrass, UF/IFAS Extension Manatee County, Palmetto.

9:10 **State of the industry** – Reggie Brown, Florida Tomato Committee, Maitland.

9:20 **Tospovirus-resistant variety outlook for South Florida** - Samuel Hutton, UF/IFAS, GCREC, Wimauma. Page 6

9:40 **Wet stem scars and postharvest decay in tomatoes –** Jerry Bartz, UF/IFAS, Plant Pathology Department, Gainesville. Page 8

10:00 **Efficacy of Nimitz (Fluensulfone) using drip irrigation in tomato production** – Monica Ozores-Hampton, UF/IFAS, SWFREC, Immokalee. Page 10

10:20 **Minimizing crop impacts using vertical management zones for nematode control -** Joe Noling, UF/IFAS, CREC, Lake Alfred. Page 13

10:40 **New sensor technology for yield estimation and disease detection** - Reza Ehsani - Agricultural and Biological Engineering, UF/IFAS, CCREC, Lake Alfred. Page 15

11:00 **Keeping your private applicator license current** – Crystal Snodgrass, Manatee County Extension, Palmetto. Page 17

11:20 – Lunch (on your own)

MODERATOR: Monica Ozores-Hampton, UF/IFAS, SWFREC, Immokalee.

1:00 **Tomato production, trade, and the impact of the suspension agreement** – Zhengfei Guan, UF/IFAS, GCREC, Wimauma. Page 18

1:20 **Social accountability among agricultural employers –** Fritz Roka, UF/IFAS, SWFREC, Immokalee. Page 21

1:40 **Research efforts to improve target spot management on tomato -** Gary Vallad, UF/IFAS, GCREC, Wimauma. Page 23

2:00 **Reducing reliance on neonicotinoid insecticides in Florida tomato production** - Hugh Smith and Phil Stansly, UF/IFAS, GCREC, Wimauma and SWFREC, Immokalee. Page 28

2:20 **Herbicide resistance management in tomato** – Nathan Boyd, UF/IFAS, GCREC, Wimauma. Page 30

2:40 **Possible impacts of the whitefly Q biotype on viral diseases in tomato** – Jane Polston, UF/IFAS, Plant Pathology Department, Gainesville. Page 33

3:00 **Industry updates** – Gene McAvoy, UF/IFAS Extension Hendry County, Labelle.

3:45 Adjourn, CEUs will be provided!

PRODUCTION GUIDES

Tomato varieties for Florida - Eugene McAvoy, UF/IFAS Hendry County Extension Services, LaBelle and Monica Ozores-Hampton, UF/IFAS, SWFREC, Immokalee. Page 35

Fertilizer and nutrient management for tomato - Monica Ozores-Hampton, UF/IFAS, SWFREC, Immokalee. Page 37

Water management for tomato - Monica Ozores-Hampton, UF/IFAS, SWFREC, Immokalee. Page 41

Weed control in tomato - Nathan Boyd, UF/IFAS, GCREC, Wimauma and Peter Dittmar, UF/IFAS, Horticultural Sciences Department, Gainesville. Page 44

Tomato fungicides - Gary E. Vallad, UF/IFAS, GCREC, Wimauma. Page 46

Tomato biopesticides and other disease control products - Gary E. Vallad, UF/IFAS GCREC, Wimauma. Page 60

Insecticides and miticides for management of tomato pests – Hugh Smith, UF/IFAS, UF/IFAS GCREC, Wimauma Phil Stansly, UF/IFAS, SWFREC, Immokalee, and Susan E. Webb, UF/IFAS, Entomology and Nematology Dept., Gainesville, FL. Page 63

Nematicides registered for use on Florida tomato - Joseph W. Noling, UF/IFAS, CREC, Lake Alfred. Page 79

Tospo-Resistant Variety Outlook for South Florida

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INTRODUCTION

Damaging outbreaks of several invasive species of thrips and two emerging thrips-vectored tospoviruses, Tomato chlorotic spot virus (TCSV) and Groundnut ringspot virus (GRSV), are significantly impacting tomatoes in Florida. The key vector, the western flower thrips, has developed resistance to all currently available insecticides. Another important vector, the common blossom thrips, may also be developing insecticide resistance. Outbreaks of palm thrips have traditionally been confined to the Miami-Dade production area, but outbreaks of this species have recently occurred in other areas as well. Development of effective disease management strategies requires an integrated approach against the vectors and the tospoviruses.

Sw-5 is a major gene for resistance to Tomato spotted wilt virus (TSWV), a related tospovirus. *Sw-5* also confers resistance to TCSV and GRSV. However, because tospoviruses were previously not a significant problem in South Florida, there was little need to emphasize tospovirus resistance when developing varieties adapted to the area. In light of the current situation, there is an urgent need to evaluate the adaptability of existing commercial cultivars containing *Sw-5*, and to develop and evaluate new hybrids possessing virus resistance.

The objective of this work was to evaluate the performance of multiple large-fruited, tospovirus-resistant hybrids under commercial settings in Homestead, FL.

MATERIALS AND METHODS

Two hybrid trials were conducted in grower fields in Homestead, FL during the winter 2015-16 season. Seed of 45 *Sw-5*-containing hybrids and of three susceptible checks (‘Sanibel’, ‘Florida 47’ and ‘Fla. 8970’) were obtained from seed companies or from the UF/IFAS tomato breeding program (Table 1). Seed were sown directly into 128-well transplant trays. Transplants were grown in a greenhouse and planted to the field approximately six weeks after sowing. Planting dates were October 10th for Trial 1 and December 17th for Trial 2. Transplants were planted to field beds with six-foot between-row spacing, and in-row spacing was 20-inches. Experimental design for both trials was a randomized complete block design, with four blocks and 20-plant plots. Three hybrids (‘Sanibel’, ‘Quincy’ and ‘Southern Ripe’) were planted to larger, 80-plant plots.

In each trial, hybrids were rated for bacterial spot disease sensitivity. Ratings were made on a per-plot basis using the Horsfall and Barratt scale (1945), where 1 = 0%, 2 = 0%-3%, 3 = 3%-6%, 4 = 6%-12%, 5 = 12%-25%, 6 = 25%-50%, 7 = 50%-75%, 8 = 75%-87%, 9 = 87%-94%, 10 = 94%-97%, 11 = 97%-100%, and 12 = 100% diseased tissue. Ratings were conducted on December 17th for Trial 1 and on February 4th for Trial 2. Trial 1 was not harvested due to poor field conditions during the season. Trial 2 was harvested twice, on March 22nd and on April 5th. The harvests were conducted over three of the four blocks and from sixteen of the 20 plants per plot. Forty-eight plants per block were harvested for the three hybrids with larger plot sizes (‘Sanibel’, ‘Quincy’ and ‘Southern Ripe’). For each harvest, mature-green through ripe fruit were picked and graded in the field for marketability and fruit size. General comments regarding fruit marketability were recorded during grading. Statistical analyses and mean separations were performed using SAS.

RESULTS AND DISCUSSION

The South Florida environment for winter tomato production is unique and particularly challenging one, given that temperatures are cooler, day lengths are shorter, and soil is calcareous. Moreover, conditions are often favorable for bacterial spot disease (*Xanthomonas perforans*) and can be conducive for graywall as well. Until recently, little attention was given toward evaluation of tospovirus-resistant hybrids in this area. But in light of recent viral outbreaks, it is urgent to identify resistant cultivars that perform well in this environment. Sanibel is a jointless-pedicel hybrid with a strong vine, good bacterial spot tolerance, and fair graywall resistance; this hybrid continues to be widely grown in Dade County and provides a benchmark for hybrid performance.

Although two hybrid trials were planted in fall/winter 2015 for this work, excessive rainfall early in the season resulted in a nearly complete loss of Trial 1. Bacterial spot ratings were made on both trials. Several hybrids that showed greater sensitivity to bacterial spot were not included in Trial 2. Both trials were scouted for virus infection, but incidence was extremely low, and no TCSV- or GRSV-infected plants were identified in either trial. Harvesting was done only for Trial 2. In this trial, total marketable yields of the hybrids varied, ranging from under 1000 boxes per acre to 1824 boxes/A (Table 2). Overall, fruit size tended to be small. This is reflected in the lower XL yields, and the trend is consistent with grower reports for much of the 2015-16 winter season.

Sanibel averaged 1632 and 357 boxes/A of total and XL yield, respectively (Table 2). Twenty-one tospovirus-resistant hybrids had total marketable yields not significantly different than that of Sanibel (Table 2). The UF/IFAS hybrids 15x0236, 15x0234 and 15x0233 each have jointless-pedicels and also yielded comparably to Sanibel; however, hybrids 15x234 and 15x233 each had lower XL yields than Sanibel. Fla. 8955, 15x0123, 14x1211, Fla. 8884, and Fla. 8945 also had total yields comparable to Sanibel but significantly lower XL yields. Two hybrids, FTM2263 and 15x0123 had the highest XL yields among all hybrids, while XL yield for Southern Ripe was also numerically high, but not significantly different than Sanibel.

Bacterial spot sensitivity was comparable to that of Sanibel for most of the hybrids that were harvested (Table 1, Table 2). However, six hybrids had significantly more disease in one or both of the trials; among these, RFT890053, Resolute, SV7101TD and 15x0115 were more sensitive in one of the trials, while Brickyard and Southern Ripe were more severely infected in both trials. Although incidence of graywall was generally very low for the trial, one hybrid, Quincy, showed a high incidence across all replications.

These results provide useful information for identifying hybrids to include in future trials, and for growers interested in identifying tospovirus-resistant hybrids for their own testing in South Florida.

ACKNOWLEDGEMENTS

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LITERATURE CITED

Horsfall, J.G. and R.W. Barratt. 1945. An improved grading system for measuring plant diseases. Phytopathology 35:655.

Table 1. Bacterial spot disease sensitivity among tospovirus-resistant hybrids.

Line	Source	Tospo[1]	Mean DSI[2] Trial 1	Trial 2
15x0235	UF/IFAS	R	nd	5.3 h
15x0232	UF/IFAS	R	nd	5.4 gh
15x0234	UF/IFAS	R	5.3 hi	5.5 f-h
Fla. 8973	UF/IFAS	R	5.5 f-i	5.5 f-h
Skyway	Enza Zaden	R	5.7 e-i	5.5 f-h
15x0122	UF/IFAS	R	5.5 f-i	5.6 f-h
Sanibel	Seminis	S	5.4 g-i	5.7 e-h
Quincy	Seminis	R	4.5 j	5.7 e-h
15x0236	UF/IFAS	R	5.2 i	5.8 d-h
15x0233	UF/IFAS	R	5.7 e-i	5.8 d-h
15x0114	UF/IFAS	R	nd	5.8 d-h
14X1210	UF/IFAS	R	nd	5.8 d-h
15x0237	UF/IFAS	R	5.5 f-i	5.9 d-h
Fla. 8945	UF/IFAS	R	6.0 b-h	5.9 d-h
Fla. 8970	UF/IFAS	S	5.7 e-i	6.0 c-g
Red Defender	HM Clause	R	5.8 d-i	6.0 c-g
Fla. 8955	UF/IFAS	R	6.0 b-h	6.0 c-g
14x1211	UF/IFAS	R	nd	6.0 c-g
15x0123	UF/IFAS	R	nd	6.0 c-g
FL 47	Seminis	S	5.8 d-i	6.1 b-f
15x0124	UF/IFAS	R	nd	6.1 b-f
Fla. 8884	UF/IFAS	R	nd	6.1 b-f
XTM8135	Sakata	R	5.3 hi	6.3 a-f
FTM2263	Sakata	R	5.8 d-i	6.3 a-f
SV7101TD	Seminis	R	6.8 ab	6.4 a-e
RFT890053	Syngenta	R	5.9 c-i	6.5 a-d
Resolute	BEJO	R	6.0 b-h	6.5 a-d
15x0115	UF/IFAS	R	nd	6.5 a-d
Southern Ripe	Seminis	R	6.7 ab	6.8 ab
BRICKYARD	Syngenta	R	6.3 b-e	6.9 a
Fla. 8969	UF/IFAS	R	5.3 hi	nd
Red Bounty	HM Clause	R	5.7 e-i	nd
Fla. 8891	UF/IFAS	R	5.7 e-i	nd
BEJO 3040	BEJO	R	5.8 d-i	nd
Volante	Sakata	R	6.1 b-h	nd
Fla. 8866	UF/IFAS	R	6.1 b-h	nd
15x0113	UF/IFAS	R	6.1 b-h	nd
FTM1129	Sakata	R	6.2 b-g	nd
Fla. 8942	UF/IFAS	R	6.2 b-g	nd
RFT890054	Syngenta	R	6.3 b-f	nd
15x0128	UF/IFAS	R	6.3 b-e	nd
SUMMERPICK	Syngenta	R	6.4 b-e	nd
SV7631TD	Seminis	R	6.5 a-d	nd
Dixie Red	Seminis	R	6.6 a-c	nd
15x0118	UF/IFAS	R	7.1 a	nd

[1] Response to tospoviruses as conferred by the *Sw-5* gene: R = Resistant, S = Susceptible

[2] Disease severity index rated on the Horsfall-Barratt scale (Horsfall and Barratt, 1945), where higher numbers indicate more disease; nd = no data. Mean separation by Duncan's multiple range test at $P \leq 0.05$. For each line, means within columns followed by the same letter are not significantly different.

Table 2. Total and extra-large marketable yields and percentage of culled fruit among tospovirus-resistant hybrids for mature-green through ripe stage fruit harvested in March-April, 2016 from a commercial field in Homestead, FL.

Line	Source	Tospo [1]	Marketable Yield (25 lb boxes/acre) [2] Total	Extra-large	Percent cull
15x0236	UF/IFAS	R	1824 a	368 bc	14 a-f
15x0234	UF/IFAS	R	1715 ab	210 d-h	17 a-d
Sanibel	Seminis	S	1632 a-c	357 bc	18 ab
Fla. 8955	UF/IFAS	R	1627 a-c	206 d-h	16 a-e
FTM2263	Sakata	R	1564 a-d	564 a	18 a-c
RFT890053	Syngenta	R	1488 a-e	361 bc	12 b-f
15x0232	UF/IFAS	R	1460 a-e	241 c-g	12 b-f
Fla. 8973	UF/IFAS	R	1452 a-e	265 c-f	12 d-f
Brickyard	Syngenta	R	1402 a-e	291 b-e	19 a
Southern Ripe	Seminis	R	1396 a-e	418 b	9 fg
15x0123	UF/IFAS	R	1395 a-e	542 a	18 ab
Quincy	Seminis	R	1384 a-e	233 c-g	12 c-f
15x0233	UF/IFAS	R	1376 a-e	156 e-h	18 a-d
Red Defender	HM Clause	R	1371 a-e	320 b-d	13 a-f
15x0114	UF/IFAS	R	1358 a-e	311 b-d	14 a-f
14x1211	UF/IFAS	R	1346 a-e	204 d-h	16 a-d
FL 47	Seminis	S	1300 b-e	275 c-f	10 e-g
Skyway	Enza Zaden	R	1284 b-e	239 c-g	10 e-g
Fla. 8884	UF/IFAS	R	1259 b-e	206d-h	17 a-d
15x0124	UF/IFAS	R	1212 b-e	245 c-g	17 a-d
Resolute	BEJO	R	1211 b-e	315 b-d	5 g
Fla. 8945	UF/IFAS	R	1139 c-e	119 gh	18 a-c
SV7101TD	Seminis	R	1135 c-e	292 b-e	10 e-g
Fla. 8970	UF/IFAS	S	1126 c-e	157 e-h	18 a-d
14X1210	UF/IFAS	R	1097 de	134 f-h	14 a-f
15x0122	UF/IFAS	R	1074 de	167 e-h	19 a
15x0237	UF/IFAS	R	1064 de	88 h	13 a-f
15x0235	UF/IFAS	R	993 e	156 e-h	17 a-d
15x0115	UF/IFAS	R	992 e	107 gh	10 e-g
XTM8135	Sakata	R	977 e	283 b-e	15 a-f

[1] Response to tospoviruses as conferred by the *Sw-5* gene: R = resistant, S = susceptible

[2] Mean separation by Duncan's multiple range test at $P \leq 0.05$. For each line, means within columns followed by the same letter are not significantly different.

Wet Stem Scars and Postharvest Decay in Tomatoes

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Postharvest losses of tomatoes may become extensive when fields are exposed to high rainfall, dew, fog, or conditions associated with reduced transpiration at the time of harvest (Bartz, et al., 2015a). Factors partially responsible for decay associated with "wet harvests" include an increased tendency for fruit to develop surface cracks and to be prone to injury during harvest. Free water on fruit surfaces aids in the dispersal of pathogens and inoculation of wounds. Lesions developing on fruit after wet harvests are often internal, beginning under or beside the stem scar. For example, 88% of the lesions in a representative box of fruit sampled from a shipment rejected by a receiver were either internal or associated with the stem scar (Bartz, 1980). This internal lesion location was consistent with that which occurred among fruit that had been infiltrated by an aqueous cell suspension of bacteria (Bartz and Showalter, 1981). If fruit increased in weight by ≥0.1 g during an immersion in inoculum contaminated water, nearly all of the fruit decayed during subsequent storage. By contrast, a decay incidence of only 5 to 15% occurred when the fruit were similarly exposed to soft rot inocula but their weight increase was < 0.1 g (Bartz, 1981).

Bacteria may internalize in tomato fruit through stem scar structures even before harvest and handling. Samish and Etinger-Tulczynska (1963) reported that a red-pigmented bacterium (*Serratia marscens*) applied to the calyx surface of fruit on field-grown tomatoes was subsequently isolated from internal fruit tissues several days later. Wingard (1924) observed the development of bacterial soft rot on 62.5% of tomatoes still attached to plants after fruit were contaminated with "pieces of decayed fruits to their unpunctured surfaces." Lesions on 80% of the fruit began at the stem-fruit juncture. A review of internalization of *Salmonella enterica* by tomato fruit detailed evidence that cells of this bacterium survived better and were more resilient to aqueous chlorine solutions if allowed to dry on stem scars as compared with the unbroken cuticle (Bartz, et al. 2015b). The applications of suspensions of *S. enterica* described in the literature did not always include conditions expected to cause movement of aqueous cell suspensions into fruit as reported by Bartz and Showalter (1981).

Lesion development within tomato stem scars has been linked with other postharvest decays of tomato fruit. Pritchard and Porte (1923) concluded that watery rot (now called sour rot) among commercially shipped fruits resulted from stem scar infections. Lesions were not common at wounds since commercial fruit are relatively free of wounds. Moreover, laboratory inoculations led to infections at both wounds and stem scars.

Gas exchange for tomato fruit has been shown to occur through apertures in the stem scar even prior to harvest. Clendenning (1948) concluded that the corky ring was a "massive" annular lenticel. This area is loosely covered by the calyx and is connected to large intercellular spaces associated with vascular tissues (Seaton and Gray, 1936). The intercellular spaces enable free water movement through the tissues. An application of wax to the stem scar and corky ring caused green fruit to become hypoxic, not ripen and deteriorate internally (Brooks, 1937). Clendenning (1948) observed a similar response among developing fruit by applying wax to the base of the stem. Stahl et al., (2015) observed gas egress from distinct areas within the stem scar of tomato fruit that were submerged in water and exposed to a vacuum. Bubbles can also be induced by squeezing fruit or by warming cool fruit (Bartz, unpublished). The apertures are composed of corky tissues and qualify as lenticels. Gas bubbles from lenticels are large and emerge persistently in comparison with small amounts of egress associated with other structures within the stem scar (Stahl, et al. 2015) (Fig.1). Coverage of both the large lenticel like openings and the inter-aperture corky ring with wax prevented normal ripening by blocking gas exchange.

These lenticels appear to be the pathways by which water and suspended microbes can move into tomato fruit. Dye solutions (nigrosin or aniline blue) were combined with cells of *Salmonella enterica* and were infiltrated into stem scars. Fruit were dissected and tissue sections applied briefly to the surface of trypticase soy agar (TSA) plates. Colonies formed on the medium in clusters around prints of the stem scar and surrounding shoulder tissues. These areas coincided with dye accumulation in the fruit, evidence that bacterial cells internalized along with the dye through stem scar tissues. Stem scars were exposed to a suspension of India ink to reaffirm that the lenticels were large enough to enable soft rot bacteria to internalize. India ink has been used as a surrogate for Gram negative bacteria in evaluation of suture closures after eye surgery (Taban et al. 2005). Size of the carbon particles in the ink suspension was confirmed by forcing a sample through a filter used to sterilize water (STERITECH, 2015). The water exiting the filter was clear, whereas the particles were held up on the filter surface. By contrast, ink was observed in internal tissues of tomato fruit after various treatments (Fig. 2). The lenticels were large enough to enable bacteria to internalize.

Fruit exposed to soft rot inoculum by either immersion (5-sec) or mist, developed lesions during subsequent storage. Most of the lesions developed at the juncture of pericarp, endocarp and edge of stem scar (Fig. 3). These infections coincided with the lenticels that were revealed when gas was forced out of fruit (Stahl, et al., 2015). Very few lesions developed at other locations on fruit. Decay incidence varied among the untreated control fruit in different experiments ranged from < 33 % to 100% by 2 to 7 days post-inoculation. After storage for 7 days, decay incidence was commonly > 67%. Fruit ripeness did not appear to be a factor as ripe fruit were as susceptible as green fruit.

To evaluate how rapidly inoculation occurs, we treated fruit in various ways after a 5-sec immersion in aqueous cell suspensions of soft rot bacteria. In one series of experiments, fruit were washed in 150 ppm chlorine (pH 6.5) for 1 min within 5 sec to 60 min after inoculation (Table 1). Those treated within 5 sec rarely or never developed bacterial soft rot. If the chlorine wash was delayed for 120 seconds, an average of 5% of the fruit developed lesions by 5 days over four separate experiments. If the delay was extended to 60 min, an average of 73% of the fruit developed lesions, whereas the control (inoculated alone) average for these four experiments was 100%. Wiping stem scars with a dry paper towel at similar intervals after inoculation (Table 2) led to a similar pattern. In comparison with decay incidence among control fruit, wiping fruit with a clean paper towel after a standard 10-min drain period used in most of our experiments led to an approximately 50% reduction in decay incidence (80 versus 44%, Pr>F=0.056).

Since fruit harvested during wet conditions are likely to have a degree of water congestion, we flooded the stem scars of water congested fruit with India ink. Ink penetration was observed within 5 seconds of contact, demonstrating Johnson's report on bacterial suspension movement into water flooded apertures on plants (Johnson, 1947).

Unfortunately, reducing the interval between harvest and chlorine wash to less than 60 min does not appear feasible for large scale commercial tomato producers. Small farms with limited acreage could accommodate these treatments. However, it is important for all tomato growers to recognize the hazards associated with wet tomato fruit, whether the moisture arises from condensation, rainfall or is on fruit at the time of harvest.

Chlorine wash treatments applied after reasonable intervals between harvest and packing are of some benefit depending on the delay and fruit sample. Washing fruit in chlorinated water at 1 hr after inoculation produced an approximately 45% reduction in decay incidence (Table 3). A similar reduction occurred if the wash was a more manageable 4 hrs after inoculation. However, if the fruit were held over-night prior to packing (18-hr delay), then the decay incidence would not be significantly reduced by the chlorine wash. Note that over all treatments discussed above, lesions primarily began at the stem scar.

Fruit with attached receptacles (stem and calyx) were dip-inoculated to determine if such structures provided protection against bacterial internalization in four separate experiments with storage for 2 to 5 days. Stems off averaged 90% decay and stems on averaged 52% decay. The difference is significant with a Pr>f=0.0066. Decay incidence among fruit with stems varied among the experiments ranging from 7% to 100% within 2 days after inoculation. An attached calyx provides some protection but based on anecdotal reports from South Florida this past winter and from the Eastern Shore of Va. several years ago, heavy rainfall can lead to inoculated fruit prior to harvest (Bartz, et al., 2012). Such fruit have a potential for beginning to decay while being treated with ethylene. Some of these fruit may have cuticle cracking due to rainfall and infections begin in those cracks. However, based on our tests, water flooding the stem depression can move bacteria into lenticels beneath the calyx.

REFERENCES

Bartz, J. A. 1980. Causes of a postharvest loss in a Florida tomato shipment. Plant Dis. 64:934-937.

Bartz, J. A. 1981a. Ingress of suspensions of Erwinia carotovora subsp. carotovora into tomato fruit. Proc. Fifth Int. Conf. Plant Path. Bact. Cali. pp. 452-460.

Bartz, J. A., Sargent, S. A., & Scott, J. W. 2012. Postharvest quality and decay incidence among tomato fruit as affected by weather and cultural practices. University of Florida, IFAS Extension. http://edis.ifas.ufl.edu/pdffiles/PP/PP29400.pdf.

Bartz, J. A., Sargent, S. A., and Scott, J. W. 2015a. Weather fronts and postharvest decays and safety of field-grown tomatoes. Proc. IVth Int. Symp. on Tomato Diseases. (eds. Paret et al.) Acta Hort. 1069:333-340. ISHS.

Bartz J.A. and Showalter R. K. 1981. Infiltration of tomatoes by aqueous bacterial suspensions. Phytopathology 71:515-518.

Bartz, J. A., Yuk, H.-G., Mahovic, M. J., Warren, B. R., Sreedharan, A., and Schneider, K. R. 2015b. Internalization of *Salmonella enterica* by tomato fruit. Food Control 55:141-150.

Brooks, C. 1937. Some effects of waxing tomatoes. Proc. Am. Soc. Hort. Sci. 35:720.

Clendenning, K. A. 1948. Growth studies of normal and parthenocarpic tomato fruits. Can. J. Res. 26:507-513.

Johnson, J. 1947. Water-congestion in plants in relation to disease. University of Wisconsin Research Bulletin, 160:1-35.

Pritchard, F. J. and Porte, W. S. 1923. Watery-rot of tomato fruits. A physiological form of *Oospora lactis*; effect on the host; penetration of the cell walls by enzymatic action. J. Agric. Res. 24: 885-906.

Samish, Z., and Etinger-Tulczynska, R. 1963. Distribution of bacteria within the tissue of healthy tomatoes. Appl. Microbiol. 11:7-10.

Seaton, H. L. and Gray, G. F. 1936. Histological study of tissues from greenhouse tomatoes affected by blotchy ripening. J. Agric. Res. 52:217-224.

Stahl, S. L., Bartz, J. A., Huber, D.J., Spiceland, D., Lee, J. H., and Elkahky, M. T. 2014. An alternative route for bacterial internalization in tomato fruit (abstr). Phytopathology 104:S3.113.

Stahl, S. L., Huber, D., Bartz, J. A., and Lee, J. H. 2015. Visual assessment of gas-exchange sites in harvested tomato fruit (abstr). HortScience 50(9):S13.

STERITECH 2015. http://www.sterlitech.com/blog/2014/06/26/defining-a-pore-size-and-sterile-filtering-0-2-microns-vs-0-22-microns-what%E2%80%99s-the-difference.

Taban, M., Sarayba, M. A. Ignacio, T. S., Behrens, A., and McDonnell, P. J. 2005. Ingress of India Ink into the anterior chamber through sutureless clear corneal cataract wounds. Arch. Ophthalmol. 123:643-648.

Wingard, S. A. 1924. Bacterial soft-rot of tomato. Phytopathology 14:451-459.

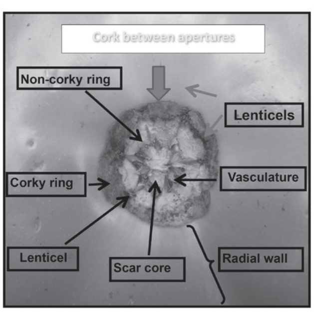

Figure 1. Illustrated structure of tomato stem scar (from Stahl, et al., 2015).

Figure 2. Internal section of fruit infiltrated through stem scar with diluted India ink. Arrows point to accumulations of ink particles..

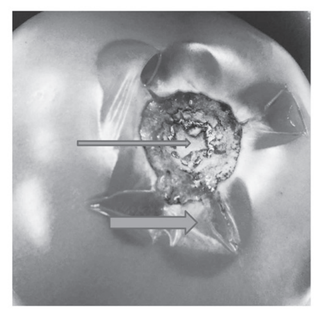

Figure 3. Typical lesion associated with stem scar of inoculated tomato fruit, with small arrow indicating sound columella and large arrow directed to soft rot lesion.

Table 1. Effect of short delays between stem scar inoculation and chlorine treatment[1] on incidence of bacterial soft rot after 5 days at 25 °C.

Experiment no.	#1	#2	#3	#4	Avg.
Control	100	100	100	100	100 a[2]
5 seconds	0	0	0	0	0 c
10 seconds	0	0	7	0	2 c
120 seconds	0	13	7	0	5 c
60 min	100	100	47	47	73 b

[1] Fruit swirled in 150 ppm chlorine (pH 6.5) for 1 min and then wiped dry.
[2] Values not followed by the same letter were different at Pr<0.05.

Table 2. Decay incidence and wiping fruit dry[1] within a short delay after inoculation.

Experiment no.	#1	#2	Avg.
Control	100	100	100a[2]
5 sec	13	0	7d
10 sec	0	0	0d
120 sec	27	13	20c
60 min	53	80	67b

[1] Inoculum blotted from stem scar with dry paper towel.
[2] Values not followed by the same letter were different at Pr<0.05.

Table 3. Incidence of bacterial soft rot after 7 days in storage as affected by a delay between inoculation[1] and washing fruit in a chlorine solution[2].

Experiment no.	# 1	# 2	#3	Avg.
Control	67	73	80	73 a[3]
Wash after 1 hr	47	27	47	40 c
Wash after 4 hr	47	27	47	42 bc
Wash after 18 hr	80	33	40	62 ab

[1] Fruit immersed in aqueous suspension of *Pectobacterium carotovorum* for 5 sec and then allowed to drain for 10 min.
[2] Fruit swirled in 150 ppm chlorine (pH 6.5) for 1 min and then wiped dry.
[3] Values not followed by the same letter were different at Pr<0.05.

Efficacy of Drip-injected Nimitz (Fluensulfone) to Manage Root-knot Nematodes on Tomato

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INTRODUCTION

Florida continued to be the leading fresh-market tomato State with 32,200 acres harvested generating a production value of US$453 million and an average yield of 295 hundred weight/acre in 2015 (USDA, 2016). In the past years, Florida tomato growers relied on methyl bromide (MeBr) as a broad spectrum soil fumigant against soil-borne diseases, weeds, and nematodes (Gilreath et al., 1994). Since the phaseout of MeBr began in 2005 through the Montreal protocol (U.S. Environmental Protection Agency, 2000), tomato growers were left with limited options against root-knot nematodes [RKNs (Noling, 2016)]. The loss of a broad spectrum soil fumigant and the vast number of fumigant regulations do not leave growers with highly effective RKN management options (Morris et. al, 2015). Alternatively to MeBr, fumigants such as Telone II (1,3-dichloropropene) and Paladin (dimethyl disulfide), when properly applied, may offer broad spectrum activity and can aid RKN population reduction (Dr. D. Dickson, personal communication). Pic-Clor 60 (1,3-dichloropropene plus chloropicrin) was identified as the alternative fumigant to MeBr in a survey conducted among Florida tomato growers in 2011. Nonetheless, growers undoubtedly indicated that pest-pathogen problems were increasing, and that production losses were experienced due to the lack of effective available alternatives (Snodgrass et al., 2013). Furthermore, growers specified that the use of fumigants involves risk of plant injury, high cost, and product availability uncertainty (Snodgrass et al., 2013). Vydate (oxamyl) is one of the two non-fumigant nematicides available for RKN management on tomato production in Florida (Noling, 2016). Vydate temporally paralyzes nematodes and is commonly post-plant applied as both foliar and drip-injected throughout the growing season (Wright, 1981). However, post-plant applications of Vydate have not shown complete plant growth and yield recovery once RKN infection takes place and plant damage occurs (Noling, 2016). Currently, production of Vydate has been halted due to a factory incident in which methyl mercaptan was accidentally released taking the lives of four workers [U.S. Chemical Safety Board (CSB), 2015].

Therefore, the need for soil applied non-fumigants to aid with RKN management is continuously increasing. RKNs have been found to survive fumigation in some cases where the endoparasitic nematodes penetrated residues of undecayed roots prior to treatment (Carpenter et al., 2000). Moreover, latest research has shown that current alternative fumigants to MeBr with low vapor pressure and high boiling point do not distribute vertically in the soil profile allowing RKN survival in deeper layers (Noling, 2016). Root-knot nematode management then should be viewed as a composite of tactics not relaying on fumigation alone. Nimitz, active ingredient fluensulfone (ADAMA Agricultural Solutions Ltd., Raleigh, NC), is a novel chemistry of the fluoroalkenyl thioester group developed to target RKNs in selected low bush berries (strawberries), cucurbit, leafy, and fruiting vegetables (Navia, 2014a). Nimitz is the first new, true nematicide to be introduced in the market for more than 20 years having the signal word of 'Caution', which involves no handling restrictions,12 REI (re-entry interval), and no complicated personal protective equipment requirements (Navia, 2014b). In contrast to carbamates and organophosphates, Nimitz does not act by nematode paralysis via inhibition of acetylcholinesterase activity (Kearn et al., 2014; Oka et al., 2009; Oka et al., 2013). Previous studies have shown that Nimitz has true nematicidal activity as well as systematic activity in the plant (Kearn et al., 2014; Oka et al., 2009; Oka et al., 2011). The dosage and method of application of Nimitz is 56 to 112 fl. oz/acre applied via drip irrigation, banded incorporated, or broadcast incorporated. Since 2008 preliminary studies on carrot (*Daucus carota* subsp. *sativus*), cucumber (*Cucumis sativus* L.), eggplant (*Solanum melongena*), squash (*Cucurbita* spp.), potato (*Solanum tuberosum* **L.), sweet potato (***Ipomoea batatas*), lettuce (*Lactuca sativa*), and tomato have shown that application of Nimitz reduced galling on plant roots and lowered RNKs as compared with the untreated control (Dickson and Mendes, 2013; Rubin et. al, 2011). In a tomato-cucumber double-cropping system, Nimitz reduced galling index by 73% in the tomato crop and continued to provide additional RKN management to the second crop (Morris et. al, 2015).

OBJECTIVE

To evaluate the effect of drip-injected Nimitz combined with Pic-Clor 60 on tomato plant vigor, root galling, RKN population density, and yield.

MATERIALS AND METHODS

A study was conducted in fall 2014 on a commercial tomato farm near Myakka City, FL. The field used for the trial had a history of high RNK pressure; however, the initial nematode population density before treatment application (16 July 2014) was 10 RNK/100 cc soil. The field was irrigated with drip irrigation. Treatments are described in Table 1. Nimitz treatments were injected in a randomized complete block design with four replications and plots were 40 ft long on an 8 inch-high bed with a width of 36 inches on 6 ft. centers. Treatments were injected into the drip tape using a spot sprayer with an open flow of 2.2 gallons per minute (gpm) (Model GRN-7822-201; Countyline Tractor Supply

Table 1. Treatments applied to manage root-knot nematode (*Meloidogyne* spp.) on tomato grown during fall 2014 in Myakka City, FL.

Treatment	Fumigation (5 Aug.)	Nimitz application rate (2 Sept.)[z]	Water application rate (6 Sept.)
Control	Pic-Clor[y] 60 at 250 lb/acre	None	None
Nimitz	Pic-Clor 60 at 250 lb/acre	56 fl. oz/acre	650 GPA[x]
Nimitz	Pic-Clor 60 at 250 lb/acre	80 fl. oz/acre	650 GPA

[z] For treatment injection, 1,100 GPA of water were first applied, followed with 5,000 GPA for Nimitz application, and 650 GPA to flush and clear the drip tape.

[y] Pic-Clor 60 = 1,3-dichloropropene plus chloropicrin (40:60, w/w).

[x] GPA = Gallons per acre.

Co., LaBelle, FL). In each plot the drip tape was cut at the end and closed using locking fittings to prevented cross-contamination among treatments (DripWorks, Inc., Willits, CA). Tomatoes were grown following industry standards for production practices (Table 2) and UF/IFAS recommendation for pest and disease control (Santos et al., 2013).

Data collection: Average minimum, mean, maximum daily air temperatures and total rainfall accumulation were recorded by the Florida Automated Weather Network (FAWN) for Balm, FL. Pre-treatment application, at midseason, and at final harvest, six soil cores/plot were collected at 8-inches deep following a zig zag pattern were collected using a soil probe (Oakfield Apparatus, Inc., Oakfield, WI) and mixed thoroughly to create one composite sample per 250 cc of soil. For preservation, samples were placed in a cooler containing wet ice. Soil samples were then sent to LLH Ag and Research Services, LLC (Tifton, GA) for nematode quantification and identification. A representative harvest unit (RHU) of 10 plants was marked at the center of each plot. At midseason (31 Oct. 2014) and final harvest (23 Dec. 2014), three plants at the edges of the RHU and six plants within RHU were selected for RKN galling evaluation, respectively. RKN galling was assessed according to Hussey and Janssen (2002) rating system, where zero = no traces of galling, 1 = infection with few small galls, 2 = less than 25% of roots galled, 3 = between 25 to 50%, 4 = between 51 and 74%, and 5 = greater than 75 % of roots galled. Plant vigor and health parameters were visually assessed at 21 days after treatment (DAT) based on a 1-10 scale, where 1 = poor overall plant growth and 10 = excellent uniform plant growth. Yield was classified into marketable and unmarketable. Marketable fruit yield was graded according to USDA size category specifications—extra-large (diameter > 2.75 inches), large (2.50 to 2.78 inches), and medium (2.25 to 2.53 inches) (USDA, 1997). Unmarketable fruit yield was weighed based upon the presence of defects such as sunscald, scratch, off-shape, catface, and graywall (Jones et al., 1991; Ozores-Hampton et al., 2010).

Root galling index, RKN soil population density, and yield were subjected to analysis using analysis of variance (ANOVA) and means were separated according to Duncan's multiple range test at 5% confidence level using SAS (SAS 9.3, SAS Institute Inc., Cary, NC, 2012). RKN count data were transformed using the squared-root function prior to analysis.

Table 2. Cultural practices used in the application of Nimitz pre-plant drip injected to manage root-knot nematode (*Meloidogyne* spp.) on tomato grown during fall 2014 in Myakka City, FL.

Variety	HM1823
Plant population	3,630 plants/acre
Plastic mulch	Virtually impermeable film polyethylene mulch, white on black (Berry Plastics, Evansville, IN)
Drip tape	8-mm drip tape with 12.5-inch emitters spacing and a flow rate of 0.004 gpm (Model Jain Turbo Cascade 11653050; Jain Irrigation, Inc., Jalgaon, India).
Planting date	12 Sept. 2014
Linear ft per acre	7,260
Bed spacing (center to center)	6 ft
Bed height	9 inches
Bed width	25 inches
Plant spacing	24 inches
Harvest date	25 Nov., 10 and 23 Dec. 2014

Table 3. Summary of minimum, mean, and maximum daily average air temperatures and total rainfall during fall 2014 in Myakka City, FL.

	Temperature (°F)			Total rainfall
Period	Minimum	Mean	Maximum	(inches)
September[z]	70.0	76.4	87.6	9.0
October	61.5	72.3	84.5	2.2
November	51.6	62.2	74.7	7.2
December	50.9	61.0	73.4	0.2
Average/total	58.5	68.0	80.1	18.5
Fall 10-year average	59.7	69.6	81.7	7.7

[z] The temperature averages and rainfall totals were recorded daily from 12 Sept. 2014 through 23 Dec. 2014. Data source: Florida Automated Weather Network (<http://fawn.ifas.ufl.edu/>).

Table 4. Effect of pre-plant, drip-injected Nimitz on plant vigor, root-knot nematode (*Meloidogyne* spp.) galling index, and soil population density in tomato grown during fall 2014 in Myakka City, FL.

	Plant vigor (rating 1-10)[z]	Root galling index (rating 1-5)[y]		Nematodes/ 100 cc soil[x]	
Treatment	7 Oct.	31 Oct.	23 Dec.	31 Oct.	23 Dec.
Pic-Clor 60[w]	10	1.9a[v]	4.4a	7.5	3265.0a
Pic-Clor 60 plus Nimitz 56 fl. oz/acre	10	0.7b	1.9b	5.0	120.0b
Pic-Clor 60 plus Nimitz 80 fl. oz/acre	10	0.8b	2.1b	5.0	632.5b
P-value	-	0.0001	0.0001	0.96	0.001
Significance	-	***	***	NS	***

[z] Plant vigor was visually assessed at 21 DAT based on a 1-10 scale, where 1 = poor overall plant growth and 10 = excellent uniform plant growth.

[y] 0 = no galling, 1 = trace infection with a few small galls, 2 ≤ 25% root galls, 3 = 25-50%, 4 = 51-74%, and 5 ≥ 75 % of root galls (Hussey and Janssen, 2002).

[x] Second-stage juveniles (J2) count data were transformed using the squared-root function before statistical analysis.

[w] Pic-Clor 60 = 1,3-dichloropropene plus chloropicrin (40:60, w/w).

[v] Within columns means followed by different letters are significantly different according to Duncan's multiple range test at 5%.

NS *, **, *** Nonsignificant or significant at P ≤ 0.05, 0.01, or 0.001, respectively.

RESULTS AND DISCUSSION

Weather conditions. Overall, mean air temperatures were 1.6 °F lower when compared with the previous 10-year average fall temperature from September through December [FAWN, 2014 (Table 3)]. Average minimum and maximum air temperatures were 1.2 and 1.6 °F lower than the previous 10-year average, respectively. There were no freezing events reported during the growing season. Cumulative season rainfall was 10.8 inches higher than the previous 10-year average (FAWN, 2014).

Plant vigor, root galling, and RKN soil density. Application of Nimitz to fumigated soil did not have an effect on plant vigor. Tomato plants among all treatments presented excellent uniform growth (Table 4). Similarly, in a tomato-cucumber double-cropping system, application of Nimitz did not affect tomato plant vigor; nonetheless, Nimitz improved cucumber plant vigor as compared to the untreated control further reducing root galling (Morris et. al., 2015). Combination of Pic-Clor 60 with both Nimitz rates facilitated an effective management of soil-borne pathogens, weeds, and nematodes producing a uniform plant growth during the season. At midseason and final harvest, Pic-Clor 60 combined with Nimitz showed lower galling index as compared to Pic-Clor 60 alone, decreasing root galling by approximately 61% and 55%, respectively (Table 4). Nevertheless, there were no significant differences among Nimitz rates. Population densities of RKN second-stage juveniles (J2) before treatments were considered low at 10/100 cc soil but acceptable for a nematode study. Pic-Clor 60 combined with Nimitz decreased population densities of RKN J2 by 88% at final harvest whereas no differences were found among treatments at midseason (Table 4). Although initial RKN population densities were low, RKN densities increased throughout the season in which Nimitz application provided an effective control. Furthermore, climate conditions of the fall 2014 season were optimal for RKN reproduction and survival. Optimum temperatures for *M. hapla* and related species range from 59 to 77 **°F** and from 77 to 86 °F for *M. javanica* and related species (Wallace, 1964). The cumulative season rainfall was 10.8 inches higher than the previous 10-year average, which offered nematodes ideal conditions to achieve their life cycles since nematodes move easily in soils with high moisture content (Djian-Caporalino et al., 2009) enhancing egg hatching (van Gundy, 1985).

Tomato fruit yield. At first and second harvests combined, differences among treatments were observed only for the extra-large fruit yield (Table 5). Pic-Clor 60 alone and Pic-Clor 60 combined with 80 fl. oz/acre of Nimitz accounted for the greatest extra-large fruit yield. However, Pic-Clor 60 combined with 56 fl. oz/acre of Nimitz was not different from Pic-Clor 60 combined with 80 fl. oz/acre of Nimitz. At third harvest, both Nimitz at 56 and 80 fl. oz/acre produced the highest fruit yield for all tomato size categories and total marketable yield, except for the unmarketable yield where no differences were found among treatments. Pic-Clor 60 alone and Pic-Clor 60 combined with 80 fl. oz/acre of Nimitz accounted for the greatest total season extra-large fruit yield. There were no differences for the remaining tomato size categories and total season marketable and unmarketable yields. Neither Pic-Clor 60 alone nor Pic-Clor 60 combined with both Nimitz rates had a significant effect on any tomato fruit size categories or on the total marketable and unmarketable yield at first and second harvest, separately (data not shown). Preliminary studies on the effect of Nimitz on yield have shown that tomato, cucumber, eggplant, and squash had slightly better or similar yields as compared to the untreated control whereas sweet potato and carrot had the best yield increases (Dickson and Mendes, 2013). In this experiment, combining Nimitz and Pic-Clor 60 as part of the nematode management program provided a level of RKN control more effective than Pic-Clor 60 alone in high nematode pressure. The highest nematode control produced the highest fruit yield for all tomato size categories and total marketable yield at the third harvest.

REFERENCES

Carpenter, J., L. Gianessi, and L. Lynch. 2000. The economic impact of the schedule U.S. phaseout of methyl bromide. Natl. Ctr. for Food and Agr. Policy. <https://www.researchgate.net/profile/Lori_Lynch/publication/267972579_THE_ECONOMIC_IMPACT_OF_THE_SCHEDULED_US_PHASEOUT_OF_METHYL_BROMIDE/links/551c0ed00cf20d5fbde2523a.pdf>.

Dickson, D.W. and M.L. Mendes. 2013. Efficacy OF MCW-2 on Florida vegetables. J. Nematol., 45:287-288 (abstr.).

Djian-Caporalino, C., H. Védie, A. Arrufat. 2009. Gestion des nématodes à galles: lutte conventionnelle et luttes alternatives. L'atout des plantes pièges. Phytoma 624: 21-25.

Florida Automated Weather Network (FAWN). 2014. Archived weather data. UF/IFAS, Gainesville, FL. 23 Dec. 2014.

Gilreath, J.P., J.P. Jones, A.J. Overman. 1994. Soilborne pest control in mulched tomato with alternatives to methyl bromide. Proc. Fla. State Hort. Soc. 107:156–159.

Hussey, R.S. and G.J.W. Janssen. 2002. Root-knot nematodes: *Meloidogyne* species, pp. 43–70. In: Starr J.L., Cook R., Bridge J., (eds.). Plant Resistance to Parasitic Nematodes. Wallingford, UK: CABI Publishing.

Jones, J.P., R.E. Stall, and T.A. Zitter. 1991. Compendium of tomato diseases. 1st ed. Amer. Phytopathological Soc., St. Paul, MN.

Kearn, J., E. Ludlow, J. Dillon, V. O'Conner, and L. Holden-Dye. 2014. Fluensulfone is a nematicide with a mode of action distinct from acetylcholinesterases and macrocyclic lactones. Pest. Biochem. Physiol. 109:44-57.

Morris, K.A., D.B. Langston, D.W. Dickson, R.F. Davis, P. Timper, and J.P. Noe. 2015. Efficacy of fluensulfone in a tomato–cucumber double cropping system. J. Nematol., 47:310–315.

Navia, P.A. 2014a. Nematode control efficacy of NimitzTM (fluensulfone) on peppers with polyethylene mulch in a commercial operation. 22nd Intl. Pepper Conf., Viña del Mar, Chile. Book of Abstr. p, 82.

Navia, P.A. 2014b. New nematicide gets to the root of management problems. Agri-view. 5 May 2016. <http://www.capitalpress.com/apps/pbcs.dll/article?AID=2014141119957>.

Noling, J.W. 2016. Nematode management in tomatoes, peppers, and eggplant. Univ. Florida, Inst. Food Agr. Sci., Electronic Data Info. Source, ENY032. 20 June 2016. <https://edis.ifas.ufl.edu/pdffiles/NG/NG03200.pdf>.

Oka, Y., S. Shimshon, and N. Tkachi. 2009. Nematicidal efficacy of MCW-2, a new nematicide of the fluoroalkenyl group, against the root-knot nematode *Meloidogyne javanica*. Pest Manag. Sci. 65:1082-1089.

Oka, Y., S. Shukar, and N. Tkachi. 2011. Systemic nematicidal activity of fluensulfone against the root-knot nematode *Meloidogyne incognita* on pepper. Pest Manag. Sci. 68:268-275.

Oka, Y., S. Shukar, and N. Tkachi. 2013. Influence of soil environments on nematicidal activity of fluensulfone against *Meloidogyne javanica*. Pest Manag. Sci. 69:1225–1234

Ozores-Hampton, M., E. McAvoy, S. Sargent, and P. Roberts. 2010. Evaluation of tomato yellow leaf curl virus (tylcv) resistant and Fusarium crown rot (fcr) resistant tomato variety under commercial conditions in southwest Florida. Proc. Fla. Tomato Inst., 53:11-15.

Rubin, B., Y. Mishael, and D. Harush. 2011. Fluensulfone (MCW-2) migration in soil as influenced by the drench water volume. R. H. Smith Faculty Agr., Hebrew Univ. Jerusalem, Rehovot, Israel.

SAS. 2012. SAS/STAT user's guide, Ver. 9.3, SAS Institute, Cary, NC.

Snodgrass, C., M. Ozores-Hampton, A. MacRae, and J. Noling. 2013. Fumigation practices and challenges among Florida tomato growers: survey results. Fla. Tomato Inst. Proc. PRO 529:20-21. <http://swfrec.ifas.ufl.edu/docs/pdf/veg-hort/tomato-institute/proceedings/ti13_proceedings.pdf>.

U.S. Chemical Safety Board. 2015. DuPont LaPorte facility toxic chemical release. Chem. Safety Board, Washington, D.C. 5 June 2016. <http://www.csb.gov/dupont-laporte-facility-toxic-chemical-release-/>.

U.S. Department of Agriculture. 1997. United States standards for grades of fresh tomatoes. U.S. Dept. Agr., Agr. Mktg. Serv., Washington D.C. 23 Dec. 2015. < <https://www.ams.usda.gov/sites/default/files/media/Tomato_Standard%5B1%5D.pdf>.

U.S. Department of Agriculture. 2016. Vegetable 2015 summary. U.S. Dept. Agr., National Agricultural Statistics Service, Washington, D.C. 7 June 2016. <http://usda.mannlib.cornell.edu/usda/current/VegeSumm/VegeSumm-02-04-2016.pdf>.

U.S. Environmental Protection Agency. 2000. Protection of stratospheric ozone: Incorporation of Clean Air Act amendments for reductions in Class I, Group VI controlled substances. Environ. Protection Agency, Washington, D.C. Federal Register. 65:70795–70804.

Van, S.D. 1985. Ecology of *Meloidogyne* spp. Emphasis on environmental factors affecting survival and pathogenicity. In: Sasser, J.N., Caryer, C.C. (eds.). An Advanced Treatise on *Meloidogyne*. Vol. 1: Biology and Control. North Carolina State University Graphics, Raleigh, NC (USA), pp. 77-182.

Wallace, H.R. 1964. The biology of plant parasitic nematodes. St. Martin's Press, New York: 62-69.

Wright, D.J. 1981. Nematicides: Mode of action and new approaches to chemical control. in B. M. Zuckerman and R. A. Rhode, eds. Plant parasitic nematodes. New York: Academic Press: 421-449.

Table 5. First and second harvests combined, third, and total marketable and unmarketable (cull) tomato fruit yield by size categories in response to pre-plant, drip-injected Nimitz during fall 2014 in Myakka, FL.

	First and second harvests				Third harvest				Total season harvest				
Treatment	**XL[z]**	**L**	**M**	**TM**	**XL**	**L**	**M**	**TM**	**XL**	**L**	**M**	**TM**	**Cull**
	(25-lb boxes/acre)												
Pic-Clor 60[y]	728a[x]	282	227	1,237	10b	64b	210b	284b	738a	347	437	1,521	88
Pic-Clor 60 plus Nimitz 56 fl. oz/acre	602b	319	215	1,136	37a	146a	418a	602a	642b	447	617	1,706	119
Pic-Clor 60 plus Nimitz 80 fl. oz/acre	689ab	295	168	1,152	40a	128a	402a	570a	726a	441	586	1,753	146
P-value	0.04	0.58	0.12	0.24	0.03	0.02	0.007	0.007	0.05	0.10	0.07	0.08	0.33
Significance	*	NS	NS	NS	*	*	**	**	*	NS	NS	NS	NS

[z] XL= Extra-large (5x6 industry grade); L=Large (6x6); M=Medium (6x7); and TM=total marketable.

[y] Pic-Clor 60 = 1,3-dichloropropene plus chloropicrin (40:60, w/w).

[x] Within columns means followed by different letters are significantly different according to Duncan's multiple range test at 5%.

NS *, **, *** Nonsignificant or significant at P ≤ 0.05, 0.01, or 0.001, respectively.

Minimizing Crop Impacts Using Vertical Management Zones for Nematode Control

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Prior to 1950, Florida vegetable culture would best be described as nomadic. One or two vegetable crops were produced in sequence on rented land after expensive clearing operations had been performed or after long pasture rotations to minimize soil borne pest and disease problems. Once a problem developed, Florida truck farmers (as they were called at the time) were then forced to migrate from one field or area to another, opening new land and abandoning the old to avoid the crop pests which, perforce, became more severe with reuse of the same fields. As urban growth increased, suitable land became more difficult to locate as well as prohibitively expensive, both in terms of purchase or leasing, and land preparation. Due to these constraints, Florida vegetable farmers increasingly adopted the use of soil fumigants to manage established weed, nematode, and disease pests within their fields. However, even at this time, use of these fumigants were not always considered sufficient for nematode and disease control.

In 1965 an integrated systems approach to sandy soil pest management using methyl bromide, chloropicrin, and plastic mulch was introduced to the Florida vegetable industry to solve these "old land" pest problems which developed in repeatedly cultivated fields. When nematodes were observed to be a problem, plant damage was generally observed in areas where methyl bromide was not applied such as row ends where flow was discontinued prematurely or where flow was delayed as the tractor was advancing into the field and delivery lines were yet to be charged or in areas where exhausted fumigant cylinders were changed. There were never a lot of complaints registered against the performance and consistency of Methyl bromide. It was a chemical compound with very high vapor pressure and a very low boiling point which once delivered into the soil, exploded from a liquid to form a rapidly expanding front of gas. From the injection point it raced radially outward and downward, through the traffic pan, to depths of 2 to 3 feet from the point of injection, killing everything in its path. Growers did not worry to any great extent about nematodes, disease, or weeds, either for the primary crop or the double crop which followed because of its rapid diffusion throughout the entire soil profile and broad spectrum efficacy.

As previously reported, the two biggest differences in chemical characteristics between methyl bromide and all of the alternative fumigants are vapor pressure and boiling point. Because of the significantly lower vapor pressure (sometimes as much as a hundred fold) and higher boiling points, the alternative fumigants volatilize to gas and diffuse through soil much more slowly. They do not race through the vertical soil profile like that of methyl bromide, and in fact, don't move appreciably at all into deeper soil profiles. Last year at this meeting, we reported on the presence of a traffic pan which was observed to occur just below the base of the raised, plastic mulch covered bed. We showed in field experimentation that the traffic pan forms a pretty formidable barrier to diffusion of alternative fumigants into deeper soil when they were injected 8 to 10 inches deep at the base of the raised bed (Figure 1).

In practical terms, the compacted traffic pan occurs just below the depth of the deepest tillage implement used in the field and has been shown to unavoidably cause changes in soil hydraulic conductivity, diffusion of fumigant gases, and thus soil fumigation efficacy and field distribution of nematodes and crop damage. Our research is predicated on the belief that it is the presence of the traffic pan coupled with the differences in vapor pressure and boiling point of the alternative fumigants which so limit soil movement and spatial distribution of fumigants in soil. This limited movement is a major cause for the increase in root-knot nematode problems that was reported in a recent UF Extension survey of Florida tomato growers, and for the severe and reoccurring problems associated with sting nematode in Florida strawberry to specifically name a few. The focus of today's presentation and proceedings paper is to discuss new research results evaluating new soil fumigant placement strategies that view nematode management as a composite and integration of vertical management zones (Figure 2).

Why is the restricted downward diffusion of fumigants below the traffic pan so important? It is important because we have repeatedly demonstrated from deep soil probe sampling of different strawberry, tomato, eggplant, potato, and citrus fields, the presence of plant parasitic nematodes of economic importance at soil depths of 2 to 4 feet in all of these fields (Figure 1). We have not sampled a central ridge or flatwoods soil where we have not found nematodes in quantity at soil depths well below the depths that we ever sample for nematodes and more importantly, where the new, methyl bromide alternative fumigants go. We do not claim to understand why nematodes migrate to such depths. There are no roots (food) at these depths so we can only speculate that some type of evolutionary escape mechanism is in action to point nematodes away from hostile environment (hot, dry soils). Do not think for a moment that root knot nematode does not possess the capability of vertical migration, either up or down within the soil profile. The research literature repeatedly documents root knot nematode as capable of moving vertically through the soil as rates as high as 2.5 inches per day. They are not the slow moving sloths that many think they are, and in some instances, nematodes placed at 3, 4 or even 5 feet below the transplanted crop were shown to impact crop yield and fruit quality of a 90-100 day old crop via upward migration and plant feeding.

We would contend that most nematodes are pretty effectively controlled by fumigants within the plant bed, but the damage in the primary crop occurs as a result of rapid recolonization of the plant bed from nematodes migrating upward from depths below the traffic pan. It is this same early season recolonization of the primary crop that has caused tomato growers to report an increase in nematode problems within the tomato industry since the loss of methyl bromide and which has caused many south Florida tomato growers to discontinue double cropping production practices altogether. Minimizing these types of crop impacts we believe requires using vertical management zones for nematode control (Figure 2).

So if deep placement is such a requirement and prerequisite for effective nematode control within the vertical management zone program, why has Yetter coulter and deep-placement equipment not resolved the problem? The Yetter system, both prebed and broadcast, utilize a 30 inch coulter which is attached in advance of the injection knife to create a track for the fumigant knife to move through the soil. The coulter blade is charged with creating the slit opening in the soil which reduces drag and minimizes disturbance to the soil profile, which in addition to other features of the rig, is important for reducing gas emissions from soil. On the trailing edge of the coulter at about a 10-12" level, is a knife where the fumigant delivery tube is attached. The press wheels, as well as the coulters and knives, are spring loaded to easily move up and independently over rocks, stumps, hard clays, and shallow spodic layers without raising the entire rig out of the ground or breaking shear pins. Herein probably lies the problem with achieving deeper placement of the fumigant with Yetter equipment. The springs are largely insufficient to force a cut through the compacted traffic pan to place the fumigant below the traffic pan. The coulter and injection shank simply ride along and dispense fumigants on top of the traffic pan layer. Even when it shallowly slits into or even through the traffic pan, gas movement takes the path of least resistance----up. It is for this reason that we see that Yetter Coulter rigs are currently not used to any great extent in Florida. Growers have not been able to demonstrate their value and prove them to be problem solving and cost effective. The fumigants just aren't placed as deep as many people think they are with the Yetter system!

We have yet to be able to extensively demonstrate the efficacy and yield benefit of the vertical management zone approach to Florida <u>tomato</u> growers. Early season rainfall, tropical storms, elevated water tables with seep irrigation, and other problems of grower concerns and coordination have interfered with opportunities to conduct these trials. In one tomato trial this past spring, we were not able to really challenge the in-row deep shank treatments with nematodes that we included in combination with standard grower bed treatments. It was observed however, that most of the root galls which formed on tomato roots at the Parrish, FL large scale demonstration trial, formed on secondary roots (many of which were surface soil adventitious roots) during later stages of tomato crop growth and not on any tap or deep anchorage roots which would have suggested nematode infection of the first roots they encounter migrating upward from deep soil horizons. The question we believe needs to be addressed is whether the galls formed from survivors of the Pic Clor 60 treatment within the raised mulch covered bed? As indicated, we were not able to challenge with nematodes the deep shank treatments that were summer applied to the flat 4 weeks in advance of bedding. The lack of differences in this trial could very well have also been attributed to the precision in which the fumigant was applied into the bed center where future bedded rows were supposed to be without GPS.

It is unfortunate that we are forced to report on strawberry yield trial results with vertical management zones rather than that of tomato or of other south Florida vegetables. Part of the difficulty we have had reflects the need to put deep shank or deep drip treatments out well in advance of seep irrigation practices which mandate the water table to be raised and artificially perched above the spodic horizon. We have also been challenged by the timing of early season heavy rainfall and the slow passage of tropical storms which have flooded fields and interfered with opportunities in which to conduct spring deep placement trials. Using historical records of rainfall and depth to water table assessments, we have determined that April and May are the most opportune times in which to make the deep placement treatments in central and south Florida. This occurs in nematode infested fields either at the end of the spring crop, or possibly even into early June after soil preparation and well in advance of the bedding in July.

A considerable amount of work on vertical management zones in strawberry has been completed and we would contend that it provides a barometer for what we might expect to see in tomato. In strawberry we have evaluated summer broadcast, in-row prebed, and deep drip preplant fumigant applications with Telone II and Telone EC (12-18 gpta). All trails were conducted in commercial fields with long histories of reoccurring problems of Sting nematode. Sting nematode, *Belonolaimus longicaudatus*, is the primary nematode pest of strawberry in Florida. Through our sampling efforts, it has been repeatedly detected at soil depths up to four feet. Strawberry yield responses within these vertical management zone grower trials have generally been consistent and impressive. Strawberry yield increases of 25 and 29 percent were observed in deep shank summer broadcast applications when applied in combination with the grower standard fumigant treatment at bedding in the fall. Fields receiving deep (16") subsurface drip fumigant treatments in combination with grower standard shank treatments to the bed increased strawberry yields by 9 percent. Prebed, in-the-row applications have varied in yield response from 2 to 45 percent from the bed alone treatment in the different trials. The observed variability was not exclusively determined by nematode pressure. These fields form the focus of future research efforts.

In summary, the deep fumigant placement, vertical management zone strategy is needed because nematodes are deep dwelling organisms, that occur well below the traffic pan which forms a near impermeable soil layer to the downward diffusion of bed applied soil fumigant gases. In Florida strawberry we have seen yield increases of 2 to 45 percent following deep placement of Telone II or Telone EC at 15-18 gpta as either summer broadcast, prebed, or subsurface drip treatments below the traffic pan. For deep fumigant placement, the vertical management zone strategy is gaining traction across the state and elsewhere as a new nematode management technique. Since last year, six new deep shank application systems have been observed in operation on various different strawberry, pepper, and tomato producing farms across the state and Georgia. These new systems all share some of the same custom features such as: (1) deep (16-20 inch) multiport, forward swept, resettable shanks; (2) sophisticated fumigant delivery systems to ensure spatial uniformity of application within soil; (3) large coulter blades to cut debris and reduce drag and soil disturbance; (4) Wings to horizontally split the fumigant stream on individual shanks; and (5) gauge wheels to track a constant soil depth during application (Figure 3). These systems do not come cheaply, some of which were reported to be in excess of $30,000. To save money and avoid unnecessary treatment costs requires a monitoring, map building process which characterizes root galling and or damage being expressed in the crop on a field basis so as to avoid the deeper soil core sampling requirement.

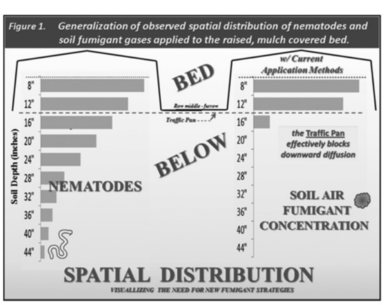

Figure 1. Generalization of observed spatial distribution of nematodes and soil fumigant gases applied to the raised, mulch covered bed.

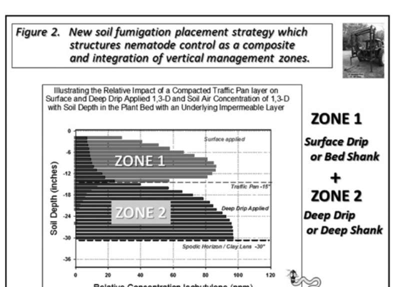

Figure 2. New soil fumigation placement strategy which structures nematode control as a composite and integration of vertical management zones.

Figure 3. Main features of new deep shank fumigant application Rigs

New Sensor Technology for Yield Estimation and Disease Detection

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INTRODUCTION

Smart farming or precision agriculture can be defined as a scientific and technological comprehensive system designed to optimize agricultural production and management choices. While used in row crops, it has not been widely used in fruit and vegetable production because the needed technologies were not available or cost effective for widespread use. However, small unmanned aerial vehicles (SUAVs) and advanced sensor systems are two new technologies that could potentially make applying precision agriculture to fruit and vegetable production more feasible. SUAVs are powered aerial vehicles that weigh less than 50 lb and can be operated autonomously or remotely by a pilot (Fig. 1). The Federal Aviation Administration (FAA) recently released rules that allow the general public to use SUAVs for commercial use. SUAVs along with an advanced sensor system can bring the concept of smart farming to fruits and vegetable production.

There are a large number of tasks that smart farming technologies assist growers with, but probably the most immediate application is for disease and stress detection as well as yield estimation.

DISEASE AND STRESS DETECTION

Scouting for disease and pests and monitoring crop health are some of the most critical and costly tasks in fruit and vegetable production. Plant health monitoring is often performed to detect and assess the presence of biotic (diseases) and abiotic (nutrition) stress. Early detection of pests and disease, especially at the asymptomatic stage, could be a valuable tool for managing plant stress and could significantly reduce losses. The current disease detection technique relies on human scouting followed by a laboratory test such as polymerase chain reaction (PCR) or nutrient analysis. This approach is usually costly and time-consuming and is limited to the human capability in detecting the symptoms. There are several sensing systems that can help managers and crop scouts in better detection of disease symptoms. One of the most common is optical sensors which operate based on the principle of spectral reflectance. The reflectance from the canopy in the visible and infrared regions of the electromagnetic spectra is known to provide the information on the physiological stress levels in plants. Some of these wavebands are specific to a certain disease or stress condition and can be used to identify plant diseases. The difference in the reflectance of a healthy and a diseased tree in the visible-infrared region can be detected using spectro spectroscopic and imaging optical sensors. Various optical sensors are being developed and evaluated to detect diseases and other plant stress. These portable optical sensors offer a real-time detection of plant diseases. Some of the sensors being used for disease or stress detection are spectroradiometers, multi-band sensors, mid-infrared spectrometers, and hyperspectral cameras. The applications of optical sensors for disease detection in fruits and vegetable production have been widely studied (Sankaran and Ehsani, 2011, 2013; Mishra et al. 2012; Sankaran et al., 2012, 2013).

In spite of significant developments in sensor technologies, there are a few challenges that need to be addressed for practical applications. As optical systems are very sensitive to light conditions, incident light play an important role in determining the reflectance spectra. Changes in natural light conditions may limit their application. This issue could be resolved by using an artificial light source, an internal light source, or performing disease detection during the night time.

YIELD ESTIMATION

Early and accurate yield forecasting is important for many crops, but traditional techniques are time-consuming, labor intensive, and often inaccurate. SUAVs or unmanned platforms equipped with suitable sensors can be used for counting the fruits directly. In 2015, the USDA funded a project at University of Pennsylvania and University of Florida to investigate the use of SUAVs for yield estimation of citrus, tomato, and blueberry. With a focus on data-driven techniques to improve estimation accuracy, this project incorporates direct fruit counts through close range imaging, followed by a correction based on ground-truth fruit count data. As a part of this project, a vision-based sensor system is under development for direct counting of mature tomato.

In order to study the spectral characteristics of tomato an experiment was conducted. Tomato leaves and 300 tomato fruit samples of different types and maturity levels were collected from a field located northwest of Myakka City, Florida, United States. These samples included 100 raw green, 100 mature green and 100 red tomatoes. A high intensity light with an angle of 40 degrees emitted from a halogen light toward the samples located at a 70-cm distance from the source of the light. The reflected light spectrum was measured using a portable spectrometer installed at a 40-cm distance from the samples. The result of the reflected light spectrums from tomato leaves and tomato fruit at different maturity levels are shown in Fig. 2. It was found that tomatoes and tomato leaves significantly absorb most of visible light and reflect between 10 and 40% of emitted visible light. However, the amount of near infrared emitted light reflected by these samples was between 40 and 88%. In some bands, i.e. 735 to 815 nm, tomato leaves were found to reflect only about 40% and absorb 60% of the emitted light. For the raw green tomato sample, approximately 67% was reflected and 33% was absorbed. For mature green tomato samples, reflectance and absorbance were approximately 75% and 25% respectively; for red tomato samples, reflectance and absorbance were approximately 88% and 12%, respectively These values seem to be a good indicator for classifying the different maturity levels of the tomato samples. However, some drawbacks of using a spectrometer is its high cost, complexity of installation, calibration, and lengthy data analysis process.

In order to reduce the complexity of data analysis when visible and near infrared spectrometers are used as sensors, the normalized difference vegetation index (NDVI) is used as the tomato maturity level indicator. Results of statistical analysis of tomato leaves and 300 fruit samples based on NDVI is shown in Fig. 3. Based on these results, the median NDVI value for tomato leaves was 0.15. NDVI increased almost linearly to 0.17 for raw green, 0.19 for matured green, and 0.22 for red tomato samples. Thus, calculating NDVI simplifies the detection and classification process for the tomato samples. However, the drawbacks were the initial cost, sensor setup complexity, and calibration.

A low-cost commercial charge-coupled device (CCD) camera as an image sensor that includes a built-in image processing algorithm based on red, green and blue (RGB) color signatures of the input image. An embedded system along with a software program were developed and optimized for robust detection of tomatoes with different levels of maturity in real-time. This system is also capable of estimating the yield of tomato fields based of different levels of maturity (Fig. 4).

This system was tested where some of tomato samples were in front of the camera. In this experiment tomato samples included 10 raw green, seven mature green, and 17 red tomato samples of different sizes. The results of detecting and counting tomato samples based on different maturity levels are shown in Fig. 5. As a result, the developed system was able to immediately detect, count, and classify almost 90% of raw green, 85% of mature green, and 85% of red tomato samples according to their maturity level and based on trained RGB color signatures. Some unavoidable error uncertainties occurred due to the overlap of two very similar colored tomato sample that were very close to each other or where one tomato sample was obscured by another tomato sample.

CONCLUSIONS

Recent advances in SUAVs, unmanned vehicles, and sensors systems along with the new rules and regulations that allow their use in small fields can potentially be a new tool for fruits and vegetable growers. The most immediate applications will be in early disease detection and yield estimation. This report has discussed the development of a new small and low-cost system that can most likely be used with a UAS or unmanned/manned vehicle for yield estimation. Although initial results have been very promising, more field trials, validation, and improvements are needed to make this sensor system ready for commercial use.

REFERENCES

Sankaran, S. and R. Ehsani. 2011. Visible-near infrared spectroscopy based citrus greening detection: Evaluation of spectral feature extraction techniques. Crop Protection 30(11):1508-1513.

Sankaran, S. and R. **Ehsani**. 2013. Comparison of visible-near infrared and mid-infrared spectroscopy for classification of Huanglongbing and citrus canker infected leaves. Agricultural Engineering International: CIGR Journal 15 (3): 75-79.

Sankaran, S. and R. Ehsani. 2012. Detection of Huanglongbing disease in citrus using fluorescence spectroscopy. Transactions of the ASABE 55 (1): 313-320.

Sankaran, S., J.M. Maja, S. Buchanon, and R. Ehsani. 2013. Huanglongbing (citrus greening) detection using visible-near infrared and thermal imaging techniques. Sensors 13: 2117-2130.

Sankaran, S., R. Ehsani, S.A. Inch, and R.C. Ploetz. 2012. Evaluation of visible-near infrared reflectance spectra of avocado leaves as a non-destructive sensing tool for detection of laurel wilt. Plant Disease 96 (11): 1683-1689.

Figure 1. Powered aerial vehicles operated autonomously or remotely by a pilot.

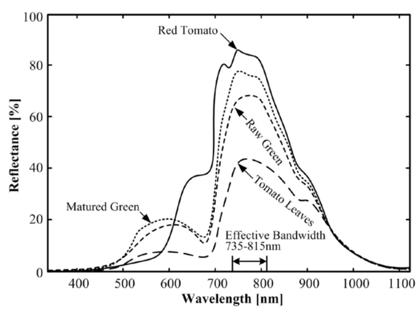

Figure 2. Result of the reflected light spectrums from tomato leaves and tomato fruit at different maturity levels.

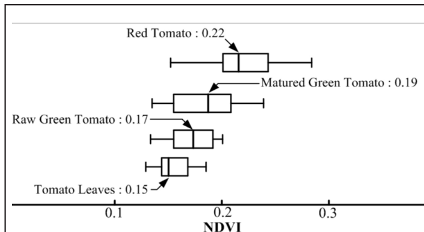

Figure 3. Results of statistical analysis of tomato leaves and 300 fruit samples based on NDVI.

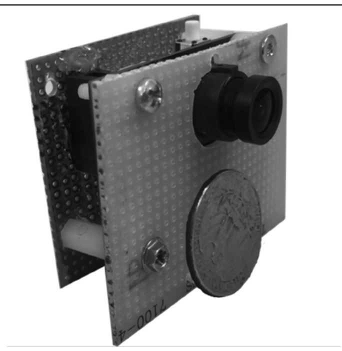

Figure 4. Software programs were developed and optimized for robust detection of tomatoes with different levels of maturity in real-time.

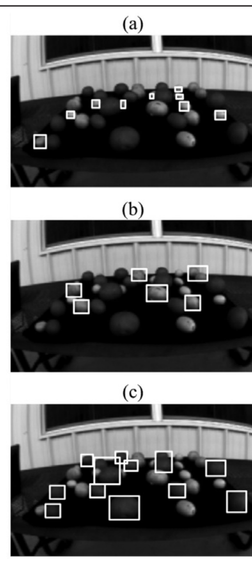

Figure 5. Results of detecting and counting tomato samples based on different maturity levels.

Keeping your Private Applicator License Current

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INTRODUCTION

The Florida Department of Agriculture and Consumer Services (FDACS) govern the licensing of Restricted Use Pesticide (RUP) applicators. There are many types of licenses. However, most fruit and vegetable producers hold Private Applicator licenses. A Private Applicator is defined as someone who applies or supervises the application of RUPs on his or her own property or the property of their employer for the purpose of producing an agricultural commodity. FDACS and the University of Florida/Institute of Agriculture Science (UF/IFAS) Pesticide Information Office have partnered to assist license holders with exam preparation materials and classes, exam administration, and obtaining continuing education units (CEUs). The Pesticide Information Office is located in Gainesville, FL. However, most county Extension offices provide producer assistance in counties throughout Florida.

EXAMS

An applicant for a Private Applicator RUP license must pass two exams with a 70% or better in order for a license to be issued. The two exams include Core (Chapter 487) and Private Applicator. Both exams contain 50 multiple choice questions. The current version of the Core exam does not include any math problems. However, the Private Applicator includes 10 math questions pertaining to equipment calibration and product dilution. Recently, FDACS has allowed the inclusion of an approved conversion sheet to be used by examinees (Fig. 1). Exams are administered at county Extension offices. However, different offices have different testing schedules. Exams are free to take as many times as needed. Many offices are now offering computer based testing. One attraction of computer based testing is that a test taker will learn their score immediately versus paper based test results which may take approximately two weeks for delivery. Computer based tests can only be taken once per day and test taker must apply on-line for a voucher to take a test at least one day before they intend to take a test. Not all county offices have been selected and at this time computer based testing is a pilot project. Other offices still offer traditional paper testing.

County Extension offices with computer based testing and schedules can be found at this link: https://pesticideexam.ifas.ufl.edu/public/countyList.faces

Exam results for both exam types are usually posted here as soon as they are available: http://ceupublicsearch.freshfromflorida.com/examsearch.asp

You will also receive a paper notification from FDACS stating your exam results. If you pass one exam and fail the other, your passing score will be good for one year after your exam was taken. After you have received notification that your exams were passed, the cost to receive your license is $100.00 payable to FDACS. Your license will expire four years from the issue date. The fastest way to obtain and pay for your license is to apply online at:

https://aesecomm.freshfromflorida.com/Test_mp.aspx

STUDY MATERIALS

Many county Extension offices offer exam prep classes aimed at increasing understanding of exam material. CEUs are typically offered with these classes for current license holders. Contact your county office for more information on exam prep classes. The UF/IFAS Pesticide Information Office and UF/IFAS bookstore offer a variety of study materials to be used in preparation for exams including study guides, DVDs, and interactive training which can be found here: http://pested.ifas.ufl.edu/

The study guides tend to be the most popular. The one recommended for Core is called "Applying Pesticides Correctly", SM1. "Private Applicator Pest Control", SM53 is available for Private. Both are available from the UF/IFAS Bookstore located at: http://ifasbooks.ifas.ufl.edu/.

Many county Extension offices also carry them for purchase.

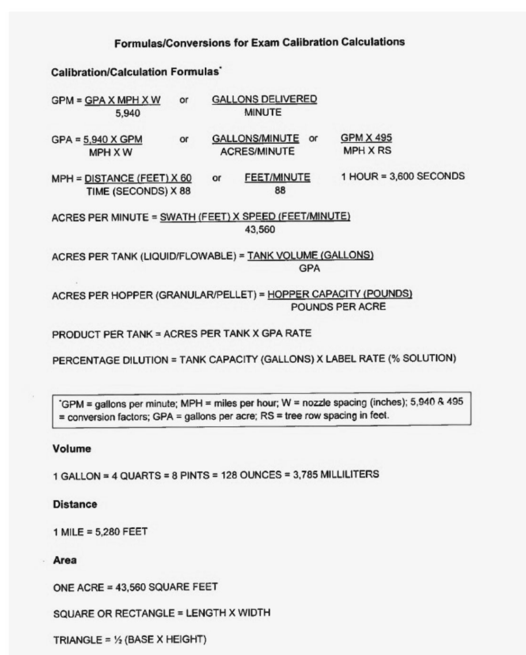
LICENSE RENEWAL

During the four year licensing period, license holders can choose to obtain CEUs for license renewal. Four CEUs are required in Core and four in Private. CEUs can be obtained in a variety of different ways including: CEU approved programs or classes, articles, and online modules. CEU classes are offered by most county Extension offices as well as through private industry representatives. CEU articles are available through the UF/IFAS Pesticide Information Office: http://pested.ifas.ufl.edu/onlinepesticide-ceus/index.html

Hillsborough County Extension: http://hillsborough.ifas.ufl.edu/ornamental_production/CEUs.shtml

Citrus Industry Magazine: http://citrusindustry.net/ceu/ and Florida Grower Magazine: http://www.growingproduce.com/crop-protection/ceu-series/

All approved CEU opportunities can be found on the Public Database Search website at: http://ceupublicsearch.freshfromflorida.



Formulas/Conversions for Exam Calibration Calculations

Calibration/Calculation Formulas*

GPM = $\frac{\text{GPA X MPH X W}}{\text{5,940}}$ or $\frac{\text{GALLONS DELIVERED}}{\text{MINUTE}}$

GPA = $\frac{\text{5,940 X GPM}}{\text{MPH X W}}$ or $\frac{\text{GALLONS/MINUTE}}{\text{ACRES/MINUTE}}$ or $\frac{\text{GPM X 495}}{\text{MPH X RS}}$

MPH = $\frac{\text{DISTANCE (FEET) X 60}}{\text{TIME (SECONDS) X 88}}$ or $\frac{\text{FEET/MINUTE}}{\text{88}}$ 1 HOUR = 3,600 SECONDS

ACRES PER MINUTE = $\frac{\text{SWATH (FEET) X SPEED (FEET/MINUTE)}}{\text{43,560}}$

ACRES PER TANK (LIQUID/FLOWABLE) = $\frac{\text{TANK VOLUME (GALLONS)}}{\text{GPA}}$

ACRES PER HOPPER (GRANULAR/PELLET) = $\frac{\text{HOPPER CAPACITY (POUNDS)}}{\text{POUNDS PER ACRE}}$

PRODUCT PER TANK = ACRES PER TANK X GPA RATE

PERCENTAGE DILUTION = TANK CAPACITY (GALLONS) X LABEL RATE (% SOLUTION)

*GPM = gallons per minute; MPH = miles per hour; W = nozzle spacing (inches); 5,940 & 495 = conversion factors; GPA = gallons per acre; RS = tree row spacing in feet.

Volume

1 GALLON = 4 QUARTS = 8 PINTS = 128 OUNCES = 3,785 MILLILITERS

Distance

1 MILE = 5,280 FEET

Area

ONE ACRE = 43,560 SQUARE FEET

SQUARE OR RECTANGLE = LENGTH X WIDTH

TRIANGLE = ½ (BASE X HEIGHT)

CIRCLE = 3.14(R^2) R = RADIUS = ½ DIAMETER

Figure 1. Conversion sheet allowed for use by Private Applicator examinees.

com/. This website allows a license holder to search for specific dates and CEUs in specific categories.

County Extension offices also have videos and other opportunities.

Once CEUs have been obtained a Record of Attendance form is issued. These forms are proof that you earned a CEU. It is very important that you hold onto these forms. Before your license expires FDACS sends a renewal notice with instructions on how to renew. You can upload your Record of Attendance forms to: https://aesecomm.freshfromflorida.com/Test_mp.aspx for quick submission or send in copies by mail. Be sure to keep a copy for your records. Licenses can be renewed for up to one year after they expire. A $50.00 late fee is assessed if you renew more than 60 days after expiration.

CONCLUSION

RUP licensing and obtaining CEUs can often be confusing. However, it is the license holder's responsibility to obtain and renew his/her license. UF/IFAS Extension is here to help its license holders stay current with their licenses and CEUs. Our goal is not only to help our producers comply with FDACS regulations, but to ensure they stay up-to-date on the latest pesticide laws, news, and research findings. If you have questions pertaining to licensing, don't hesitate to contact your county Extension agent.

REFERENCES

Fishel, F.M. Applying Pesticides Correctly. Gainesville: UF/IFAS Communications, 2014. Print.

Fishel, F.M. Private Applicator Agricultural Pest Control. Gainesville: UF/IFAS Communications, 2014. Print.

Public Database Searches website: http://ceupublicsearch.freshfromflorida.com/

UF/IFAS Pesticide Information Office website: http://pested.ifas.ufl.edu/

Tomato Production, Trade, and the Impact of the Suspension Agreement

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INTRODUCTION

While the United States is the largest producer of tomatoes in the world, the industry production capacity decreased significantly over the last 10 years. According to the National Agricultural Statistics Service of the U.S. Department of Agriculture (USDA-NASS), the tomato production in 2005 was approximately 3.9 billion pounds from 136,000 acres, but it decreased about 30% to 2.7 billion pounds and 97,500 acres in 2015 (Figure 1). The production value has also decreased from 1.6 to 1.2 billion dollars over the same period. The marked reductions appeared mainly in California and Florida, two major producers accounting for about 70% of total tomato production in the U.S. While production in California reduced from 1.2 to 0.9 billion pounds, it decreased from 1.6 to 0.9 billion pounds in Florida between 2005 and 2015 (Figure 1). The production value of California tomatoes decreased from 370 to 330 million dollars, and that of Florida tomatoes decreased from 810 to 450 million dollars. This downward trend was significant, particularly for the Florida tomato industry. The significant reductions were mainly due to the challenges from changing production and marketing environments, in particular, the increasing competition from Mexico, which has a major concern for the U.S. tomato industry. This study provides an overview of the trade between the U.S. and Mexican tomato industries and investigates how the weekly shipments and prices of the U.S. and Mexican tomatoes have evolved under the Suspension Agreements.

COMPETITION WITH MEXICO

The U.S. tomato industry competes with the Mexican tomato industry. Historically, tariffs on imports of Mexican tomatoes were in place to protect U.S. producers, but the North American Free Trade Agreement (NAFTA) signed in 1992 gradually eliminated tariffs on Mexican tomatoes. The NAFTA increased the imports and market competition moving towards the free trade (Ghazalian, 2014). Due to the increased competition from Mexico, the US Department of Commerce and exporters of fresh tomatoes from Mexico entered into "Suspension Agreements". The agreements set reference (floor) prices for imports of fresh tomatoes from Mexico, a voluntary price restraint (VPR) to ensure that Mexican tomatoes would not be sold at less than the fair market value (Baylis and Perloff, 2010; Grant et al., 2010; Kosse et al., 2014; Ghazalian, 2014). However, despite the suspension agreements, the imports from Mexico have steadily increased since early 1990s (Ghazalian, 2014). According to the Foreign Agricultural Service of the U.S. Department of Agriculture (USDA-FAS), the imports from Mexico increased from 1.8 billion pounds in 2005 to 3.1 billion pounds in 2015 (Figure 1). Imports from Mexico peak in the winter season when southern Florida is the predominant U.S. producer.

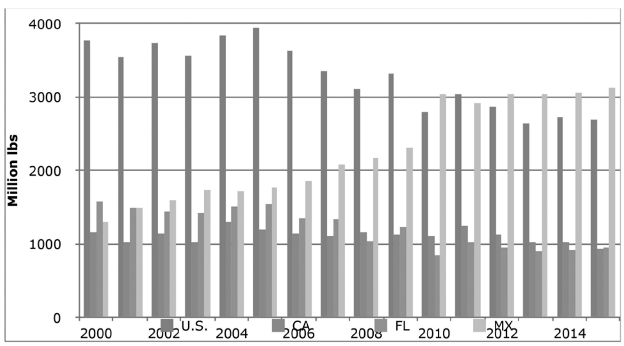
SUSPENSION AGREEMENTS

Past Suspension Agreements. On April 18, 1996, the U.S. tomato industry filed a petition to the U.S. Department of Commerce (USDC) to initiate an antidumping investigation to determine whether Mexico was dumping tomatoes to the U.S. market (USDC, 1996). The initial suspension agreement was signed on December 6, 1996, which set the VPR on the imports of Mexican tomatoes at 21.08 cents per pound for winter tomatoes (i.e., October 23 – June 30) and 17.2 cents per pound for summer tomatoes (i.e., July 1 – October 22) (USDC, 1996). The agreement's intent was to ensure there was no undercutting or suppressing of fresh market tomato prices in the United States. Since then, the tomato trade disputes between the United States and Mexico took place several times. On May 22, 2002, as the Mexican tomato industry was willing to withdraw the initial suspension agreement, the USDC terminated the 1996 suspension agreement and reopened the antidumping case. The USDC and Mexico eventually renewed the agreement on December 4, 2002 (2002 suspension agreement). Under the 2002 suspension agreement, the VPR for winter tomatoes was increased to 21.69 cents per pound while it remained unchanged for summer tomatoes (USDC, 2002). The Mexican tomato industry again announced to withdraw the 2002 suspension agreement on November 26, 2007, and the USDC and Mexico signed a new agreement on January 22, 2008 (2008 suspension agreement). The VPR of the 2008 suspension agreement remained the same as in the 2002 agreement (USDC, 2008).

NEW SUSPENSION AGREEMENT

The latest tomato suspension agreement was signed on March 4, 2013 (2013 suspension agreement), which established the new VPR for imports of Mexican tomatoes. The new VPR was set according to the characteristics of tomato production. As in Table 1, for tomatoes grown in the open-field and adapted environments, the VPR was set at 31.00 cents per pound for winter tomatoes and 24.58 cents per pound for summer tomatoes (USDC, 2013). For tomatoes grown in controlled environments, the VPR was set at 41.00 and 32.51 cents per pound for winter and summer tomatoes, respectively (USDC, 2013). Furthermore, the VPR for specialty tomatoes (loose) was set at 45.00 and 35.68 cents per pound for winter and summer tomatoes, whereas the VPR for specialty tomatoes (packed) was set at 59.00 and 46.79 cents per pound, respectively (USDC, 2013). Despite the new suspension agreement, the U.S. tomato industry still has concerns that imports from Mexico may continue to hurt the sustainability of the industry.

Regarding the effects of the suspension agreements, Baylis and Perloff (2010) examined the effects of the VPR on tomato trade and concluded that the trade diversion would occur due to the VPR. In other words, when the tomato price is restrained at the VPR, Mexico would export more tomatoes to Canada, but Canada would increase the exports to the United States. Ghazalian (2014) also examined the new suspension agreement,



Source: National Agricultural Statistics Service (NASS) and Foreign Agricultural Service (FAS)

Figure 1. Tomato production in the US and tomatoes imported from Mexico, 2000 – 2015.

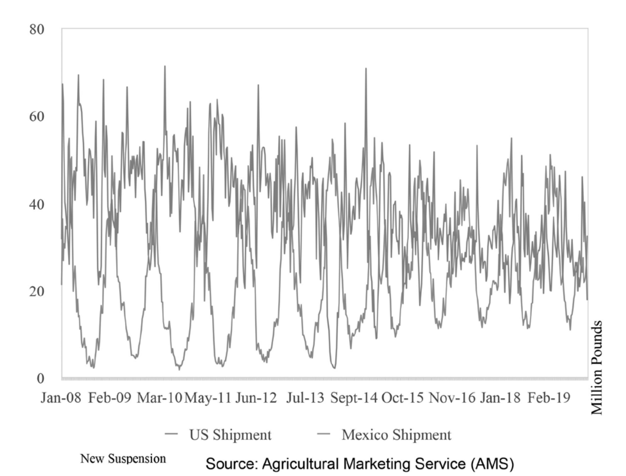
Table 1. Reference prices in 2013 suspension agreement ($/lb.)

Tomatoes	July 1 – October 22	October 23 – June 30
Open field and adapted environment	0.2458	0.31
Controlled environment	0.3251	0.41
Specialty – loose	0.3568	0.45
Specialty – packed	0.4679	0.59

Source: United States Department of Commerce (USDA)

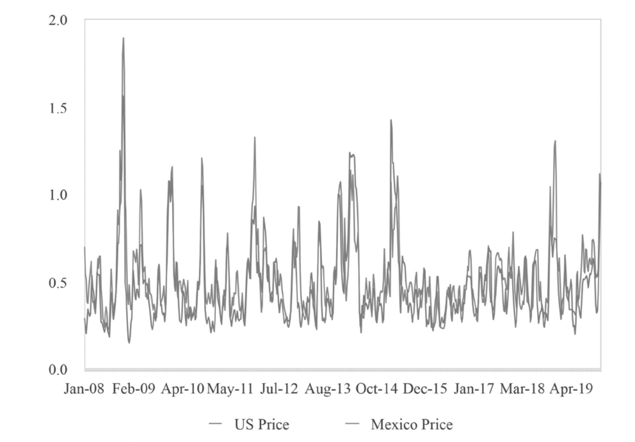
Table 2. Summary of prices before and after the 2013 suspension agreement

	Before	After
Price correlation	0.81	0.83
Average imported price	$0.46	$0.53
Average domestic prices	$0.45	$0.48
Volatility of imported prices	$0.20	$0.19
Volatility of domestic prices	$0.24	$0.15
Ratio of the binding prices	16%	32%



Source: Agricultural Marketing Service (AMS)

Figure 2. Weekly shipments of the U.S. and Mexican tomatoes of selected shipping points, 2004 – 2015.



Source: Agricultural Marketing Service (AMS)

Figure 3. Weekly prices of the U.S. and Mexican tomatoes, 2004 – 2015.

showing that the new agreement would decrease the US imports of fresh tomatoes from Mexico, but it would increase the imports of Mexican processed tomato products. Recently, Asci et al. (2016) simulated the impact of the new suspension agreement on tomato demand, and found that the new agreement might be more likely to increase the demand for Mexican field-grown and greenhouse tomatoes rather than U.S. field-grown tomatoes.

WEEKLY SHIPMENTS AND PRICES UNDER SUSPENSION AGREEMENTS

According to the Agricultural Marketing Service of the U.S. Department of Agriculture (USDA-AMS), the weekly shipments of the U.S. tomatoes were negatively correlated with those of the Mexican tomatoes based on the data from selected shipping points (Figure 2). Over the period between 2004 and 2015, the average weekly U.S. shipments from selected shipping points showed a decreasing trend, while that of Mexican shipment showed a marked upward trend. The weekly shipments were volatile, and most domestic tomatoes were shipped during the summer season, while Mexican tomatoes were shipped during the winter season.

The weekly prices also showed volatile patterns with high correlation between the U.S. and Mexican tomatoes (Figure 3). Before the 2013 suspension agreement, the correlation coefficient between prices of domestic and imported tomatoes was 0.81, while it changed to 0.83 after the agreement, suggesting markets for tomatoes from the two countries are now more closely interrelated (Table 2). The weighted average of the weekly U.S. tomato prices was \$0.45 per pound during 2011-2013 before the new agreement and rose to \$0.48 per pound for 2013-2015 after the agreement. In contrast, the average price of tomatoes imported from Mexico increased from \$0.46 to \$0.53 per pound after the agreement during the same periods. The new agreement should have contributed to the increase in imported tomato prices. In addition, the agreement has stabilized farm prices. The standard deviation of domestic prices decreased from \$0.24 to \$0.15 under the new VPR. The price volatility decreased significantly. The volatility of Mexican tomato prices remained about the same for the same periods (\$0.20 to \$0.19).

The shaded area in Figure 3 indicates the periods during which the weekly imported prices were restrained at the reference prices. Before the new agreement, 76 observations of prices were restrained at the reference prices, accounting for 16% of all samples during the period. Under the new agreement, the ratio increased to 32%, suggesting the agreement did play a more significant role in preventing the price from falling below the reference prices (Table 2). This is because the new agreement substantially increased the reference prices. Before the latest 2013 agreement, imported prices were restrained mostly in January, February and March, when Florida tomatoes dominate the market. Under the new agreement, the binding reference prices also occurred in April and May, during which tomato imports were still high. These periods are also in the production window of Florida tomatoes, thus occurrence of restrained prices improves the profitability of the Florida tomato industry. In sum, the new agreement has resulted in a more stable market and more protection of the domestic producers.

REFERENCES

Asci, S., J.L. Seale, O. Gulcan, and J.J. VanSickle. 2016. U.S. and Mexican Tomatoes: Perceptions and Implications of the Renegotiated Suspension Agreement. Journal of Agricultural and Resource Economics 41(1): 138-160.

Baylis, K., and J.M. Perloff. 2010. Trade Diversion from Tomato Suspension Agreements. Canadian Journal of Economics 43(1): 127-151.

Ghazalian, P.L. 2014. The New Tomato Suspension Agreement: What are the Implications for Trade Flows? Canadian Journal of Agricultural Economics 63(3): 359-380.

Grant, J.H., D.M. Lambert, and K.A. Foster. 2010. A Seasonal Inverse Almost Ideal Demand System for North American Fresh Tomatoes. Canadian Journal of Agricultural Economics 58(2): 215-234.

Kosse, J.E., S. Devadoss, and J. Luckstead. 2014. U.S.-Mexico Tomato Dispute. Journal of International Trade Law and Policy 13(2): 167-184.

USDC. 1996. Suspension of Antidumping Investigation: Fresh Tomatoes from Mexico. Federal Register 61(213): 56618-56621. United States Department of Commerce.

USDC. 2002. Suspension of Antidumping Investigation: Fresh Tomatoes from Mexico. Federal Register 67(241): 77044-77053. United States Department of Commerce.

USDC. 2008. Suspension of Antidumping Investigation: Fresh Tomatoes from Mexico. Federal Register 73(18): 4831-4840. United States Department of Commerce

USDC. 2013. Fresh Tomatoes from Mexico: Suspension of Antidumping Investigation. Federal Register 78(46): 14967-14979. United States Department of Commerce.

SA8000: Social Accountability Coming to a Farm Near You

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The Fair Food Standards Council (FFSC) was established in 2011 to implement the 2010 agreement between the Coalition of Immokalee Workers (CIW) and the Florida Tomato Exchange (FFSC, 2015). "Participating" retail buyers would buy tomatoes from "participating" tomato growers and pay an additional one cent for every pound they purchase. The extra money would be passed on to farm workers. Another important stipulation of the agreement was that "participating" growers would implement and maintain a code of conduct developed by the CIW. The agreement and establishment of the FFSC represented a significant development in agricultural labor relations and the first implementation of a social accountability program within an agricultural industry.

Social accountability (SA), also known as "corporate responsibility," has taken hold in a number of retail industries, most notably in the garment and shoe industries. The fundamental goal of SA is to ensure that employers provide a safe, healthy, and humane workplace for their employees (Henkle, 2005). SA has its origins in the UN's 1948 Declaration of Human Rights (UN, 1948). Over the years, individual countries have adopted national labor laws and the International Labor Organization (ILO) has established various conventions in regards to child labor, discrimination, occupational health and safety, collective bargaining, minimum wage, and weekly work hours (SAI, 2014). In 2001 human rights concepts, national laws and ILO conventions were merged into the first edition of SA8000. SA8000 provides a framework and checklist for third-party auditors to judge whether a specific workplace is safe, healthy, and humane. SA concepts are evolving and increasingly retailers and brand-name manufacturers are pushing SA standards to be adopted within their supply chains. SA8000 was developed as a generic international standard and has been revised four times. The latest version was published in 2014.

The purpose of this paper is three fold. First, describe the most current version of SA8000. Second, compare and contrast SA8000 with the CIW Code of Conduct. Third, discuss some of the costs and benefits of embracing SA protocol. It is likely that SA will become increasingly important to agricultural producers, particularly to specialty crop growers who employ large numbers of seasonal and migrant workers. Understanding the elements of a SA protocol should help growers and other agricultural employers prepare to implement the necessary changes in their labor management practices.

The 2014 version of SA8000 is broken into nine (9) categories. Each category is listed below with a brief description of employer responsibilities. These descriptions are written as generic employer requirements without regard to the specific conditions of a given industry such as agriculture.

CHILD LABOR

- SA8000 defines a "child" to be less than 15 years of age. Someone who is between 15 and 18 is considered to be a "young" worker;
- Employment of children is strongly discouraged;
- If children are employed, special provisions must be made so that they attend school, do not work at night, and are not exposed to any physically or mentally hazardous conditions.

FORCED LABOR

- Prohibited: human trafficking;
- Prohibited: withholding pay, papers, property, or any other benefits which bind workers to a given job or employer;
- Prohibited: collecting fees or deposits as a condition of employment;
- At the end of a standard work day, workers are free to leave;
- Workers are free to terminate their employment with reasonable notice.

SAFE AND HEALTHY WORKPLACE

- Provide a safe and healthy work environment;
- Prevent or minimize all physical and mental hazards;
- Provide necessary personal protective equipment to workers at no cost to mitigate hazard risks;
- Company to appoint a safety officer;
- Organize a safety committee with a balance of management and worker representatives; committee meetings will keep records of issues discussed and preventive actions if so needed;
- Conduct regular safety trainings for all workers;
- Documented procedures to detect, prevent, and eliminate or at least mitigate hazards;
- Provide clean toilette facilities;
- Provide adequate supply of potable water;
- Provide suitable spaces for meal breaks;
- If dormitories are provided, spaces must be clean and safe;
- Allow workers the right to voluntarily leave a worksite if they feel they are in imminent danger.

FREEDOM OF ASSOCIATION

- Employers must allow workers to form and join unions in order for workers to collectively bargain for pay, benefits, and better workplace conditions;
- If trade unions are not available or if they are restricted by national or regional laws, workers must be given the freedom to organize their own company-level committees from which they can collectively express grievances and/or bargain for higher pay and benefits.

DISCRIMINATION

- Prohibited: differential pay, hiring, promotion, or training practices based solely on a worker's age, gender, marital status, caste, disability, sexual orientation, ethnic origin, or religious affiliation;
- Prohibited: allowing behaviors within the workplace that are deemed threatening, abusive, exploitative, or sexually coercive;
- Prohibited: requiring female workers to undergo pregnancy or virginity tests;
- Prohibited: interfering with a worker's personal rights to be observant of their religious or cultural heritage.

DISCIPLINARY PRACTICES

- Prohibited: use of corporal punishment or any behavior deemed to be verbally abusive or mentally coercive.
- Goal: treat all workers with "dignity and respect."

WORKING HOURS

- Not to exceed 48 hours per week if not already set by national or regional weekly hourly limits;
- No more than 6 consecutive working days unless permitted by national law or collective bargaining agreements;
- Overtime work is to be voluntary, not to exceed 12 hours per week, and not done so on a consistent basis unless permitted by national law or collective bargaining agreements;

REMUNERATION (PAY)

- Wages paid to meet local minimum wage levels or levels agreed to by collective bargaining agreements;
- Prohibited: deductions for disciplinary actions except when permitted by national law or collective bargaining agreements;
- Workers be given information in a timely manner as to how their weekly pay and benefits were determined; information must be clearly understood by the workers;
- Overtime paid at a premium rate as set forth by national law or collective bargaining agreements;
- "False apprenticeships" not allowed as a way of avoiding paying appropriate wages and other social security benefits.

MANAGEMENT SYSTEM

- Written policies that describe in detail how the SA8000 standards are being implemented; policies include how SA8000 practices are communicated to the workers; SA8000 documents will be available for review by the general public; SA8000 documents will be prominently displayed throughout the company's premises, communicated to its customers, suppliers, and sub-contractors, and available for review by the general public;
- Establishment of a Social Performance Team (SPT), which includes a balance of management and worker representatives; SPT conducts routine internal audits to assess the company's compliance with SA8000 standards, assess potential and emerging risks, and suggest ways to strengthen SA8000 compliance;
- Creation of a complaint management and resolution system by which grievances from workers and managers can be filed, investigated, and adjudicated;
- External third-party verification through unannounced audits;
- If SPTs or external auditors find evidence of non-compliance with SA8000, company readily adopts corrective actions and seeks to prevent future non-compliance activities;
- A company's SA8000 plan includes communicating and making reasonable efforts to ensure that all of its suppliers and sub-contractors follow SA8000 standards as well.

The Code of Conduct developed by the CIW closely follows the SA8000 outline. The CIW Code has zero tolerance for child or forced labor; prohibits discrimination, sexual harassment, and workplace violence; requires growers to maintain electronic time keeping to accurately record hours of work; mandates worker participation in "Health and Safety" committees; requires a process of "progressive discipline"; and requires regular and frequent meetings to educate new and current workers about their rights and responsibilities under the Code. Most notably, the Code mandates that each "participating" grower create and maintain a worker-compliant process. Workers are encouraged to call officials at the CIW or the FFSC to report employer non-compliance with the Code or to voice complaints about any perceived abusive behaviors.

The CIW Code of Conduct includes other requirements which are specific to tomato growing operations, such as disallowing "cupping" and requiring shade structures near the fields to be available to workers during lunch and rest breaks. The Code requires that all workers be hired directly by the grower and not through a farm labor contractor. The FFSC was created as the official auditor for compliance with the Code among "participating" growers. Audits occur at least once a year or when worker complaints are investigated.

As growers review the provisions of SA protocols, they will realize that many of the SA elements already exist as U.S. federal laws. The Fair Labor Standards Act (FLSA - 1939), the Migrant Seasonal Farmworker Protection Act (MSPA – 1983), and civil rights legislation provide the legal basis for minimum wages, restrictions on employing children (18 years and under), and prohibitions on discrimination and harassment within the workplace. For agricultural employers, the most notable changes from adopting SA standards will be increased worker involvement in basic company governance. Worker input will be solicited through various health and safety committees and through a formal grievance resolution process. Most growers in Florida have had little if any experience in dealing with trade unions and collective bargaining. While formal agricultural worker unions may never be the norm in Florida, those growers who want to become SA certified must take organizational steps to actively include worker input into the labor management aspects of the farming operation.

The cost of SA certification will largely be measured as the cost of external audits, not unlike what growers already have to handle in terms of food safety or DOL Wage-Hour investigations. Benefits of SA certification can be viewed from two perspectives. First, some evidence exists that working conditions are directly correlated to worker productivity (Billikopf 1996, 1997, 1999, and 2001). If SA certification enhances the workplace environment, then one should expect an improvement in overall productivity and/or cost efficiency.

A second benefit may be in the form of market access. Florida tomato and citrus growers have often cited the U.S. regulatory environment, particularly with respect to agricultural labor, has placed them at a competitive disadvantage with foreign growers. As "social justice" issues continue to resonate among consumers, retail brands will apply increasing pressure on its suppliers to become SA complaint. If Florida/U.S. specialty crop growers embrace SA practices, they may improve their overall competitive position among U.S. food retailers even at prices higher than what would be available from foreign imports.

REFERENCES

Billikopf, G.E. (1996). Crew workers split between hourly and piece-rate pay. California Agriculture, 50(6), 5-8. Retrieved from https://ucanr.edu/repositoryfiles/ca5006p5-69809.pdf

Billikopf, G.E. (1997). Workers prefer growers over FLCs. California Agriculture, 51(1), 30-32. Retrieved from http://ucce.ucdavis.edu/files/repositoryfiles/ca5101p30-67644.pdf

Billikopf, G.E. (1999). Farmworkers positive about their jobs, but suggest improvements. California Agriculture, 53(1), 33-36. Retrieved from http://ucanr.edu/repositoryfiles/ca5301p33-67360.pdf

Billikopf, G.E. (2001). Interpersonal communication tops concerns of farm supervisors. California Agriculture, 55(5), 40-43. Retrieved from http://ucanr.edu/repositoryfiles/ca5505p40-68932.pdf

FFSC. 2015. Fair Food Standards Council home page. http://www.fairfoodstandards.org/about/. Accessed June 29, 2016.

Henkle, D. 2005. GAP Inc. sees supplier ownership of compliance with workplace standards as an essential element of socially responsible sourcing. Journal of Organizational Excellence (Winter 2005):17-25.

SAI. 2014. Social Accountability 8000 International Standard. http://sa-intl.org/_data/n_0001/resources/live/SA8000%20Standard%202014.pdf. Accessed June 12, 2016.

UN. 1948. The Universal Declaration of Human Rights. Paris, France, 1948. http://www.un.org/en/universal-declaration-human-rights/. Accessed June 26, 2016.

[1] "Cupping" occurs when a tomato bucket is crowned or filled over the bucket's height.

Research Efforts to Improve Target Spot Management on Tomato

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INTRODUCTION

Target spot continues to challenge many tomato growers throughout Florida. The disease is caused by the fungus *Corynespora cassiicola*. Foliar symptoms initially consist of small, pinpoint, water-soaked lesions that appear on the upper leaf surface. These initial lesions are easily mistaken for bacterial spot or speck, or even other fungal diseases, but become more distinct as the lesions increase in size. Target spot lesions are circular, zonate with a distinct brown to tan center and often surrounded by a chlorotic halo, although the amount of chlorosis can vary. Expanding lesions can coalesce leading to rapid yellowing and blighting of leaves. Stems and petioles are also susceptible to the pathogen and can be girdled leading to accelerated blighting. Of greater concern is the susceptibility of fruit to infection. Typical fruit symptoms begin as small brown pitted lesions on green fruit that can rapidly expand during ripening, leading to larger zonate lesions that will often crack in the center. Occasionally, symptoms on small immature fruit will include small upraised areas that can be mistaken for bacterial spot; although they lack the typical scabby appearance and are a much smaller diameter than the symptoms commonly associated with bacterial spot. Yield losses due to direct fruit infections can vary greatly. However, lesions not only expand rapidly during ripening, but also compromise fruit to infection by secondary organisms. Failure to cull infected fruit can lead to dramatic postharvest losses during shipping. Target spot development is favored by long periods of high humidity, prolonged leaf wetness (16-44 hours) and high temperatures (28-32°C) (Pernezny, 2000).

This necrotrophic fungus has a broad host range encompassing 380 plant genera and 530 species of plants, which includes monocots, dicots, ferns, and one cycad (Alfieri et al. 1984; Smith, 2009). Although some *C. cassiicola* strains can elicit disease symptoms on a wide range of hosts, some strains appear host specific; whereas other studies show that strains can infect a range of hosts (Smith, 2009). Dixon (2009) demonstrated that *C. cassiicola* strains isolated from 9 crops, 12 weed species, and 18 ornamentals exhibited pathogenicity on tomato, illustrating the potential of diverse plant hosts to harbor isolates infective to tomato. The importance of host wounding to *C. cassiicola* infectivity may vary depending on strain and host plant. Some studies showed wounding was necessary for strain infectivity (McRitchie, 1973; Chase, 1982; Kingsland, 1985), while wounding exacerbated strain infectivity in other studies (Sobers, 1965; Pernezny, 1996). Pernezny (1996) reported greater development of target spot in tomato following storms that would facilitate wounding of the aerial portions of the plant from wind-blown soil particles (Pernezny, 1996).

As a saprophyte, *C. cassiicola* was reported to survive for up to 2 years on crop debris (Pernezny, 1993). Kingsland (1985) compared *C. cassiicola* isolates recovered from the debris of papaya, tomato, and cucumber, and found isolates remained pathogenic to tomato and cucumber, but not to papaya. Indicating that some isolates can be strictly saprophytic on one plant species and pathogenic on another. Other studies indicate the potential for *C. cassiicola* to exist as an epiphyte of some plants without causing disease (Onesirosan et al. 1974).

Since no commercially resistant tomato varieties are available for target spot, growers rely on cultural practices and the judicious application of fungicides for disease management (Pernezny et al. 1996; Schlub et al. 2009; Vallad et al. 2011). However, fungicide resistance is a major concern and already documented for *C. cassiicola* towards quinone outside inhibitor (QoI) and succinate dehydrogenase inhibitor (SDHI) fungicides, corresponding to FRAC groups 11 and 7, respectively (Adkison et al., 2012; Aguiar et al., 2015; Date et al., 2004; Ishii et al., 2007 & 2011; Miyamoto et al., 2009 & 2010; Vallad et al., 2011). Although little information regarding the full extent of fungicide resistance throughout Florida populations of *C. cassiicola* is available, preliminary data based on in vitro testing of strains collected from field outbreaks and subsequent greenhouse and field trials identified strains exhibiting resistance to QoI and SDHI fungicides (Adkison et al. 2012; Vallad et al. 2011).

The following is a summary of field studies performed during the Fall of 2014 and 2015 evaluating the efficacy of various fungicides and fungicide programs for the management of target spot. Tomato trials consisted of either single row (10 or 14 plant) in the case of fungicide evaluations or three row (30 or 42 plant) plots in the case of fungicide program evaluations on 5 ft row spacing, with seedlings (cvs. Tygress in 2014 or HM1823 in 2015) set on either 18 or 24-inch plant spacing (2014 and 2105, respectively), and irrigated through a drip irrigation system. Fungicide treatments were applied using a high-volume tractor sprayer, equipped with drop down booms with eight Tee Jet ATR 80 hollow cone nozzles per plant row (4 per side) calibrated to deliver either 60, 90 & 120-gallon (2014) or 50, 75 & 100 (2015) gallon spray volumes per acre at 210 psi. Fungicide treatments were arranged in trials as a randomized complete block design with four replicate plots per treatment, including a control and a grower standard. Additional applications of bactericides and insecticides, and other fungicides were made as necessary to minimize the impact of insect pests, and bacterial spot and late blight during trials. Plots were inoculated 2 to 4 weeks after planting with a 10^5 conidia/ml suspension containing 0.01% (v/v) Silwet L77, and rated every 2 to 4 weeks as disease progressed. Fruit were hand-harvested from 10 plants in each plot and graded for size and disease at least once. Target spot severity, area under disease progress curve (AUDPC) values, tomato yield, and diseased fruit were collected, transformed as necessary, and analyzed using the General Linear Mixed Model function (PROC GLIMMIX) of the Statistical Analysis System (SAS ver. 9.4) package with treatment means separation based on Fisher's protected LSD ($\alpha = 0.05$).

RESULTS

Fungicide evaluations, Fall 2014. Moderate disease pressure was observed in Fall 2014 (Table 1). Many of the fungicides in the study were alternated (alt.) weekly with Bravo Weatherstik (Bravo). Average disease severity on 14 Nov ranged from 2.4% (Scala alt. Bravo Weatherstik) to 9.1% (Control). However, by the completion of the trial on 7 Jan, average disease severity increased from 42.6% (Switch alt. Bravo Weatherstik) to 83.8% (Control). Based on AUDPC values, treatments that included BmJ alt. Bravo, Oso, Quadris, Fontelis, Bravo, Serenade Optimum alt. Bravo, and Quintec alt. Bravo were statistically equivalent to the Control. In addition, Penncozeb 75DF, Oso alt. Bravo, Inspire alt. Bravo, and Quadris Top alt. Bravo, were statistically equivalent to weekly applications of Bravo Weatherstik alone, which was the grower standard in this trial. Applications of either Revus Top, Aprovia Top, Fluopyram 500SC, Inspire Super, Scala, or Switch alternated with Bravo were statistically superior to weekly applications of Bravo. Foliar applications of Scala or Switch alternated with Bravo, reduced disease severity by nearly 65% compared to the Control by the end of the trial. Tremendous fruit drop, presumably due to inclement weather, prevented an accurate harvest. However, remaining fruit were stripped and assessed for the incidence of diseased fruit. Fontelis, Oso (alone or with Bravo), Penncozeb 75DF, Revus Top, Bravo, Serenade Optimum + Bravo, and Scala + Bravo were statistically equivalent to the Control. Fluopyram 500SC + Bravo, Inspire + Bravo, Quadris Top + Bravo, Switch + Bravo, Inspire Super + Bravo, Quintec + Bravo, and BmJ + Bravo statistically reduced target spot incidence on fruit.

Fungicide evaluations, Fall 2015. Disease pressure was initially slow to develop in Fall 2015, but increased rapidly from 2 Dec to 13 Dec with high variation among treatments (Table 2). For this study, many of the fungicides were alternated weekly with Penncozeb 75DF, and weekly applications of Penncozeb 75DF was used as the grower standard. On 2 Dec, average disease severity ranged from 18.5% (Switch alt. Penncozeb 75DF) to 81.5% (Control); and from 48.4% (Zing alt. Penncozeb 75DF) to 81.5% (Oso + Induce) by 13 Dec. Based on AUDPC values, Oso + Induce and Zing were statistically equivalent to the control. Switch alt. Penncozeb 75DF was statistically superior to Penncozeb 75DF alone. Applications of either QuadrisTop, Inspire Super, Zing, Priaxor Xemium, Scala, or Topguard EQ alternated with Penncozeb 75DF were statistically equivalent to Switch alt. Penncozeb 75DF. Treatments had no significant effect on target spot incidence on fruit (data not shown).

Fungicide program evaluations, Fall 2014. Five fungicide programs were evaluated for the management of target spot (Table 3). Compared to the control, all programs reduced disease severity based on AUDPC. However, only programs 2, 3 and 5 reduced disease significantly compared to the control. Program 1, which alternated Fontelis with Scala and Inspire Super in addition to weekly applications of Bravo Weatherstik, was statistically equivalent to the Control in terms of foliar disease severity and AUDPC; but still statistically reduced the incidence of infected fruit compared to the control. Substituting Penncozeb 75DF for Bravo Weatherstik as the base contact fungicide statistically improved disease control based on AUDPC, as can be observed by comparing Programs 1 and 2, but did not reduce the incidence of infected fruit. Program 6 included Folicur (not labeled for tomato), which statistically reduced disease the greatest among all programs based on AUDPC and also had the lowest incidence of diseased fruit.

Fungicide program evaluations, Fall 2015. Eleven fungicide programs were evaluated for the management of target spot (Table 4). Fungicide program had a significant effect on disease severity on 2 Dec. Compared to the Control, neither weekly nor twice weekly applications of Bravo Weatherstik alone (Programs 2 & 3), nor weekly applications of Cuprofix 40D + Penncozeb 75DF (Program 1) provided effective control of target spot. Programs consisting of weekly applications of either Bravo Weatherstik + Cuprofix 40D + Penncozeb 75DF (Program 4), Actigard + Bravo Weatherstik (Program 5), or Actigard + Penncozeb 75DF (Program 6) statistically reduced disease over the control. By 12 Dec, disease increased rapidly and unevenly across the trial, thereby reducing the ability to differentiate statistical differences among fungicide programs. Programs had no statistical effect on the amount of diseased fruit culled at harvest.

Table 1. Evaluation of fungicides for the management of target spot in Fall 2014 field trials at GCREC, Wimauma, FL.

Treatment, rate (application)[w]	Foliar disease severity (%):[x] 14-Nov		16-Dec		7-Jan		AUDPC[y]		Diseased Fruit (%)	
BmJ (CX-10250), 4.5 oz (1,3,5,7); Bravo Weatherstik, 2 pt (2,4,6)	7.6	ab	71.4	a	81.5	ab	880	a	12.4	f-i
Control (1-7)	9.1	a	62.5	a	83.8	a	852	ab	23.3	a-e
Oso, 6.5 oz (1-7)	7.6	ab	55.0	ab	83.8	a	780	a-d	23.5	a-e
Quadris, 6.2 floz (1-7)	6.2	a-d	62.5	a	71.4	abc	776	a-d	19.1	b-g
Fontelis, 16 floz (1-7);	4.4	a-e	58.8	ab	83.8	a	774	a-d	26.9	a-d
Bravo Weatherstik, 2 pt (1-7)	3.6	cde	62.5	a	66.8	bcd	725	a-e	15.4	c-h
Serenade Optimum, 12 oz (1,3,5,7); Bravo Weatherstik, 2 pt (2,4,6)	5.2	a-d	48.4	abc	81.5	ab	703	a-e	15.2	d-h
Quintec, 6 oz (1,3,5,7); Bravo Weatherstik, 2 pt (2,4,6)	6.4	abc	48.4	abc	71.4	abc	675	b-e	11.1	hig
Penncozeb 75DF, 2 lb (1-7)	5.4	a-d	48.4	abc	71.4	abc	661	cde	23.0	a-e
Oso, 6.5 oz (1,3,5,7); Bravo Weatherstik, 2 pt (2,4,6)	3.6	cde	48.4	abc	76.3	abc	657	c-f	13.2	e-g
Inspire, 7 floz (3,5,7); Bravo Weatherstik, 2 pt (2,4,6)	3.0	de	55.0	ab	62.5	cd	645	def	7.2	i
Quadris Top, 8 floz (3,5,7); Bravo Weatherstik, 2 pt (2,4,6)	6.4	abc	31.4	cd	81.5	ab	594	efg	9.0	hi
Revus Top, 7 floz (3,5,7); Bravo Weatherstik, 2 pt (2,4,6)	6.2	a-d	26.3	de	66.8	bcd	513	fgh	20.7	b-f
Aprovia Top, 13.5 floz (3,5,7); Activator90, 0.125 % v/v (3,5,7); Bravo Weatherstik, 2 pt (2,4,6)	6.4	abc	26.3	de	55.0	de	473	ghi	10.1	hig
Fluopyram 500SC, 6.8 floz (1,3,5,7); Bravo Weatherstik, 2 pt (2,4,6)	3.0	de	31.4	cd	55.0	de	455	hi	7.0	i
Inspire Super, 20 floz (3,5,7); Bravo Weatherstik, 2 pt (2,4,6)	3.0	de	18.5	ef	62.5	cd	387	i	10.0	hig
Scala, 7 floz (1,3,5,7); Bravo Weatherstik, 2 pt (2,4,6)	2.4	e	10.9	g	48.4	ef	284	j	15.0	d-h
Switch, 11 oz (1,3,5,7); Bravo Weatherstik, 2 pt (2,4,6)	3.0	de	12.9	fg	42.6	f	279	j	9.5	hi
P =	0.0082		< 0.0001		< 0.0001		< 0.0001		< 0.0001	

[w] Listed treatment rates are per acre basis unless noted otherwise. Treatments were applied 21 Oct, 28 Oct, 4 Nov, 12 Nov, 2 Dec, 15 Dec, and 21 Dec, corresponding to weekly applications of 1 to 7 above. [x]The severity of disease was assessed as the percentage of canopy affected. The Horsfall-Barratt scale was used for all ratings, but values were converted to mid-percentages prior to statistical analyses. [y]Area under the disease progress curve (AUDPC) values were calculated using the formula: $\Sigma([(xi+xi-1)/2](ti-ti-1))$ where x is the rating at each evaluation time and (ti-ti-1) is the time between evaluations.

[z] Means followed by the same letter are not significantly different according to Fisher's LSD test (α=0.05).

DISCUSSION

The four presented studies are representative of spring field trials performed during the same year (data not shown) and demonstrate the limits of fungicidal activity available for target spot management (Table 5). Similar to previous reports (Adkison et al., 2012; Aguiar et al., 2015; Date et al., 2004; Ishii et al., 2007; Miyamoto et al., 2007; Vallad et al., 2011), the fungicide Quadris that contains the active ingredient (a.i.) azoxystrobin provided little to no control of target spot as a solo product (Table 1) or when alternated with Penncozeb 75DF (Table 2), as would be expected in the presence of a pathogen resistant to QoI fungicides. The succinate dehydrogenase inhibitor (SDHI) containing fungicides, Fontelis (a.i. penthiopyrad), Luna (a.i. fluopyram), Aprovia Top (a.i. benzovindiflupyr), or Priaxor (a.i. fluxapyroxad) gave intermediate levels of control, although activity varied from trial to trial and among the different SDHI formulations. Prior studies demonstrate that resistance to SDHI fungicides can vary among isolates and among the various SDHI fungicides. The demethylase inhibitor fungicide Inspire (difenoconazole) also gave intermediate level of disease control. The methionine biosynthesis inhibitor containing fungicides Inspire Super (a.i. cyprodinil + difenoconazole), Scala (a.i. pyrimithanil) and Switch (a.i. cyprodinil + fludioxonil) were consistently among the top performing fungicides.

The contact fungicides chlorothalonil and mancozeb are commonly used as general maintenance fungicides for their broad-spectrum activity and multi-site mode of action that minimizes the risk of developing resistant pathogen populations. As such, both fungicides provided some level of control, although control was best during early ratings and often negligible by the end of trials. Any differences observed among the contact fungicides varied. In addition, the Fall 2015 evaluation of fungicide programs found little benefit of splitting Bravo Weatherstik applications (Table 4); although higher application rates may have produced a different outcome. Actigard, a chemical inducer of systemic acquired resistance, is commonly used for the suppression of bacterial diseases (bacterial spot and bacterial speck) and also appeared to benefit target spot management in several trials; although efficacy varied among trials.

In 2014, tremendous fruit drop occurred presumably due to inclement weather that compromised harvest accuracy, so yield data was not collected. However, remaining fruit were still assessed for the incidence of diseased fruit. An immediate observation was plots that included Switch in both trials exhibited significantly less fruit drop and less infected fruit compared to the control and fungicide programs without Switch (Tables 1 and 3). The other notable observation was that some fungicides that were ineffective against foliar symptoms of target spot appeared to have better efficacy against fruit infections. For example, BmJ, Quintec, Quadris Top, and Inspire were either ineffective or only moderately effective against foliar symptoms of target spot, still reduced the incidence of infected fruit (Table 1). Sufficient disease pressure didn't appear until near the termination of trials in 2015 and then progressed rapidly leading to higher variability. This variability interfered with efforts to differentiate treatment effects on foliage and fruit infection at the end of the trial (Table 2 and 4).

Additional research during 2016 – 2017 will include field and greenhouse studies to assess the effect of fungicide rate and timing on disease development. From 2015 – 2016, a survey was conducted of *C. cassiicola* strains from throughout tomato production areas of Florida. *In vitro* assessments of strains for sensitivity to available fungicides are in progress. Results of these field and lab studies should improve fungicide recommendations in the near future. However, it is unlikely that fungicides alone will provide a long-term solution for target spot. Additional studies are ongoing to better understand the ability of *C. cassiicola* to persist in the field in soil and plant debris; and to understand weather factors that could lead to the development of a disease forecasting system. Finally, renewed efforts to screen and develop tomato lines with resistance to *C. cassiicola* have begun. These research efforts are possible due to a recent grant awarded to Drs. Gary Vallad, Sam Hutton, Mathews Paret, and Pamela Roberts through the Florida Specialty Crop Black Grant Program administered by the Florida Department of Agriculture and Consumer Services.

Table 2. Evaluation of fungicides for the management of target spot in Fall 2015 field trials at GCREC, Wimauma, FL.

	Foliar disease severity (%):[x]					
Treatment, rate (application)[w]	**2-Dec**		**13-Dec**		**AUDPC[y]**	
Non-treated control	81.5	a[z]	78.4	ab	4102	a
Oso, 6.5 oz + Induce, 0.125 %v/v (1-7)	66.8	ab	81.5	a	3456	ab
Zing, 36 floz (1-7)	49.3	abc	66.8	abc	2635	abc
Quadris, 6.2 floz (2,4,6); Penncozeb 75DF, 1.5 lb (1,3,5,7)	48.4	abc	55.0	bcd	2488	bc
Inspire, 7 floz (2,4,6); Penncozeb 75DF, 1.5 lb (1,3,5,7)	42.6	bcd	62.8	abc	2285	bcd
Actigard, 0.5 oz (1-7)	42.6	bcd	58.8	a-d	2247	bcd
Penncozeb 75DF, 1.5 lb (1-7)	35.7	cde	76.3	ab	2063	c-f
Luna Experience, 10 floz (2,4,6); Penncozeb (1,3,5,7)	37.5	cde	66.8	abc	2057	c-f
Aprovia Top, 10.5 floz (2,4,6); Penncozeb (1,3,5,7)	35.7	cde	62.8	abc	1966	c-f
QuadrisTop, 8 floz (2,4,6); Penncozeb (1,3,5,7)	26.3	def	58.8	a-d	1531	d-g
Inspire Super, 20 floz (2,4,6); Penncozeb (1,3,5,7)	26.3	def	51.7	cd	1491	d-g
Zing, 34 floz (2,4,6); Penncozeb (1,3,5,7)	26.3	def	48.4	cd	1472	d-g
Priaxor Xemium, 8 floz (2,4,6); Penncozeb (1,3,5,7)	22.0	efg	62.5	abc	1381	efg
Scala, 7floz (2,4,6); Penncozeb 75DF, 1.5 lb (1,3,5,7)	22.1	efg	58.8	a-d	1335	fg
Topguard EQ, 14 floz (2,4,6); Penncozeb (1,3,5,7)	22.1	efg	55.0	bcd	1307	fg
Switch, 11 oz (2,4,6); Penncozeb (1,3,5,7)	18.5	fg	66.8	abc	1202	gh
P =	< 0.0001		0.0025		< 0.0001	

[w] Listed treatment (Trt) rates are per 100 gal/A basis unless noted otherwise. Treatments were applied 8 Oct, 15 Oct, 29 Oct, 12 Nov, 19 Nov, 4 Dec, and 11 Dec (corresponding with applications 1 to 7).
[x] The severity of disease was assessed as the percentage of canopy affected. The Horsfall-Barratt scale was used for all ratings, but values were converted to mid-percentages prior to statistical analyses.
[y] Area under the disease progress curve (AUDPC) values were calculated using the formula: Σ([(xi+xi-1)/2](ti-ti-1)) where x is the rating at each evaluation time and (ti-ti-1) is the time between evaluations.
[z] Means followed by the same letter are not significantly different according to Fisher's LSD test (α=0.05).

LITERATURE CITED

Adkison, H., Margenthaler, E., Burlacu, V., Willis, R., and Vallad, G.E. (2012). Occurance of resistance to respiratory inhibitors in *Corynespora cassiicola* isolates from Florida tomatoes. Phytopathology 102:S4.2.

Aguiar, F.M., Vallad, G.E., and Reis, A. (2016) In vitro sensitivity of *Corynespora cassiicola* isolates from different hosts and geographic regions from Brazil, to fungicides. V International Symposium on Tomato Diseases, submitted.

Alfieri, S.A., Jr., Langdon, K.R., Wehlburg, C. and Kimbrough, J.W. (1984). Index of Plant Diseases in Florida. Florida Dept. of Agriculture and Consumer Sciences, Division of Plant Industry. Bull. No. 11 (Revised). 389p.

Chase, A. R. (1982). Corynespora leaf spot of *Aeschynanthus pulcher* and related plants. Plant Disease 66:739-740.

Date, H., Kataoka, E., Tanina, K., Sasaki, S., Inoue, K., Nasu, H., and Kasuyama, S. 2004. Sensitivity of *Corynespora cassiicola*, causal agent of Corynespora leaf spot of cucumber, to thiophanate-methyl, diethofen- carb and azoxystrobin. Jpn. J. Phytopathol. 70:10-13.

Dixon, L. J., Schlub, R. L., Pernezny, K., & Datnoff, L. E. (2009). Host specialization and phylogenetic diversity of *Corynespora cassiicola*.Phytopathology, 99:1015-1027.

Ishii, H., Miyamoto, T., Ushio, S., & Kakishima, M. (2011). Lack of cross-resistance to a novel succinate dehydrogenase inhibitor, fluopyram, in highly boscalid-resistant isolates of *Corynespora cassiicola* and *Podosphaera xanthii*. Pest management science, 67:474-482.

Kingsland GC (1985) Pathogenicity and epidemiology of *Corynespora cassiicola* in the Republic of the Seychelles. Acta Hortic (ISHS) 153:229-230.

McRitchie, J. J., & Miller, J. W. (1973). Corynespora leaf spot of zebra plant. In Proc Fla State Hort Soc (Vol. 86, pp. 389-390).

Miyamoto, T., Ishii, H., Seko, T., Kobori, S., & Tomita, Y. (2009). Occurrence of *Corynespora cassiicola* isolates resistant to boscalid on cucumber in Ibaraki Prefecture, Japan. Plant Pathology, 58:1144-1151.

Miyamoto, T., Ishii, H., Stammler, G., Koch, A., Ogawara, T., Tomita, Y. & Kobori, S. (2010). Distribution and molecular characterization of *Corynespora cassiicola* isolates resistant to boscalid. Plant Pathology, 59:873-881.

Onesirosan, P. T., Arny, D. C., & Durbin, R. D. (1974). Host specificity of Nigerian and North American isolates of *Corynespora cassiicola*. Phytopathology, 64:1364-1367.

Pernezny, K., & Simone, G. W. (1993). Target spot of several vegetable crops. Plant Pathology Department PP-39. Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida. Available: http://edis. ifas. ufl. edu/VH052.

Pernezny, K., Datnoff, L.E., Mueller, T. and Collins, J. (1996). Losses in fresh-market tomato production in Florida due to target spot and bacterial spot and the benefits of protectant fungicides. Plant Disease 80:559-563.

Pernezny, K., Datnoff, L.E., Rtherford, B. and Carroll, A. (2000). Relationship of temperature, growth sporulation, and infection of tomato by the target spot fungus *Corynespora cassiicola*. 1999-2000 Report of Tomato Research Committee (Florida Tomato Committee).

Schlub, R. L., Smith, L. J., Datnoff, L. E., & Pernezny, K. (2009). An overview of target spot of tomato caused by *Corynespora cassiicola*. In II International Symposium on Tomato Diseases 808 (pp. 25-28).

Smith, L. J., Datnoff, L. E., Pernezny, K., & Schlub, R. L. (2009). Phylogenetic and pathogenic characterization of *Corynespora cassiicola* isolates. In II International Symposium on Tomato Diseases 808 (pp. 51-56).

Sobers EK (1966) A leaf spot disease of azalea and hydrangea caused by *Corynespora cassiicola*. Phytopathology 59:455-457.

Vallad, G.E. and Burlacu, V. (2011) Initial characterization of *Corynespora cassiicola* and *Alternaria* spp. affecting Florida tomatoes: Fungicide resistance, pathogen variability, and host resistance. Proceedings of the Florida Tomato Institute Proceedings, 2011. Naples, FL, p. 23-26.

Table 3. Evaluation of fungicide programs for the management of target spot in Fall 2014 field trials at GCREC, Wimauma, FL.

Fungicide Program	Treatment, Rate/A (applications)[w]	Disease Severity (%):[x] 14-Nov		16-Dec		13-Jan		AUDPC[y]		Diseased Fruit (%)	
1	Bravo Weatherstik, 2 pt (1-7); Fontelis, 16 floz (3,5,7); Scala, 7 floz (4,6); Inspire Super, 20 floz (5)	5.2	ab[z]	60.4	ab	73.4	ab	754	a	14.4	b
2	Penncozeb, 2 lb (1-7); Fontelis, 16 floz (3,5,7); Scala, 7 floz (4,7); Inspire Super, 20 floz (5)	3.0	b	42.6	bc	55.0	bc	532	b	16.3	b
3	Penncozeb, 2 lb (1-7); Fontelis, 16 floz (3,5,7); Scala, 7 floz (4); Inspire Super, 20 floz (5); Switch, 14 oz (6,7);	3.0	b	31.4	c	42.6	cd	415	bc	11.6	bc
4	Actigard, 0.5 oz (1-7); Penncozeb, 2 lb (1-7); Fontelis, 16 floz (3,5,7); Scala, 7 floz (4); Switch, 14 oz (6,7);	3.0	b	15.4	d	55.0	bc	346	c	14.0	bc
5	Actigard, 0.5 oz (1-7); Penncozeb, 2 lb (1-7); Folicur, 8 oz (2,4,6); Fontelis, 16 floz (3,5,7); Scala, 7 floz (4); Switch, 14 oz (6,7)	3.0	b	12.9	d	31.4	d	241	d	7.9	c
6	Non-Treated Control, (1-7)	9.1	a	76.3	a	97.0	a	999	a	34.4	a
	P =	0.0275		< 0.0001		< 0.0001		<0.0001		0.0032	

[w] Listed treatment rates are per acre basis unless noted otherwise. Treatments were applied 21 Oct, 28 Oct, 4 Nov, 12 Nov, 2 Dec, 15 Dec, and 21 Dec, corresponding to weekly applications of 1 to 7 above.

[x] The severity of disease was assessed as the percentage of canopy affected. The Horsfall-Barratt scale was used for all ratings, but values were converted to mid-percentages prior to statistical analyses.

[y] Area under the disease progress curve (AUDPC) values were calculated using the formula: $\Sigma([(x_i+x_{i-1})/2](t_i-t_{i-1}))$ where x_i is the rating at each evaluation time and (t_i-t_{i-1}) is the time between evaluations.

[z] Means followed by the same letter are not significantly different according to Fisher's LSD test (α=0.05).

Table 4. Evaluation of fungicide programs for the management of target spot in Fall 2015 field trials at GCREC, Wimauma, FL.

Fungicide Program	Treatment, rate (application)[w]	Disease Severity (%)[x] 2-Dec		Disease Severity (%)[x] 12-Dec	Diseased Fruit No.	Diseased Fruit Wt. (lb)
1	Cuprofix 40D, 2 lb (1-7); Penncozeb 75DF, 2 lb (1-7)	71.4	ab[y]	62.8	52.7	21.1
2	Bravo Weatherstik, 2 pt (1-7)	62.5	abc	64.6	31.7	15.7
3	Bravo Weatherstik, 1 pt (2x / wk; 1-7)	71.4	ab	62.8	40.9	17.0
4	Cuprofix, 2 lb (1-7); Penncozeb, 2 lb (1-7); Bravo Weatherstik, 2 pt (1-7)	55.0	bcd	40.6	30.0	12.5
5	Actigard, 0.5 oz (1-7); Bravo Weatherstik, 2 pt (1-7)	48.4	bcd	48.4	36.8	12.8
6	Actigard, 0.5 oz (1-7); Penncozeb, 2 lb (1-7)	55.0	bcd	67.1	46.6	19.1
7	Bravo Weatherstik, 2 pt (1-7); Fontelis, 16 floz (3,5,7); Scala, 7 floz (4,6); Inspire Super, 20 floz (5)	37.5	d	58.8	33.0	11.7
8	Penncozeb, 2 lb (1-7); Fontelis, 16 floz (3,5,7); Scala, 7 floz (4); Inspire Super, 20 floz (5)	42.6	cd	51.7	46.6	20.5
9	Penncozeb, 2 lb (1-7); Fontelis, 16 floz (3,5,7); Scala, 7 floz (4); Inspire Super, 20 floz (5); Switch, 14 oz (6,7)	62.8	abc	71.4	62.4	24.4
10	Actigard, 0.5 oz (1-7); Penncozeb, 2 lb (1-7); Fontelis, 16 floz (3,5,7); Scala, 7 floz (4,7); Inspire Super, 20 floz (5); Switch, 14 oz (6,7)	61.5	abc	66.9	51.0	18.2
11	Actigard, 0.5 oz (1-7); Penncozeb, 2 lb (1-7); Fontelis, 16 floz (3,5,7); Scala, 7 floz (4); Inspire Super, 20 floz (5); Switch, 14 oz (6,7); Folicur, 8 floz (2,4,6)	45.3	cd	59.7	40.9	17.6
12	Non-Treated Control	88.5	a	91.0	61.7	23.9
	P =	0.0094		0.2980	0.6458	0.6954

[w] Listed treatment rates are per 100 gal/acre basis unless noted otherwise. Treatments were applied 21 Oct, 28 Oct, 4 Nov, 12 Nov, 2 Dec, 15 Dec, and 21 Dec, corresponding to weekly applications of 1 to 7 above; in some cases applications were made two times per a week (2x).

[x] The severity of disease was assessed as the percentage of canopy affected. The Horsfall-Barratt scale was used for all ratings, but values were converted to mid-percentages prior to statistical analyses.

[y] Means followed by the same letter are not significantly different according to Fisher's LSD test (α=0.05).

Table 5. Common fungicides labelled for target spot on tomato.

Mode of action (FRAC)	Fungicide	Commercial name
Multi-site, contact fungicide (M3)	mancozeb	Dithane/Penncozeb
Multi-site, contact fungicide (M5)	chlorothalonil	Bravo
QoI; strobilurins (11)	azoxystrobin fluoxastrobin pyraclostrobin trifloxystrobin	Quadris Evito Cabrio Flint
QoI; non-strobilurins (11)	fenamidone famoxidone	Reason Tanos (+ cymoxanil)
SDHI; Succinate dehydrogenase inhibitors (7)	boscalid penthiopyrad fluopyram fluxapyroxad benzovindiflupyr	Endura Fontelis Luna Tranquility (+ pyrimethanil) Luna Sensation (+ trifloxystrobin) Priaxor (+ pyraclostrobin) AproviaTop (+ difenoconazole)
DMI; Demethylase inhibitors (3)	difenoconazole	RevusTop (+ mandipropamid) Inspire Super (+ cyprodinil) Inspire
Methionine biosynthesis inhibitors (9)	pyrimethanil cyprodinil	Scala Switch (+ fludioxonil) Inspire Super (+ difenoconazole)

Reducing Reliance on Neonicotinoid Insecticides in Florida Tomato Production

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WHITEFLY BIOTYPES IN FLORIDA

The sweetpotato whitefly, *Bemisia tabaci*, has been recorded in Florida since 1900. It rarely caused crop damage until 1986, when the B biotype of *B. tabaci* became established in the state. The B biotype is characterized by a wide host range, the ability to transmit over 150 viruses, the ability to induce crop disorders, including irregular ripening of tomato and silverleafing of squash, and the tendency to develop resistance to many insecticide modes of action. The B biotype quickly displaced the previous biotype in Florida, and has been the key pest of tomato in the state since the late 1980s, primarily due to its ability to transmit plant viruses, particularly *Tomato yellow leaf curl virus*. TYLCV was first reported in Florida in 1997.

Biotype Q of *B. tabaci* was first detected in Florida in 2004 in ornamental nurseries. Biotypes are morphologically identical and can only be distinguished by genetic analysis. Globally, biotype Q has been characterized by the tendency to develop resistance to neonicotinoid insecticides and growth regulators. Establishment of the Q biotype in field crops in Florida would present new challenges to the state's growers because of the Q biotype's tolerance to key insecticides and its ability to displace the B biotype in environments where insecticide use is prevalent. In order to confirm the biotype status of *B. tabaci* affecting crop production in the state, routine testing must be carried out. From late 2013 through early 2015, populations of *B. tabaci* were collected from nineteen agricultural sites in Hendry, Hillsborough, Indian River, Manatee, and Miami-Dade counties as part of a resistance monitoring project funded in part by the Florida Tomato Institute. Sixteen populations were collected from commercial tomato fields, two were collected from the wild host *Emilia fosbergii* (tasselflower) and one population was collected from squash. Analysis by Dr. Cindy McKenzie of USDA ARS - Fort Pierce confirmed that all populations belonged to the B biotype. However, from late April through early June of 2016, whiteflies collected from hibiscus at five sites in Palm Beach County and one site in Highlands County were confirmed by Dr. McKenzie to be biotype Q. Assistance is requested from the vegetable industry and crop protection professionals in submitting samples of adult whiteflies for biotype analysis. For assistance submitting samples, please contact Cindy McKenzie (tel.: 772-462-5917), Lance Osborne (407-461-8329; lsosborn@ufl.edu) or Hugh Smith (813-633-4124; hughasmith@ufl.edu).

SUSCEPTIBILITY TO GROUP 4 INSECTICIDES

The nineteen confirmed biotype B populations collected from south Florida were tested at the UF/IFAS Gulf Coast Research and Education Center (GCREC) for susceptibility to imidacloprid (Admire Pro, many generics), thiamethoxam (Platinum), dinotefuran (Venom, Scorpion) and flupyradifurone (Sivanto Prime). The first three materials are classified as neonicotinoid insecticides (Group 4A) and flupyradifurone is classified as a butenolide insecticide (Group 4D) by the Insecticide Resistance Action Committee (IRAC). They all function as nicotinic acetylcholine agonists in terms of mode of action (MoA) as indicated by the IRAC Mode of Action code 4.

Susceptibility of a population to an insecticide is measured by calculating the concentration needed to kill 50% of a population subsample in a laboratory bioassay. This concentration is referred to as the LC_{50}. If the 95% fiducial (confidence) limits associated with the LC_{50}s of two populations overlap, then the LC_{50}s are considered not significantly different. Eleven field populations produced LC_{50}s for one or more insecticide that were not statistically different from the susceptible laboratory colony based on overlapping fiducial limits, indicating a similar degree of susceptibility. Two of these populations produced LC_{50}s that were not statistically different from the laboratory colony for any of the four materials tested. Seven populations produced LC_{50}s that were more than 50-fold above the laboratory colony value for imidacloprid; five populations produced LC_{50}s that were more than 50-fold above the laboratory colony for thiamethoxam and/or flupyradifurone; and 1 population produced an LC_{50} that was more than 50-fold above the laboratory colony for dinotefuran. These high LC_{50}s indicate tolerance among populations to materials tested. On the whole, populations responded in a similar way to Admire and Platinum, and in a similar way to Venom and Sivanto (Figure 1).

THE TREATMENT WINDOW APPROACH TO RESISTANCE MANAGEMENT OF *B. TABACI*.

The University of Florida recommends that a treatment window approach be used to managing *Bemisia tabaci*, TYLCV and insecticide resistance in tomato and other crops. The objective is to avoid treating successive generations of the pest with compounds from the same MoA group. In general, the cross-resistance potential between sub-groups is higher than that between different groups, so rotation between sub-groups, for example groups 4A and 4D should be avoided. Nevertheless, we are still seeing relatively low levels of tolerance to flupyradifurone (Sivanto) compared to thiamethoxam and imidacloprid (Figure 1).

Since most transplants are treated with imidacloprid in the plant house and this or another group 4 insecticide at planting, the final application of a group 4 insecticide should be made not later than 30 days after planting. Alternately, the crop could be treated at planting with a soil formulation of the diamide insecticide cyantraniliprole (Verimark) saving the group 4 insecticides for the second five week treatment window. This has proved to be an effective strategy against whiteflies although using group 4 insecticides during the first five-week treatment window and

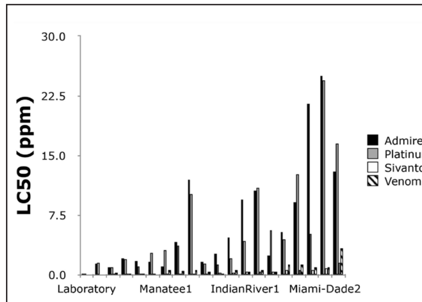

Figure 1. LC50s (ppm) for nineteen field populations of B. tabaci biotype B and a susceptible laboratory colony to four group 4 insecticides.

cyantraniliprole during the second five-week treatment window has the advantage of also providing control of leafminers and caterpillars which tend to become problematic during the later vegetative and early fruiting stages of the crop. Chlorantraniliprole, the active ingredient in Coragen, is also effective against these pests but not against whiteflies, so is often used in premixes containing thiamethoxam (group 4A). Keep in mind that the strategy of separating and confining group 4 and group 28 insecticides during the first 2 crop windows obviates the use of premixes containing both modes of action.

So, what soil applied insecticides are best for whitefly control? In one trial at SWREC comparing drenches at planting of Admire Pro and Verimark, numbers of adults and nymphs were generally lower with the Verimark drench although not significantly so on any sample date (Table 1). In another trial, each plot was inoculated with a TYLCV infected plant. Drenches with two 4A products (Admire Pro and Venom) and a 4D product (Sivanto, applied by both drench and drip) were compared. The Sivanto drench provided best whitefly control and lowest incidence of TYLCV (Table 2). Finally, drench applications of Admire Pro, Venom and Verimark at 16.4 fl oz/ac were compared with 3 drip applications of Verimark at 10.25 fl oz/ac (totaling 30.75 fl oz/ac). Not surprisingly, the drench application of Verimark gave the best control early season and the 3 drip application gave the best control late season (Table 3). This translated to lowest TYLCV incidence for the drench application of Verimark through the end of the season.

The take home message from these trials is that at-planting application of systemic insecticides is critical for good whitefly and TYLCV control. Therefore, it makes sense to use the best product available for the job. These days, the most effective products for this purpose are not always 4A neonicotinoids. Possibly, relieving pressure on these products by leaving them out of some crops would reduce selection for resistance and possibly bring them back to their former strength.

BIOPESTICIDE TRIALS

Biopesticides are reduced risk materials that usually have a 4 hour re-entry interval and zero day preharvest interval. They are as a rule more compatible with the use of biocontrol agents and commercial pollinators than conventional insecticides; however impacts of biopesticides on non-target organisms must be evaluated on a case by case basis. The need for pollinator-compatible whitefly management tools is particularly acute in greenhouse tomato production, where deployment of commercial hives is essential.

Trials were initiated in 2015 at GCREC to evaluate nine biopesticides for control of whitefly nymphs on greenhouse tomato as part of the IR4 Biopesticide Program. The biopesticides evaluated were Botanigard ES (*Beauveria bassiana* strain GHA), Grandevo (*Chromobacterium subtsugae*), M-Pede (potassium salts of fatty acids), Mycotrol-O (*Beauveria bassiana* strain GHA), PFR-97 (*Isaria fumosorosea* Apopka strain 97), Requiem (*Chenopodium ambrosioides),* and the unregistered products Agri-Colle and EPL-1001. Biopesticides were compared to Sivanto 200 SL as a conventional standard. Three weekly applications resulted in whitefly nymph numbers that were numerically lower for each material compared to the untreated control; however only the M-Pede and Sivanto treatments resulted in numbers of whitefly nymphs that were sta-

Table 1. Effect on *B. tabaci* populations of drench applications at planting with Admire Pro 4.6 EC @ 10.5 fl oz/ac or Verimark 20 SC at 13.5 fl oz/ac followed up a month later by weekly sprays of Hero at 10.3 fl oz/ac + Malathion 5 EC @ 32 fl oz/ac, SWFREC Immokalee.

	Adults per Leaf						
Treatments	**25-Sept.**	**9-Oct.**	**16-Oct.**	**23-Oct.**	**30-Oct.**	**7-Nov.**	**12-Nov. (Adults) 18-Nov. (Nymphs)**
Check	0.69 a	0.53 a	0.85 a	1.44 a	1.44 a	4.88 a	4.65 a
AdmirePro	0.28 b	0.03 c	0.09 bc	0.28 bc	0.16 bc	0.13 c	0.41 bc
Verimark	0.13 b	0.06 bc	0.03 c	0.16 c	0.03 c	0.19 bc	0.25 c
				Nymphs per 4 in²			
Check		13.90 a	11.15 a	12.70 a	15.70 a	31.55 a	27.75 a
AdmirePro		1.15 bc	1.65 bc	1.60 bc	0.70 b	1.20 b	1.40 b
Verimark		0.20 c	0.50 c	0.90 c	0.65 b	0.60 b	0.70 b

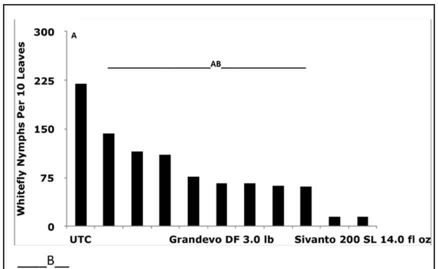

Figure 2. Average number of whitefly nymphs on greenhouse tomato treated with nine biopesticides or Sivanto. GCREC, summer 2015. F10, 30=3.35; P=0.005.

Table 2. Effect on whitefly adults and nymphs and incidence of TYLCV from application of Venom 70 SG @ 6 oz/ac, Sivanto 200 SL @ 21 fl oz/ac, and Admire Pro 4.6 SC at 10 fl oz/ac made on 7 March 2011, 5 days after planting and Sivanto 200 SL applied by drip on 8 Mar, SWFREC Immokalee. A TYLCV positive plant in the middle of each plot provided a uniform source of virus inoculum.

		Adults per five leaflets					
Treatment		**30-Mar**	**6-Apr**	**13-Apr**	**20-Apr**	**27-Apr**	**4-May**
Check		0.58 ab	0.35 ab	0.73 a	1.45 a	2.03 a	2.38 a
Venom	Drench	0.23 cd	0.13c	0.28 bc	1.13 ab	1.43 abc	1.60 b
Admire Pro	Drench	0.30 bcd	0.15 bc	0.48 ab	1.08 ab	1.93 a	1.50 b
Sivanto	Drip	0.53 abc	0.23 bc	0.25 bc	0.80 bcd	1.18 bcd	1.53 b
Sivanto	Drench	0.15 d	0.03 c	0.15 c	0.38 d	0.58 d	0.83 c
					Nymphs per 4 sq inches		
Check				10.83 a	15.67 a	25.71 a	
Venom	Drench			3.79 de	11.71 ab	24.83 a	
Admire Pro	Drench			6.50 bc	13.13 ab	17.54 bc	
Sivanto	Drip			2.17 ef	7.21 bc	19.42 ab	
Sivanto	Drench			1.38 f	2.33 c	7.50 d	
					Plants with TYLCV symptoms (%)		
Check				20.0	70.0	90.0	97.5
Venom	Drench			17.5	40.0	75.0	92.5
Admire Pro	Drench			26.3	54.1	70.3	75.7
Sivanto	Drip			32.5	47.5	75.0	95.0
Sivanto	Drench			5.0	17.5	52.5	62.5

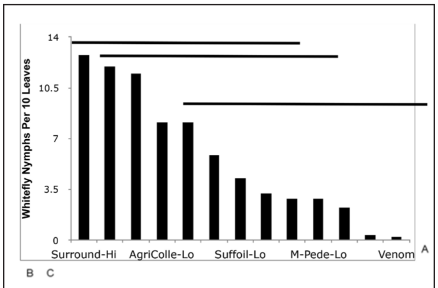

Figure 3. Average number of whitefly nymphs on field tomato treated with five biopesticides at two rates and two neonicotinoid treatments, GCREC, spring 2016. F12, 39=7.22; P< 0.0001.

tistically lower than the untreated control (Figure 2).

Trials were initiated in the spring of 2016 at GCREC to determine the potential of biopesticides as alternatives to neonicotinoid treatments during the first five week treatment window in field tomato. Five biopesticides were applied weekly at high and low rates from the week of transplanting until five weeks after transplanting, at which point all treated plots received the same rotation of conventional insecticides. The five biopesticides evaluated were Agricolle at 0.195 and 0.10 gal./acre; EPL-1001 at 0.32 and 0.21 gal./acre; M-Pede at 1.2 and 0.6 gal./acre; Surround WP (kaolin clay) at 15 or 7.5 lbs/acre; and Suffoil-X at 1.2 and 0.6 gal./acre. These biopesticide treatments were compared to two neonicotinoid treatments: Admire Pro (10.5 fl. oz./acre) at–plant followed by Platinum (3.67 fl. oz./acre) three weeks after planting; and Venom (6.0 oz./acre) at-plant followed by Venom (6.0 oz./acre) three weeks after planting. Five weeks after planting, total whitefly nymph numbers were significantly lower than the untreated control in the high rate of M-Pede and the Venom treatments, but not in other treatments (Figure 3). Phytotoxicity was observed on some treatments in the greenhouse trial but not in the field trial. Evaluations of biopesticides in the greenhouse and field are ongoing at GCREC.

Herbicide Resistance Management in Tomato

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WHAT IS HERBICIDE RESISTANCE?

Herbicide resistance is the inherited ability of a formerly susceptible plant to survive and reproduce following exposure to an herbicide dose that would normally killesusceptible plants. Resistance naturally occurs within a population but can also be induced by techniques such as genetic engineering (Ross and Lembi 2009). The portion of a plant population that is resistant is typically referred to as the resistant biotype. Resistance can be a result of a variety of reasons including mutations that inhibit binding of the herbicide to target sites within the plant or changes in herbicide movement throughout the plant. It is important to keep in mind that it is only considered true resistance if a genetic change occurs that can be inherited by the plant's offspring.

Herbicide tolerance is when a plant is naturally tolerant to a given herbicide dose and will survive and reproduce following application (Ross and Lembi 2009). This implies that the plant was never susceptible to the herbicide. The majority of herbicides utilized in agriculture are selective which means they are only effective on certain species and other species are naturally tolerant. It is important to differentiate between tolerance and the development of resistance. It is also important to differentiate between resistance and herbicide failure. Factors that may reduce herbicide effectiveness include

1. Weed Related Issues
   a. Herbicides rarely work on all species. Even broad spectrum herbicides such as glyphosate do not kill all species. Some species are naturally tolerant and this should not be confused with resistance.
   b. As a general rule, weeds are more susceptible when they are small. Larger weeds and weeds that are or have flowered are more difficult to kill. For example, biennial weeds (those that form rosettes and then flower after a period of dormancy) are much more difficult to kill once they flower.
   c. Many herbicides (ex. glyphosate) work best when weeds are actively growing. Dormant plants or plants stressed due to heat or dry soil conditions may not be adequately controlled by herbicides that are typically effective.
   d. Many perennial plants have extensive root systems and underground reproductive organs. A single herbicide application may not kill all plant organs enabling the weed to recover.
2. Application Related Issues
   a. Poor calibration or the use of reduced rates can decrease herbicide efficacy and promote the development of resistance. Use the recommended label rate.
   b. Herbicide applications immediately prior to rainfall or during periods of high wind can reduce the amount of herbicide taken up by the plant and reduce overall effectiveness.
   c. Poor coverage of the leaf can reduce efficacy especially with herbicides with low mobility within a plant (ex. Paraquat)
   d. Water quality (pH or hardness) can cause herbicides to be broken down within the tank and reduce activity in the plant or rates of uptake. Have water tested, adjust pH or add appropriate water conditioners when necessary, and do not leave herbicides

stored in spray equipment for extended periods of time. It is best to only mix what you can spray immediately.

e. Many herbicides can be safely tank-mixed but in some cases one herbicide will inhibit the activity of another

f. Time of day can also affect uptake

g. Improper use of adjuvants or not including a surfactant when recommended can reduce herbicide uptake and efficacy

h. Crop canopy interference or shading by other plants can intercept the herbicide and prevent it from coming in contact with the intended target.

HOW DOES HERBICIDE RESISTANCE DEVELOP?

Mutations naturally occur within any plant population. In some cases, the mutations make a plant non-susceptible to an herbicide that killed it in the past. The larger the plant population the more likely that such a mutation will occur. Subsequent herbicide applications will kill susceptible plants leaving the resistant biotype to grow and produce seeds. If the same mode of action is applied repeatedly, the susceptible plants will die leaving the resistant biotypes to produce seed. With repeated applications the resistant biotype will eventually dominate and the entire population of a given species can become resistant to the herbicide. If a population is resistant to one mode of action it is very common for it to be resistant to other herbicides with the same mode of action even if that herbicide has never been applied to a given field in the past. It is also possible for weeds to become resistant to multiple modes of action. The time frame for resistance to develop varies widely but it is common for plant populations to become resistant after a decade of continuous use of a product.

Herbicides differ in the likelihood of the development of resistance, the rate at which resistance develops, and the number of species that develop resistance. For example, there are more species resistant to ALS and PSII inhibitors than other modes of action (Figure 1). This is important for tomato growers to consider because halosulfuron (Sandea) is the only post-emergence herbicide that can be used for nutsedge control in tomatoes and it is an ALS inhibitor. This would suggest that there is a fairly good chance that nutsedge plants will develop resistance to halosulfuron after multiple years of use. Certain herbicide characteristics make them more prone to resistance. This includes herbicides that have a single binding site within a plant, herbicides that persist for extended periods in the soil, and herbicides that are highly effective.

There are far fewer herbicide resistant weeds in vegetables than many other crops (Figure 2). There are many reasons for this difference including: 1) the limited use of herbicides in vegetable crops in the past, 2) the use of fumigants and plastic mulches, 3) intensive cultivation, and 4) the use of hand weeding to remove survivors. Resistant weeds most frequently appear when vegetable crops are grown in areas where agronomic crops were grown in the past or where broad spectrum herbicides are used repeatedly across a range of vegetable crops for pre-transplant burn down or crop termination. The development of paraquat resistance in goosegrass is a good example of the latter phenomenon. The loss of methyl bromide has led to an increased reliance on herbicides as most of the registered fumigant alternatives do not adequately control weeds. Herbicide resistance is likely to occur with increased use but practices such as hand weeding will also inhibit or slow its development. Ironically, though herbicide resistance tends to develop slowly in vegetable crops once it occurs it is likely to spread rapidly and cause serious yield losses because: 1) there are a limited number of herbicides registered for use in vegetable crops making it difficult to find and rotate alternative modes of action, 2) vegetables rarely form a competitive canopy, and 3) vegetables are very susceptible to competition. Steps should be taken to slow the development of herbicide resistance espe-

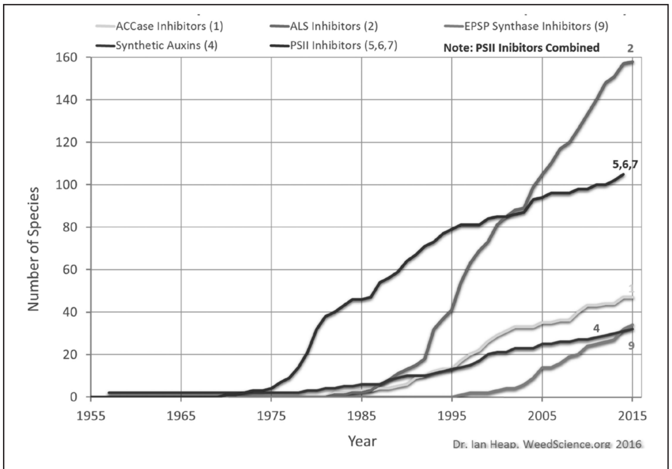

Figure 1. The number of resistant species for multiple herbicide sites of action (Heap 2016).

Table 1. Herbicide resistant weeds that may occur in Florida vegetable fields and the mode of action to which they are resistant.

Common name	Latin name	Mode of action
American black nightshade	*Solanum americanum*	PSI electron diverter
Goosegrass	*Eleusine indica*	PSI electron diverter
Palmer amaranth	*Amaranthus palmeri*	ALS inhibitors EPSP synthase inhibitors
Ragweed parthenium	*Parthenium hysterophorus*	EPSP synthase inhibitors

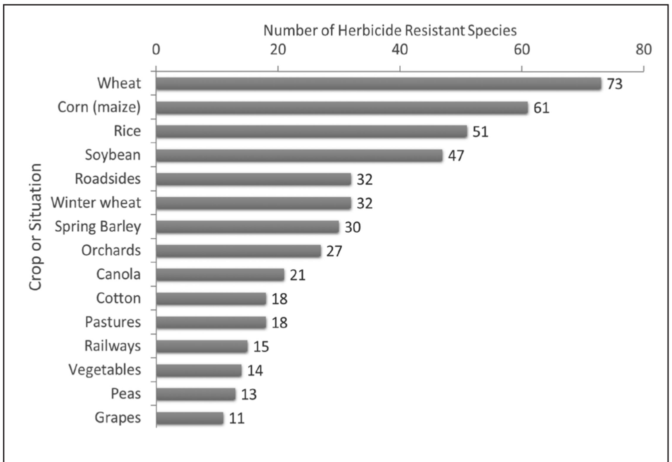

Figure 2. The number of herbicide resistant species within different crops (Heap (2016).

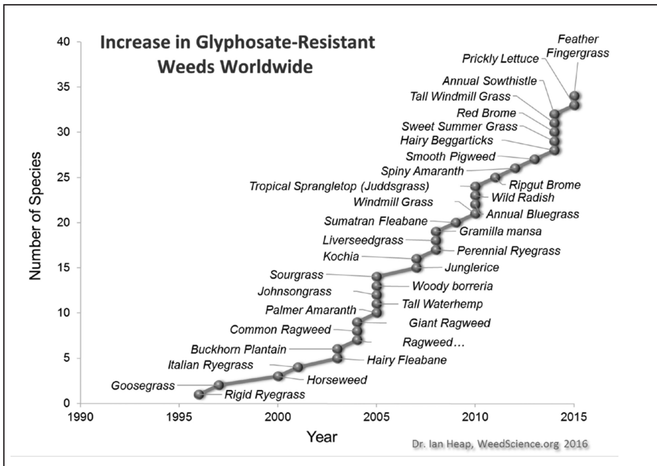

Figure 3. Weeds resistant to glyphosate worldwide.

cially given that the number of weed species that have become resistant to herbicides has dramatically increased over time and given that many of these resistant weed species commonly occur in vegetables (Figure 3). For example, goosegrass, ragweed, and wild radish are all species that commonly occur in vegetable crops and have developed resistance to glyphosate in certain regions of the world. All growers need to take the appropriate steps to reduce the risk of the development of herbicide resistance because poor management by one individual can have negative consequences for the entire community.

DETECTION AND RESPONSE TO RESISTANCE

If herbicide resistance is suspected please contact your county extension agent as soon as possible for guidance. General recommendations include:

1. Retreat the area with a different mode of action if possible
2. Use cultivators or hand weeding to remove the suspected resistant weeds
3. If necessary, destroy the localized area of the field where the resistant weeds occur
4. Rotate herbicide products and crops in subsequent years

A rapid response to suspected herbicide resistance and efforts to remove the weed before it becomes a widespread problem can significantly reduce long-term management costs. There are several indicators that suggest the advent of herbicide resistance. They include:

1. Good weed control is observed in most of the field except in localized areas. If overall poor control is observed it is very unlikely to be resistance
2. A species that used to be controlled by a particular herbicide is no longer controlled and the number of plants of that particular species is increasing from year to year
3. The uncontrolled species appears in a localized patch that spreads from year to year.
4. Dead plants of the same species are inter-mixed with plants that survived the herbicide application

Resistance can only be confirmed by studies that examine the susceptibility of a particular weed species to a range of herbicide rates. This type of research takes time but can be conducted by many weed scientists that are located at the University of Florida.

HERBICIDE RESISTANT WEEDS IN FLORIDA

The weed species present in Florida that have documented herbicide resistance can be found in table 1 (Heap 2016). This is not to say that other resistant species do not occur in Florida but this table contains the list of documented species. Herbicide resistant goosegrass is a good example of a weed that is wide spread in vegetables that is resistant to a broad spectrum herbicide (paraquat). Management of this resistant weed can lead to increased costs and yield losses. There are other weed species that are a concern for tomato growers. One key example that was mentioned earlier is nutsedge. The only post emergence herbicide for nutsedge control in tomato is halosulfuron which is typically applied repeatedly over time and in some cases multiple times in the same year. The development of resistance to this herbicide over time is likely.

MANAGEMENT OF HERBICIDE RESISTANCE

There are several management options that can delay the onset of herbicide resistance. They include:

1. Use of different modes of action over time (Vencill et al 2012). This also can be difficult for tomato growers as there are limited herbicides registered for use in tomatoes. However, there are multiple products registered for use under the plastic and the rotation of these products can delay the onset of herbicide resistance. The rotation of broad-spectrum herbicides such as paraquat which is used for pre-plant burn down or crop termination with herbicides applied under the plastic mulch can also delay the onset of resistance (Beckie 2007). In addition, the use of herbicides during the fallow period that are not used immediately prior to transplant or during the cropping period can help ensure the rotation of multiple modes of action.
2. Tank mix herbicides with multiple modes of action. A tank mix of multiple modes of action may be more effective at delaying herbicide resistance than the rotation of multiple products. However, tank mixes are more expensive and will only work as effective resistance management tools if both modes of action have activity on the same weed species during the same time period.
3. Rotate non-chemical techniques with herbicide: Rotating modes of action and the use of tank mixes will delay the development of resistance but they will not prevent it. To prevent herbicide resistance growers must adopt an integrated approach that incorporates chemical and non-chemical techniques (Evans et al. 2014). Potential tools include the use of plastic mulches to reduce weed populations, hand removal of weeds that emerge in the planting holes, and the use of cultivation as an additional technique to be used during fallow periods to kill emerged weeds.
4. Crop Rotation: This is a difficult option for individuals or companies that only produce tomatoes. The use of cover crops, cover crop/herbicide combinations or multiple herbicide chemistries during the fallow period can help reduce or delay the development of herbicide resistance.
5. Control weeds that survive herbicide applications with hand weeding or other techniques

Herbicide resistance is an issue that has the potential to affect all growers. Careful use of herbicides and the development of integrated pest management programs will at least delay the development of resistance and will reduce long-term weed management costs.

REFERENCES

Beckie H. 2007. Beneficial management practices to combat herbicide-resistant grass weeds in the northern Great Plains. Weed Technology. 21:290-299.

Evans J.A, P.J. Tranel, A.G. Hager, B. Schutte, C. Wu, L.A. Chatham and A. Davis. 2016. Managing the evolution of herbicide resistance. Pest Management Science. 72:74-80.

Ross M.A, C.A. Lembi. 2009. Applied weed science, including the ecology and management of invasive plants. 3rd edition. Pearson Prentice Hall. Pp 209-225.

Vencill W.K, R.L. Nichols, T.M. Webster, J.K. Soteres, C Mallory-Smith, N.R. Burgos, W.G. Johnson, and M.R. McCelland. 2012. Herbicide resistance: Toward an understanding of resistance development and the impact of herbicide-resistant crops. Weed Science. 60:2-30.

Heap, I. 2016. The International Survey of Herbicide Resistant Weeds. Online. Internet. June 21, 2016. Available www.weedscience.com

Possible Impacts of the Whitefly Q Biotype on Viral Diseases in Tomato

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EXECUTIVE SUMMARY

A new type of *Bemisa tabaci*, known as the Mediterranean clade (formerly Q biotype), has appeared in Florida this past spring. This whitefly is known to feed and transmit a number of viruses to and from tomato. It is most likely going to co-exist with whiteflies in the MEAM1 clade (formerly known as the B biotype) which has been in Florida since the mid1980's. This Mediterranean whitefly is known to be more resistant to pesticides than the MEAM1 whitefly. Based on our limited knowledge of its biology and its effect in other parts of the world, it is possible that we will see new viruses, lose some viruses, and see changes in the frequency of virus-infected plants. Because we lack sufficient biological information, it is not possible to make predictions as to what is likely to occur.

INTRODUCTION

The whitefly, *Bemisia tabaci* is actually a mixture of different whiteflies with different biological characteristics that together have caused many millions of dollars of crop damage around the world. These whiteflies are considered one of the world's top 100 invasive species (International Union for the Conservation of Nature and Natural Resources (IUCN) list (http://www.issg.org). *B. tabaci* is composed of whiteflies from at least 34 distinct genetic groups, each of which will soon be recognized as different species. Fortunately we only have two of these genetics groups, biotype B which is now known as *B. tabaci* MEAM1 (MEAN = Middle East Asia Minor 1) and more recently, biotype Q, which is known as *B. tabaci* Mediterranean. While both look very similar, they have several different biological characteristics that impact their roles as agricultural pests.

Whiteflies in the different clades can cause several types of damage to plants; direct damage, indirect damage due to the growth of sooty mold fungi on the whitefly honeydew and lastly, the transmission of plant viruses. Both *B. tabaci* MEAN1 and Mediterranean are known to cause all 3 types of damage. By far the most widespread damage caused by many members of the complex is through the transmission of a large number of economically important viral plant pathogens belonging to the genera: *Begomovirus, Carlavirus, Criniviruses, Ipomovirus*, and *Torradovirus* (Table 1). To date, whiteflies in the *B tabaci* complex are known to transmit at least 350 different species of virus. These viruses are transmitted in different ways (non-persistent, semi-persistent or persistent, circulative) depending upon the genus. All virus species within a genus are transmitted in the same manner.

TYPES OF TRANSMISSION BY *BEMISIA TABACI*

Non-persistent. Virus is acquired by brief probing of the infected plant by the whitefly. Most likely the virus is retained in the stylet of the whitefly (based on aphid models), and can be transmitted to a healthy plant within a few minutes. The virus is only retained by the whitefly until it probes again. So the transmission process is very fast.

Semi-persistent. The specifics depend upon the virus. In the case of viruses in the genus *Crinivirus*, the virus is acquired in less than 1 hour, transmitted within a few hours, and can be retained in the insect for as long as 3 to 5 days. In the case of viruses in the genus of *Ipomovirus*, the virus can be acquired in less than 1 hour, transmitted within a few hours, and can be retained for up to 1 day. The longer the whiteflies spend on the infected plant the greater the number of whiteflies that will acquire virus and become viruliferous (ie able to transmit).

Persistent, circulative. Viruses transmitted in this manner are acquired by feeding, which requires a minimum time of 15-30 minutes for the whitefly to reach the phloem and begin feeding. Once acquired the virus cannot be transmitted for 6 to 8 hours. But once that has occurred the virus can be retained up to the life span of the whitefly which can be as long as several weeks. The longer the whiteflies spend on the infected plant the greater the number of whiteflies that will acquire virus and become viruliferous.

We know relatively little about the transmission capabilities of these different whiteflies with different viruses. Our greatest knowledge is of viruses in the *Begomovirus* and *Crinivirus* genera, although we still have many important questions that need to be addressed in order to predict changes that can occur with the introduction of a new whitefly from a different clade, as well as to design better management recommendations. In addition, we lack basic knowledge of the transmission of virus species in the genera *Carlavirus, Ipomovirus,* and *Torradovirus*. This is because for most studies, the whitefly used in transmission studies was not identified beyond species (i.e. *B. tabaci*). And since many of these studies were conducted years ago, it is not possible to connect the virus species with its vector in the *B. tabaci* complex.

The acquisition and transmission of viruses transmitted in a semi-persistent and persistent manner by a whitefly is dependent upon how long the whitefly feeds. The more time a whitefly spends feeding on an infected plant, the more likely it is the whitefly will acquire the virus. And the more time a viruliferous whitefly spends feeding on a healthy plant, the more likely it is the whitefly will transmit the virus. Transmission of a virus in the fields is dependent upon many factors: preference of the whiteflies for the virus-infected hosts, presence of virus-infected hosts in time and space (including crop, weed, and wild plants), size of the population of the whitefly, timing of the increase in whitefly populations, and response of the whitefly to insect management practices. While we now understand many of these factors for MEAM1 and the viruses that we have experienced in Florida (ie TYLCV, ToMoV, BGYMV) we know very little of how the Mediterranean whitefly will behave.

BIOLOGICAL COMPARISON OF MEAM1 AND MEDITERRANEAN WHITEFLIES

Similarities and differences in biology between the two whiteflies might affect what virus diseases occur in tomato. Following is a brief summary of what is known and why the introduction of the Mediterranean whitefly, a whitefly from a different clade might change what viruses will appear in tomato crops in Florida in the future.

Competition and Population Size. It has been shown that some whitefly clades are more competitive than others. For example, MEAM1 whiteflies outcompeted the whitefly (clade unknown) that existed in Florida prior to the mid1980s. In fact the MEAM1 was so much better (likely due to more hosts and higher reproductive rates) that the original whitefly is believed to be extinct. This same scenario has happened in many locations. The Mediterranean whitefly has been shown to co-exist with MEAM1 in several locations (China, Spain, Israel). We know that the Mediterranean whitefly can outcompete the MEAM1 whitefly in the presence of pesticides, but in the absence of pesticides the MEAM1 whitefly will outcompete the Mediterranean. It is likely that these two whiteflies will be able to co-exist in Florida.

Host Range. Both the MEAM1 and Mediterranean whitefly will feed and reproduce on tomato. However we do not know whether there are any alternate hosts (other crops, weeds, wild plants) that will give an advantage to one or the other whitefly. Comparisons of the preferred hosts of the two whiteflies have not been made. If the Mediterranean whitefly feeds on hosts that the MEAM1 does not, then it is likely that any whitefly-transmitted viruses in those hosts could be inoculated into tomato. This is why we saw the appearance of *Tomato mottle virus* in Florida after the introduction of the MEAM1 whitefly. This virus was present in wild plants, various *Sida spp*., and was not inoculated into tomato until the new whitefly appeared which fed on both *Sida spp*. and tomato, and moved the virus from the weed into the crop. Unfortunately, we know very little about the plant hosts in Florida where the Mediterranean whitefly will feed. There are a number of viruses present in wild plants that can be transmitted by *B. tabaci*. It is possible that some of them my find their way into tomato now that we have a new whitefly.

Transmission Differences. Limited studies have indicated that there are few differences among the clades in their ability to transmit any given virus, however differences in efficiency have been measured. A few comparisons are shown in Table 2. For example, *Tomato leaf curl Taiwan virus* (ToLCTWV) was shown to be transmitted more efficiently by MEAM1 than by Mediterranean whitefly. At the same time, the MEAM1 whitefly transmitted TYLCTHV more efficiently than ToLCTWV. As a result, ToLCTWV disappeared but TYLCTHV was still present in tomato fields in Taiwan. For other viruses tested, the transmission efficiency was found to depend upon the infected host plant. In the case of TYLCV, two studies were conducted that gave different results. In one study, TYLCV was found to be transmitted equally as efficiently by the two whiteflies, and in the other study the Mediterranean whitefly was more efficient than the MEAM1 whitefly. The different results are most likely due to differences in the way the experiments were conducted. In an unrelated study, these two whiteflies were found to transmit *Cucurbit yellow stunting disorder virus* (CYSDV) with equal efficiency. Unfortunately, similar comparisons have not been conducted for most whitefly-transmitted viruses.

These biological differences between the MEAM1 and Mediterranean whiteflies may result in the following in any crop in Florida:

1. Appearance of new viruses
2. Disappearance of established viruses
3. Changes in frequency of plants infected with any whitefly-transmitted virus
4. Appearance of new diseases (virus known in a crop is found in another crop for the first time)
5. These changes can also result in regulatory responses by other states and countries that want to exclude the whiteflies, the viruses they transmit, or both.

CONCLUSIONS

The introduction of a whitefly with different biological characteristics can be expected to have an effect on the presence of whitefly-transmitted viruses. This occurred in the mid1980's in Florida when MEAM1 (formerly B biotype) appeared in Florida and caused the appearance of a number of new viruses in Florida crops. The Mediterranean whitefly may also cause changes, although hopefully not as great as those of MEAM1.

Table 1. Summary of virus families and genera reported to be transmitted by whiteflies in the ***Bemisia tabaci*** species complex

Virus Family	Virus Genus	No. of Approved Species	Mode of Transmission
Betaflexiviridae	Carlavirus	4	Non-persistent
Closteroviridae	Crinivirus	13	Semi-persistent
Geminiviridae	Begomovirus	322	Persistent, circulative
Potyviridae	Ipomovirus	6	Semi-persistent
Secoviridae	Torradovirus	5	Undetermined

Table 2. Comparison of viruses known to be transmitted by ***B. tabaci*** MEAM1 and/or Mediterranean

Virus Genus	Virus Species*	Transmission by MEAM1	Transmission by Mediterranean	Difference in Transmission Rates
Begomovirus	*Bean golden yellow mosaic virus* (BGYMV)	yes	?	?
	Tomato leaf curl Taiwan virus (ToLCTWV)	yes	yes	MEAM1 better than Med.
	Tomato mottle virus (ToMoV)	yes	?	?
	Tomato yellow leaf curl virus (TYLCV)	yes	yes	Similar, or Med better than MEAM1
	Tomato yellow leaf curl Sardinia virus (TYLCSV)	yes	yes	Depends on host plant
	Tomato yellow leaf curl Thailand virus (TYLCVThV)	yes	yes	MEAM1 better than Med.
Carlavirus	*Cowpea mild mottle virus* (CpMMV)	yes	?	?
	Melon yellowing-associated virus (MYaV)	yes	?	?
Crinivirus	*Cucurbit chlorotic yellows virus* (CCYV)	yes	yes	?
	Cucurbit yellow stunting disorder virus (CYSDV)	yes	yes	similar
	Tomato chlorosis virus (ToCV)	yes	?	?
Ipomovirus	*Squash vein yellowing virus* (SqVYV)	yes	?	?
	Cucumber vein yellowing virus (CVYV)	yes	?	?
Torradovirus	*Tomato necrotic dwarf virus* (TNDV)	yes	?	?
	Tomato torrado virus (TToV)	?	?	?

* Virus species that occur in Florida are shaded.
? – Not reported

Tomato Varieties for Florida

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Variety selections, often made several months before planting, are one of the most important management decisions may 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 1400 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 1, race 2, and in some areas race 3; Verticillium wilt (race 1); Gray leaf spot; and some tolerance to Bacterial soft rot. Available resistance to other diseases may be important in certain situations, such as Tomato yellow leaf curl in south and central Florida and Tomato spotted wilt and Bacterial wilt resistance in northwest Florida.

Horticultural Quality – Plant habit, stem type 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. In years past, we have been able to give a breakdown of which varieties are used and predominantly where they were being used but this information is no longer available through the USDA Crop Reporting Service.

TOMATO VARIETIES FOR COMMERCIAL PRODUCTION

The following varieties are currently popular with Florida growers or have done well in university trials. It is by no means a comprehensive list of all varieties that may be adapted to Florida conditions. Growers should try new varieties on a limited basis to see how they perform for them.

LARGE FRUITED VARIETIES

1. LARGE FRUITED AND BEEFSTAKE TYPES

Amelia. Main season maturity. Determinate. Vigorous, jointed hybrid. Fruit are firm and aromatic suitable for green or vine ripe. Good crack resistance. Resistance: Fusarium wilt (races 1, 2, and 3), Verticillium wilt (race 1), Root-knot nematode. Tomato spotted wilt, and Gray leaf spot.

Bella Rosa. Midseason maturity. Determinate. Medium to tall vine. Fruit are large to extra-large, deep globed shaped fruit with firm, uniform green fruits well suited for mature green or vine-ripe production. Resistance: Fusarium wilt (races 1 and 2), Verticillium wilt (race 1), Tomato spotted wilt, and Gray leaf spot.

BHN 602. Early midseason maturity. Determinate. Fruit are globe shaped but larger than BHN 640 and green shouldered. Resistance: Fusarium wilt (races 1, 2, and 3), Verticillium wilt (race 1), and Tomato spotted wilt.

BHN 975. Midseason maturity. Determinate. "Hot set" variety. Strong vine and smooth large fruit. Resistance: Fusarium wilt (races 1 and 2), Fusarium crown rot and root rot, and Verticillium wilt (race 1).

Camaro. Early midseason maturity. Determinate**.** Medium plant with limited to no pruning. Extra large globe shaped fruit. Resistant: Alternaria stem canker, Fusarium wilt (races 1, 2, and 3), Verticilium wilt (race 1). Intermediate resistance: gray leaf spot, Tomato yellow leaf curl.

Charger. Midseason maturity. Determinate. Vigorous plant with good vine cover. Extra-large, smooth, deep oblate fruit with excellent firmness, color and good flavor. Resistance: Alternaria stem canker, Fusarium wilt (races 1, 2, and 3), Verticillium wilt (race 1), Gray leaf spot, and Tomato yellow leaf curl.

Crista. Midseason maturity. Determinate. Large, deep globe fruit with tall robust plants. It does best with moderate pruning and high fertility. Good flavor, color and shelf-life. Resistant: Verticillium wilt (race 1), Fusarium wilt (races 1, 2, and 3), tomato spotted wilt and root-knot nematode.

Florida 47. Late midseason maturity. Determinate. Jointed hybrid. Uniform green, globe shaped fruit. Resistance: Alternaria stem canker, Fusarium wilt (races 1 and 2), Verticillium wilt (race 1), and Gray leaf spot.

Florida 91. Midseason maturity. Determinate. Uniform green fruit borne on jointed pedicels. Good fruit setting ability under high temperatures. Resistance: Alternaria stem canker, Fusarium wilt (races 1 and 2), Verticillium wilt (race 1), and Gray leaf spot.

Grand Marshall. Midseason maturity. Determinate. Vigorous plant with hot set and extra large to large oblate fruit. Resistant: Alternaria stem canker, Fusarium wilt (race 1 and 2). Intermediate resistance: gray leaf spot, Tomato yellow leaf curl.

HM 1823. Early season maturity. Determinate. Round tomato with strong plant habit. Strong plant and large to extra-large round fruit. Resistance: Fusarium wilt (races 1 and 2), Fusarium crown and root rot, Verticillium wilt (race 1), and Gray leaf spot.

HM 8849 CR. Early season maturity. Determinate. Strong plant and good leaf cover. Fruit extra-large, smooth and slightly flattened globe shape. Resistance: Fusarium wilt (races 1 and 2), Fusarium crown and root rot, Verticillium wilt (race 1), and Gray leaf spot.

Phoenix. Early midseason maturity. Determinate. Vigorous vine with good leaf cover for fruit protection. "Hot-set" variety with large to extra-large fruit, high quality, firm, globe shaped, and uniformly-colored. Resistance: Alternaria stem canker, Fusarium wilt (races 1 and 2), Verticillium wilt (race 1), and Gray leaf spot.

Quincy. Full season maturity. Determinate. Fruit are large to extra-large, excellent quality, firm, deep oblate shaped fruit, and uniformly colored. Resistance: Alternaria stem canker, Fusarium wilt (races 1 and 2), Verticillium wilt (race 1), Tomato spotted wilt, and Gray leaf spot.

Raceway (STM9203). Main season maturity. Determinate. Mid vigorous with good vine cover, suited for light pruning. Mostly extra-large, smooth, deep oblate fruit with great firmness and color. Gassing and vine ripe. Resistance: Alternaria stem canker, Fusarium crown and root rot, Fusarium wilt (races 1 and 2), Verticillium wilt (race 1). Intermediate resistance: Gray leaf spot.

Red Defender. Midseason maturity. Determinate. Vigorous vine with smooth, large deep red fruit with excellent firmness and shelf life. Resistance: Alternaria stem canker, Fusarium wilt (races 1 and 2), Verticillium wilt (race 1), Gray leaf spot, and Tomato spotted wilt.

Red Morning. Determinate. Early variety with medium plant. Large round fruit. Resistant: Fusarium wilt (races 1 and 2), Tomato mosaic virus. Intermediate resistance: Tomato spotted wilt, Verticillium wilt (race 1).

Red Rave. Main season maturity. Strong plant and extra-large globe shaped fruit. Good flavor suitable for vine ripe. Resistant: Fusarium wilt (races 1 and 2), Verticilium wilt (race 1).

Resolute. Mid-season maturity. Strong plant and extra large to large fruit. Resistant: Fusarium wilt (races 1 and 2), Verticilium wilt (race 1). Intermediate resistance: Tomato spotted wilt.

RFT 6153. Main season maturity. Determinate. Large plants with fruit that have good eating quality and fancy appearance in a large sturdy shipping tomato and firm enough for vine-ripe. Resistance: Fusarium wilt (races 1 and 2), Verticillium wilt (race 1), and Gray leaf spot.

RidgeRunner. Mid-early season maturity. Determinate. Variety for warm conditions. Medium tall. Determinate. Bush for the mature green market. Resistance: Fusarium wilt (races 1 and 2), Fusarium Crown and Root Rot, Verticillium (Race 1), and Tomato yellow leaf curl.

Rocky Top. Midseason season maturity. Determinate. Mostly extra-large and large firm fruit. Great eating quality and is well adapted for vine ripe production as well as high tunnel production. Resistance: Fusarium wilt (races 1, 2, and 3), Verticillium wilt (race 1), and Gray leaf spot.

Sanibel. Main season. Determinate. Large, firm, smooth fruit with light green shoulder and a tight blossom end. Resistance: Alternaria stem canker, Fusarium wilt (races 1 and 2), Verticillium wilt (race 1), Root knot nematodes, and Gray leaf spot.

Southern Ripe. Full season. Determinate. Large quality fruit. Resistant: Fusarium Crown and root rot, Tomato spotted wilt, Fusarium wilt (races 1, 2 and 3). Intermediate resistance: root-knot nematode.

Sebring. Main season. Determinate, jointed hybrid. Plant with smooth, deep oblate, firm, thick walled fruit. Resistance: Fusarium wilt (races 1, 2, and 3) Fusarium crown rot, Verticillium wilt (race 1), and Gray leaf spot.

Skyway. Main season maturity. Determinate. Strong plant. Extra large globe shaped fruit. Resistant: Fusarium wilt (races 1 and 2). Intermediate resistance: root-knot nematode, Tomato spotted wilt, Tomato yellow leaf curl.

Solar Fire. Early season maturity. Determinate. Jointed hybrid. Plant has good fruit setting ability in high temperatures. Fruit are large, flat-round, smooth, and firm, with light green shoulder. Blossom scars are smooth. Resistance: Fusarium wilt (races 1, 2, and 3), Verticillium wilt (race 1), and Gray leaf spot.

Soraya. Full season maturity. Determinate. Continuous set. Strong, large bush. Fruit are high quality, smooth, and tend toward large to extra-large. Resistance: Fusarium wilt (races 1, 2, and 3), Fusarium crown rot, Verticillium wilt (race 1), and Gray leaf spot.

SV 7631. Midseason maturity. Determinate. Medium to strong plant with extra large to large oblate fruit. Resistant: Alternaria stem canker, Fusarium wilt (races 1 and 2), Tomato spotted wilt, Verticilium wilt (race 1). Intermediate resistance: root-knot nematode.

Tasti-Lee. Midseason maturity. Determinate. Jointed hybrid with moderate heat-tolerance. Fruit are uniform green with a high lycopene content and deep red interior color due to the crimson gene. Targeted at the premium tomato market. Resistance: Fusarium wilt (races 1, 2, and 3), Verticillium wilt (race 1), and Gray leaf spot.

Tribute. Main season maturity. Fall variety. Vigorous plant with good cover. Medium large to large, smooth, globed shaped fruit with excellent firmness and color. Resistance: Alternaria stem canker, Fusarium wilt (races 1 and 2), Verticillium wilt (race 1). Intermediate resistance: Tomato spotted wilt, Gray leaf spot, and Tomato yellow leaf curl.

Volante. Midseason maturity. Determinate. "Hot set" variety with medium to tall vine. Fruit are extra-large and large, deep globed shaped with very firm, uniform green fruits well suited for mature green or vine-ripe production. Resistance: Alternaria stem canker, Fusarium wilt (races 1 and 2), Verticillium wilt (race 1). Intermediate resistance: Tomato spotted wilt and Gray leaf spot.

2. PLUM TYPE VARIETIES

BHN 685. Midseason maturity. Determinate. Vigorous bush with no pruning recommended. Large to extra-large, deep blocky fruit, globe shape fruit. Resistance: Fusarium wilt (races 1, 2, and 3), Verticillium wilt (race 1), and Tomato spotted wilt.

Mariana. Midseason maturity. Determinate. Small to medium sized plant with good fruit set. Fruit are predominately extra-large and extremely uniform in shape. Fruit wall is thick and external. Fruit internal color is very good with excellent firmness and shelf life. Resistance: Alternaria stem canker, Fusarium wilt (races 1 and 2), Verticillium wilt (race 1), Root-knot nematode and tolerant to Gray leaf spot.

Monticello. Uniform fruit size and a unique blocky shape with an improved disease resistance package. Large firm fruit with good interior quality and small blossom end scar. Resistance: Fusarium wilt (races 1 and 2), Bacterial speck, Verticillum wilt (race 1), Root knot nematode, Tomato spotted wilt virus, and Gray leaf spot.

Picus. Main season maturity. Determinate. Medium to large, vigorous plant that provides good fruit cover and sets well in hot temperatures. Fruits are large, uniform and blocky, maturing to a deep-red color with great firmness at the red stage. Resistance: Alternaria stem canker, Fusarium wilt (race 1and 2), Verticillium wilt (race 1), Tomato spotted wilt, and Cladosporium leaf mold.

Sunoma. Main season maturity. Determinate. Plant maintains fruit size through multiple harvests and has good fruit cover. Fruit are medium-large, elongated and cylindrical. Resistance: Fusarium wilt (races 1 and 2), Verticillium wilt (race 1), Root-knot nematodes, Tomato mosaic, Gray leaf spot, and Bacterial speck (race 0).

Supremo. Midseason maturity. Determinate. Mid compact plant with early maturity. Uniform predominately extra-large fruit. Suited for concentrated harvests for vine ripe and mature green markets. Resistance: Fusarium wilt (races 1, 2 and 3), Bacterial speck, Verticillium wilt (race 1), and Root-knot nematode. Intermediate resistance: Tomato spotted wilt.

Tachi. Midseason maturity. Determinate. Mid compact plant with classic saladette shape. Uniform predominately extra-large fruit, uniform and very similar to Mariana. Wide adaptability and suited for concentrated harvests for vine ripe and mature green markets. Advantage over Mariana is its resistance to tomato spotted wilt. Resistance: Alternaria stem canker, Fusarium wilt (races 1 and 2), Verticillium wilt (race 1), and Root-knot nematode.

3. CHERRY TYPE VARIETIES

BHN 268. Early to midseason maturity. Determinate. Small to medium bush with high yields an extra firm cherry tomato that holds, packs and ships well. Resistance: Fusarium wilt (race 1) and Verticillium wilt (race 1).

Camelia. Midseason maturity. Indeterminate. Deep globe, cocktail-cherry size with excellent firmness and long shelf life. Outdoor or greenhouse production. Resistance: Fusarium wilt (race 1), Verticillium wilt (race 1), and Tobacco mosaic.

Sakura. Early indeterminate hybrid. Resistant: Fusarium wilt (race 1 and 2), leaf mold, Tobacco mosaic virus.

Shiren. Compact plant with high yield potential and nice cluster. Resistance: Fusarium wilt (races 1 and 2), Tomato mosaic, and Root-knot nematodes.

Sweet Treats. Early main season maturity. Indeterminate. Strong, vigorous plant with wide adaptability. Deep pink, firm, globe shaped fruit with outstanding flavor potential. Strong against cracking. High resistance:

Fusarium wilt (race 1 and 2), Leaf mold, and Tomato mosaic. Intermediate resistance: Fusarium crown and root rot and Gray leaf spot.

4. GRAPE TOMATOES

Amai. Early main season maturity. Smooth uniform fruit, 1-2 gr more than Sweet Hearts. Uniform sizing. Dark red, firm, elongated grape-shaped fruit. High yield potential. High resistance: Fusarium wilt (race 1), Leaf mold, and Tobacco mosaic . Intermediate resistance: Root-knot nematode and Gray leaf spot.

BHN 784. Early-midseason maturity. Determinate. Heat tolerant. Resistant: Fursrium wilt (race 1).

BHN 785. Midseason maturity. Determinate. Hybrid with a strong set of very uniform size and shape fruit on a vigorous bush with good cover. Resistance: Fusarium wilt (race 1).

BHN 1022. Determinate "hot set" variety. Resistance: Fusarium wilt (race 1, 2, and 3) and Tomato spotted wilt.

Brixmore. Very early season maturity. Indeterminate. Very uniform in shape and size, deep glossy red color with very high early and total yield. High brix and excellent firm flavor. Resistance: Verticillium wilt (race1), Root-knot nematodes, and Tomato mosaic.

Cupid. Early season maturity. Indeterminate. Vigorous bush with oval shaped fruit that have an excellent red color and a sweet flavor. Resistance: Alternaria stem canker, Fusarium wilt (race 1 and 2), and Gray leaf spot. Intermediate resistance: Bacterial speck (race 0).

Jolly Girl. Early season maturity. Determinate. Extended market life with firm, flavorful grape shaped fruits with an average 10% brix. Resistance: Verticillium wilt (race 1),cracking, and Fusarium wilt (race 2).

Smarty. 69 days. Indeterminate. Vigorous bush with short internodes. Plants are 25% shorter than Santa. Good flavor, sweet and excellent flavor.

Sweethearts. Early to mid-season. Indeterminate. Bush with intermediate internodes, Brilliant red, firm, elongated grape-shaped fruit. Matures between 70 and 75 days. Crack resistance and high brix. Resistance: Fusarium wilt (race 1), Cladosporium Leaf mold, Tobacco mosaic virus.

Tami G. Early season maturity. Indeterminate. Medium tall bush with small fruits with nice shape.

Note: some of these varieties are used by only a few producers. In reality, a much smaller subset of varieties dominates the market.

Fertilizer and Nutrient Management for Tomato

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CALIBRATED SOIL TEST: TAKING THE GUESSWORK OUT OF FERTILIZATION

Prior to each cropping season, soil tests should be conducted to determine fertilizer needs and eventual pH adjustments. Obtain a UF/IFAS soil sample kit from the local agricultural Extension agent or from a reputable commercial laboratory for this purpose. If a commercial soil testing laboratory is used, be sure the laboratory uses methodologies calibrated and extractants suitable for Florida soils. When used with the percent sufficiency philosophy, routine soil testing helps adjust fertilizer applications to plant needs and target yields. In addition, the use of routine calibrated soil tests reduces the risk of over-fertilization. Over fertilization reduces fertilizer efficiency and increases the risk of groundwater pollution. Systematic use of fertilizer without a soil test may also result in crop damage from salt injury.

The crop nutrient requirements of nitrogen, phosphorus, and potassium (designated in fertilizers as N, P_2O_5, and K_2O, respectively) represent the optimum amounts of these nutrients needed for maximum tomato production (Table 1). Fertilizer rates are provided on a per-acre basis for tomato grown on 6-ft centers. Under these conditions, there are 7,260 linear feet of tomato row in a planted acre. When different row spacings are used, it is necessary to adjust fertilizer application accordingly. For example, a 200 lbs/acre N rate on 6-ft centers is the same as 240 lbs/acre N rate on 5-ft centers and a 170 lbs/acre N rate on 7-ft centers. This example is for illustration purposes, and only 5 and 6 ft centers are commonly used for tomato production in Florida.

Fertilizer rates can be simply and accurately adjusted to row spacings other than the standard spacing (6-ft centers) by expressing the recommended rates on a 100 linear bed feet (lbf) basis, rather than on a real-estate acre basis. For example, in a tomato field planted on 7-ft centers with one drive row every six rows, there are only 5,333 lbf/acre (6/7 x 43,560 /7). If the recommendation is to inject 10 lbs/acre of N (standard spacing), this becomes 10 lbs of N/7,260 lbf or 0.14lbs N/100 lbf. Since there are 5,333 lbf/acre in this example, then the adjusted rate for this situation is 7.46 lbs N/acre (0.14 x 53.33). In other words, an injection of 10 lbs of N to 7,260 lbf is accomplished by injecting 7.46 lbs of N to 5,333 lbf.

LIMING

The optimum pH range for tomato is 6.0-6.5. This is the range at which the availability of all the essential nutrients is highest. Fusarium wilt problems are reduced by liming within this range, but it is not advisable to raise the pH above 6.5 because of reduced micronutrient availability. In areas where soil pH is basic (>7.0), micronutrient deficiencies may be corrected by foliar sprays.

Calcium (Ca) and magnesium (Mg) levels should be also corrected according to the soil test. If both elements are "low", and lime is needed, then broadcast and incorporate dolomitic limestone ($CaCO_3$, $MgCO_3$). Where calcium alone is deficient, "hi-cal" ($CaCO_3$) limestone should be used. Adequate Ca is important for reducing the severity of blossom-end rot. Research shows that a Mehlich-I (double-acid) index of 300 to 350 ppm Ca would be indicative of adequate soil-Ca. On limestone soils, add 30-40 lbs/acre of Mg in the basic fertilizer mix. It is best to apply lime several months prior to planting. However, if time is short, it is better to apply lime any time before planting than not to apply it at all. Where the pH does not need modification, but Mg is low (below 15 ppm, Mehlich-3 soil test index), apply magnesium sulfate or potassium-magnesium sulfate.

Changes in soil pH may take several weeks to occur when carbonate-based liming materials are used (calcitic or dolomitic limestone). Oxide-based liming materials (quick lime -CaO- or dolomitic quick lime -CaO, MgO-) are fast reacting and rapidly increase soil pH. Yet, despite these advantages, oxide-based liming materials are more expensive than the traditional liming materials, and therefore are not routinely used. The increase in pH induced by liming materials is not due to the presence of Ca or Mg. Instead, it is the carbonate (CO_3) and oxide (O) part of $CaCO_3$ and CaO, respectively, that raises the pH. Through several chemical reactions that occur in the soil, carbonates and oxides release OH- ions that combine with H^+ to produce water. As large amounts of H^+ react, the pH rises. A large fraction of the Ca and/or Mg in the liming materials gets into solution and binds to the sites that are freed by H^+ that have reacted with OH^-.

FERTILIZER-RELATED PHYSIOLOGICAL DISORDERS

Blossom-End Rot. Growers may have problems with blossom-end-rot, especially on the first or second fruit clusters. Blossom-end rot (BER) is a Ca deficiency in the fruit, but is often more related to plant water stress than to Ca concentrations in the soil. This is because Ca movement into the plant occurs with the water stream (transpiration). Thus, Ca moves preferentially to the leaves. As a maturing fruit is not a transpiring organ, most of the Ca is deposited during early fruit growth.

Once BER symptoms develop on a tomato fruit, they cannot be alleviated on this fruit. Because of the physiological role of Ca in the middle lamella of cell walls, BER is a structural and irreversible disorder. Yet, the Ca nutrition of the plant can be altered so that the new fruits are not affected. BER is most effectively controlled by attention to irrigation and fertilization, or by using a calcium source such as calcium nitrate when soil Ca is low. Maintaining adequate and uniform amounts of moisture in the soil are also keys to reducing BER potential.

Factors that impair the ability of tomato plants to obtain water will increase the risk of BER. These factors include damaged roots from flooding, mechanical damage or nematodes, clogged drip emitters, inadequate water applications, alternating dry-wet periods, and even prolonged overcast periods. Other causes for BER include high fertilizer rates, especially potassium and nitrogen. Calcium levels in the soil should be adequate when the Mehlich-3 index is 300 to 350 ppm, or above. In these cases, added gypsum (calcium sulfate) is unlikely to reduce BER. Foliar sprays of Ca are unlikely to reduce BER because Ca does not move out of the leaves to the fruit.

Gray Wall. Blotchy ripening (also called gray wall) of tomatoes is characterized by white or yellow blotches that appear on the surface of ripening tomato fruits, while the tissue inside remains hard. The affected area is usually on the upper portion of the fruit. The etiology of this disorder has not been fully established, but it is often associated with high N and/or low K, and aggravated by excessive amount of N. This disorder may be at times confused with symptoms produced by the tobacco mosaic virus. Gray wall is cultivar specific and appears more frequently on older cultivars. The incidence of gray wall is less with drip irrigation where small amounts of nutrients are injected frequently, than with systems where all the fertilizer is applied pre-plant.

Micronutrients. For acidic sandy soils cultivated for the first time ("new ground"), or sandy soils where a proven need exists, a general guide for fertilization is the addition of micronutrients (in elemental lbs/acre) manganese -3, copper -2, iron -5, zinc -2, boron -2, and molybdenum -0.02. Micronutrients may be supplied from oxides or sulfates. Growers using micronutrient-containing fungicides need to consider these sources when calculating fertilizer micronutrient needs.

Properly diagnosed micronutrient defi-

TABLE 1. Fertilization recommendations for tomato grown in Florida on sandy soils testing low in Mehlich-3 potassium (K_2O).

		Recommended base fertilization[z]							Recommended supplemental fertilization[z]		
				Injected[x] (lbs/acre/day) — Weeks after transplanting[w]							
Production system	Nutrient	Total (lbs/acre)	Preplant[y] (lbs/acre)	1-2	3-4	5-11	12	13	Leaching rain[r,s]	Measured > low= plant nutrient content[u,s]	Extended harvest season[s]
Drip irrigation, raised beds, and polyethylene Mulch	N	200	0-50	1.5	2.0	2.5	2.0	1.5	n/a	1.5 to 2 lbs/acre/day for 7days[t]	1.5-2 lbs/acre/day[p]
	K_2O	220	0-50	2.5	2.0	3.0	2.0	1.5	n/a	1.5-2 lbs/acre/day for 7days[t]	1.5-2 lbs/acre/day[p]
Seepage irrigation, raised beds, and polyethylene Mulch	N	200	200[v]	0	0	0	0	0	30 lbs/A[q]	30 lbs/acre[t]	30 lbs/acre[p]
	K_2O	220	220[v]	0	0	0	0	0	20 lbs/A[q]	20 lbs/acre[t]	20 lbs/acre[p]

[z] 1 A = 7,260 linear bed feet per acre (6-ft bed spacing); for soils testing "low" in Mehlich 3 potassium (K_2O).

[y] applied using the modified broadcast method (fertilizer is broadcast where the beds will be formed only, and not over the entire field). Pre-plant fertilizer cannot be applied to double/triple crops because of the plastic mulch; hence, in these cases, all the fertilizer has to be injected.

[x] This fertigation schedule is applicable when no N and K_2O are applied preplant. Reduce schedule proportionally to the amount of N and K_2O applied pre-plant. Fertilizer injections may be done daily or weekly. Inject fertilizer at the end of the irrigation event and allow enough time for proper flushing afterwards.

[w] For a standard 13 week-long, transplanted tomato crop grown in the Spring.

[v] Some of the fertilizer may be applied with a fertilizer wheel though the plastic mulch during the tomato crop when only part of the recommended base rate is applied pre-plant. Rate may be reduced when a controlled-release fertilizer source is used.

[u] Plant nutritional status may be determined with tissue analysis or fresh petiole-sap testing, or any other calibrated method. The "low" diagnosis needs to be based on UF/IFAS interpretative thresholds.

[t] Plant nutritional status must be diagnosed every week to repeat supplemental application.

[s] Supplemental fertilizer applications are allowed when irrigation is scheduled following a recommended method. Supplemental fertilization is to be applied in addition to base fertilization when appropriate. Supplemental fertilization is not to be applied > in advance= with the pre-plant fertilizer.

[r] A leaching rain is defined as a rainfall amount of 3 inches in 3 days or 4 inches in 7 days.

[q] Supplemental amount for each leaching rain

[p] Plant nutritional status must be diagnosed after each harvest before repeating supplemental fertilizer application.

ciencies can often be corrected by foliar applications of the specific micronutrient. For most micronutrients, a very fine line exists between sufficiency and toxicity. Foliar application of major nutrients (N, P, or K) has not been shown to be beneficial where proper soil fertility is present.

FERTILIZER APPLICATION

Mulch Production with Seepage Irrigation. Under this system, the crop may be supplied with all of its soil requirements before the mulch is applied (Table 1). It is difficult to correct a deficiency after mulch application, although a liquid fertilizer injection wheel can facilitate sidedressing through the mulch. The injection wheel will also be useful for replacing fertilizer under the used plastic mulch for double-cropping systems. A general sequence of operations for the full-bed plastic mulch system is:

1. Land preparation, including development of irrigation and drainage systems, and liming of the soil, if needed.
2. Application of "cold" mix comprised of 10% to 20% of the total N and potassium seasonal requirements and all of the needed P and micronutrients. The cold mix can be broadcast over the entire area prior to bedding and then incorporated. During bedding, the fertilizer will be gathered into the bed area. An alternative is to use the "modified broadcast" technique for systems with wide bed spacings. Use of modified broadcast or banding techniques can increase P and micronutrient efficiencies, especially on alkaline (basic) soils.
3. Formation of beds, incorporation of herbicide, and application of mole cricket bait.
4. The remaining 80% to 90% of the N and K is placed in one or two narrow bands 9 to 10 inches to each side of the plant row in furrows. This "hot mix" fertilizer should be placed deep enough in the grooves for it to be in contact with moist bed soil. Bed presses are modified to provide the groove. Only water-soluble nutrient sources should be used for the banded fertilizer. A mixture of potassium nitrate (or potassium sulfate or potassium chloride), calcium nitrate, and ammonium nitrate has proven successful. Research has shown that it is best to broadcast incorporate controlled-release fertilizers (CRF) in the bed with bottom mix than in the hot bands.
5. Fumigation, pressing of beds, and mulching. This should be done in one operation, if possible. Be sure that the mulching machine seals the edges of the mulch adequately with soil to prevent fumigant escape.

Water management with the seep irrigation system is critical to successful crops. Use water-table monitoring devices and tensiometers or TDRs in the root zone to help provide an adequate water table but no higher than required for optimum moisture. It is recommended to limit fluctuations in water table depth since this can lead to increased leaching losses of plant nutrients. An in-depth description of soil moisture devices may be found in Munoz-Carpena (2004).

Mulched Production with Drip Irrigation. Where drip irrigation is used, drip tape or tubes should be laid 1 to 2 inches below the bed soil surface prior to mulching. This placement helps protect tubes from mice and cricket damage. The drip system is an excellent tool with which to fertilize tomato. Where drip irrigation is used, apply all phosphorus and micronutrients, and 20 % to 40 % of total N and K pre-plant in the bed. Apply the remaining N and K through the drip system in increments as the crop develops.

Successful crops have resulted where the total amounts of N and K were applied through the drip system. Some growers find this method helpful where they have had problems with soluble-salt burn. This approach would be most likely to work on soils with relatively high organic matter and some residual potassium. However, it is important to begin with rather high rates of N and K to ensure young transplants are established quickly. In most situations, some pre-plant N and K fertilizers are needed.

Suggested schedules for nutrient injections have been successful in both research and commercial situations, but might need slight modifications based on potassium soil-test indices and grower experience (Table 1).

SOURCES OF N-P_2O_5-K_2O.

About 30% to 50% of the total applied N should be in the nitrate form for soil treated with multi-purpose fumigants and for plantings in cool soil. Controlled-release N sources may be used to supply a portion of the N requirement. One-third of the total required nitrogen can be supplied from sulfur-coated urea (SCU), isobutylidene diurea (IBDU), or polymer-coated urea (PCU) fertilizers incorporated in the bed. Nitrogen from natural organics and most controlled-release materials is initially in the ammoniacal form, but is rapidly converted into nitrate by soil microorganisms.

Normal superphosphate and triple superphosphate are recommended for phosphorus needs. Both contribute calcium and normal superphosphate contributes sulfur.

All sources of potassium can be used for tomato. Potassium sulfate, sodium-potassium nitrate, potassium nitrate, potassium chloride, monopotassium phosphate, and potassium-magnesium sulfate are all good K sources. If the soil test predicted amounts of K_2O are applied, then there should be no concern for the K source or its associated salt index.

Table 2. Deficient, adequate, and excessive nutrient content-rations for tomato [most-recently-matured (MRM) leaf (blade plus petiole)].

				N	P	K	Ca	Mg	S	Fe	Mn	Zn	B	Cu	Mo
				%						ppm					
Tomato	MRM[z] leaf	5-leaf stage	Deficient	<3.0	0.3	3.0	1.0	0.3	0.3	40	30	25	20	5	0.2
			Adequate range	3.0 5.0	0.3 0.6	3.0 5.0	1.0 2.0	0.3 0.5	0.3 0.8	40 100	30 100	25 40	20 40	5 15	0.2 0.6
			High	>5.0	0.6	5.0	2.0	0.5	0.8	100	100	40	40	15	0.6
	MRM leaf	First flower	Deficient	<2.8	0.2	2.5	1.0	0.3	0.3	40	30	25	20	5	0.2
			Adequate range	2.8 4.0	0.2 0.4	2.5 4.0	1.0 2.0	0.3 0.5	0.3 0.8	40 100	30 100	25 40	20 40	5 15	0.2 0.6
			High	>4.0	0.4	4.0	2.0	0.5	0.8	100	100	40	40	15	0.6
			Toxic (>)								1500	300	250		
	MRM leaf	Early fruit set	Deficient	<2.5	0.2	2.5	1.0	0.25	0.3	40	30	20	20	5	0.2
			Adequate range	2.5 4.0	0.2 0.4	2.5 4.0	1.0 2.0	0.25 0.5	0.3 0.6	40 100	30 100	20 40	20 40	5 10	0.2 0.6
			High	>4.0	0.4	4.0	2.0	0.5	0.6	100	100	40	40	10	0.6
			Toxic (>)										250		
Tomato	MRM leaf	First ripe fruit	Deficient	<2.0	0.2	2.0	1.0	0.25	0.3	40	30	20	20	5	0.2
			Adequate range	2.0 3.5	0.2 0.4	2.0 4.0	1.0 2.0	0.25 0.5	0.3 0.6	40 100	30 100	20 40	20 40	5 10	0.2 0.6
			High	>3.5	0.4	4.0	2.0	0.5	0.6	100	100	40	40	10	0.6
	MRM leaf	During harvest period	Deficient	<2.0	0.2	1.5	1.0	0.25	0.3	40	30	20	20	5	0.2
			Adequate range	2.0 3.0	0.2 0.4	1.5 2.5	1.0 2.0	0.25 0.5	0.3 0.6	40 100	30 100	20 40	20 40	5 10	0.2 0.6
			High	>3.0	0.4	2.5	2.0	0.5	0.6	100	100	40	40	10	0.6

[z] MRM=Most recently matured leaf.

SAP TESTING AND TISSUE ANALYSIS

While routine soil testing is essential in designing a fertilizer program, sap tests and/or tissue analyses reveal the actual nutritional status of the plant. Therefore these tools complement each other, rather than replace one another.

When drip irrigation is used, analysis of tomato leaves for mineral nutrient content (Table 2) or quick sap test (Table 3) can help guide a fertilizer management program during the growing season or assist in diagnosis of a suspected nutrient deficiency.

For both nutrient monitoring tools, the quality and reliability of the measurements are directly related with the quality of the sample. A leaf sample should contain at least 20 most recently, fully developed, healthy leaves. Select representative plants, from representative areas in the field.

SUPPLEMENTAL FERTILIZER APPLICATIONS

In practice, supplemental fertilizer applications allow vegetable growers to numerically apply fertilizer rates higher than the standard UF/IFAS recommended rates when growing conditions require doing so. Applying additional fertilizer under the three circumstances described in Table 1 (leaching rain, 'low' foliar content, and extended harvest season) is part of the current UF/IFAS fertilizer recommendations and nutrient BMPs.

LEVELS OF NUTRIENT MANAGEMENT FOR TOMATO PRODUCTION

Based on the growing situation and the level of adoption of the tools and techniques described above, different levels of nutrient management exist for tomato production in Florida. Successful production and nutrient BMPs requires management levels of 3 or above (Table 4).

SUGGESTED LITERATURE

Cantliffe, D., P. Gilreath, D. Haman, C. Hutchinson, Y. Li, G. McAvoy, K. Migliaccio, T. Olczyk, S. Olson, D. Parmenter, B. Santos, S. Shukla, E. Simonne, C. Stanley, and A. Whidden. 2009. Review of nutrient management systems for Florida vegetable producers. EDIS HS1156, http://edis.ifas.ufl.edu/HS1156

Florida Department of Agriculture and Consumer Services. 2005. Florida Vegetable and Agronomic Crop Water Quality and Quantity BMP Manual.

http://www.floridaagwaterpolicy.com/PDFs/BMPs/vegetable&agronomicCrops.pdf

Gazula, A., E. Simonne and B. Boman. 2007. Update and outlook for 2007 of Florida=s BMP program for vegetable crops, EDIS Doc. 367, http://edis.ifas.ufl.edu/HS367Hochmuth, G., D. Maynard, C. Vavrina, E. Hanlon, and E. Simonne. 2004. Plant tissue analysis and interpretation for vegetable crops in Florida. EDIS http://edis.ifas.ufl.edu/EP081

Muñoz-Carpena, R. 2004. Field devices for monitoring soil water content. EDIS. Bul 343. http://edis.ifas.ufl.edu/ae266

Santos, B. M., E.J. McAvoy, M. Ozores-Hampton, G.E. Vallad, P. J. Dittmar, S.E. Webb, H.A. Smith, and S.M. Olson. 2013. Tomato production in Florida. EDIS, HS739, http://edis.ifas.ufl.edu/pdffiles/cv/cv13700.pdf

Simonne, E., D. Studstill, B. Hochmuth, T. Olczyk, M. Dukes, R. Muñoz-Carpena, and Y. Li. 2002. Drip irrigation: The BMP era - An integrated approach to water and fertilizer management in Florida, EDIS HS917, http://edis.ifas.ufl.edu/HS172

Studstill, D., E. Simonne, R. Hochmuth, and T. Olczyk. 2006. Calibrating sap-testing meters. EDISHS 1074, http://edis.ifas.ufl.edu/pdffiles/HS/HS32800.pdf

Table 3. Recommended nitrate-N and K concentrations in fresh petiole sap for round tomato.

Stage of growth	Sap concentration (ppm)	
	NO_3-N	K
First buds	1,000-1,200	3,500-4,000
First open flowers	600-800	3,500-4,000
Fruits one-inch diameter	400-600	3,000-3,500
Fruits two-inch diameter	400-600	3,000-3,500
First harvest	300-400	2,50w0-3,000
Second harvest	200-400	2,000-2,500

Table 4. Progressive levels of nutrient management for tomato production. [z]

Nutrient Management		
Level	Rating	Description
0	None	Guessing
1	Very low	Soil testing and still guessing
2	Low	Soil testing and implementing > a = recommendation
3	Intermediate	Soil testing, understanding IFAS recommendations, and correctly implementing them
4	Advanced	Soil testing, understanding IFAS recommendations, correctly implementing them, and monitoring crop nutritional status
5	Recommended	Soil testing, understanding IFAS recommendations, correctly implementing them, monitoring crop nutritional status, and practice year-round nutrient management and/or following BMPs (including one of the recommended irrigation scheduling methods).

[z] These levels should be used together with the highest possible level of irrigation management

Water Management For Tomato

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Water and nutrient management are two important aspects of tomato production in all production systems. Water is used for wetting the fields before land preparation, transplant establishment, and irrigation. The objective of this article is to provide an overview of recommendations for tomato irrigation management in Florida. Irrigation management recommendations should be considered together with those for fertilizer and nutrient management.

Irrigation is used to replace the amount of water lost by transpiration and evaporation. This amount is also called crop evapotranspiration (ETc). Irrigation scheduling is used to apply the proper amount of water to a tomato crop at the proper time. The characteristics of the irrigation system, tomato crop needs, soil properties, and atmospheric conditions must all be considered to properly schedule irrigations. Poor timing or insufficient water application can result in crop stress and reduced yields from inappropriate amounts of available water and/or nutrients. Excessive water applications may reduce yield and quality, are a waste of water, and increase the risk of nutrient leaching.

A wide range of irrigation scheduling methods is used in Florida, which correspond to different levels of water management (Table 1). The recommend method to schedule irrigation for tomato is to use together an estimate of the tomato crop water requirement that is based on plant growth, a measurement of soil water status and a guideline for splitting irrigation (water management level 5 in Table 1; Table 2). The estimated water use is a guideline for irrigating tomatoes. The measurement of soil water tension is useful for fine tuning irrigation. Splitting irrigation events is necessary when the amount of water to be applied is larger than the water holding capacity of the root zone.

TOMATO WATER REQUIREMENT

Tomato water requirement (ETc) depends on stage of growth, and evaporative demand. ETc can be estimated by adjusting reference evapotranspiration (ETo) with a correction factor call crop factor (Kc; equation [1]). Because different methods exist for estimating ETo, it is very important to use Kc coefficients which were derived using the same ETo estimation method as will be used to determine ETc. Also, Kc values for the appropriate stage of growth and production system (Table 3) must be used.

By definition, ETo represents the water use from a uniform green cover surface, actively growing, and well watered (such as a turf or grass covered area). ETo can be measured on-farm using a small weather station. When daily ETo data are not available, historical daily averages of Penman-method ETo can be used (Table 4). However, these long-term averages are provided as guidelines since actual values may fluctuate by as much as 25%, either above the average on hotter and drier than normal days, or below the average on cooler or more overcast days than normal. As a result, SWT or soil moisture should be monitored in the field.

Eq. [1] Crop water requirement = Crop coefficient x Reference evapotranspiration
ETc = Kc x ETo

Tomato crop water requirement may also be estimated from Class A pan evaporation using:

Eq. [2] Crop water requirement = Crop factor x Class A pan evaporation
ETc = CF x Ep

Typical CF values for fully-grown tomato should not exceed 0.75 (Locascio and Smajstrla, 1996). A third method for estimated tomato crop water requirement is to use modified Bellani plates also known as atmometers. A common model of atmomter used in Florida is the $ET_{gage.}$ This device consists of a canvas-covered ceramic evaporation plate mounted on a water reservoir. The green fabric creates a diffusion barrier that controls evaporation at a rate similar to that of well water plants. Water loss through evaporation can be read on a clear sight tube mounted on the side of the device. Evaporation from

TABLE 1. Levels of water management and corresponding irrigation scheduling methods for tomato.

Water Management Level	Rating	Irrigation scheduling method
0	None	Guessing (no specific rule is followed to irrigate)
1	Very low	Using the "feel and see" method
2	Low	Using systematic irrigation (example: 2 hrs every day from transplanting to harvest)
3	Intermediate	Using a soil moisture measuring tool to start irrigation
4	Advanced	Using a soil moisture measuring tool to schedule irrigation and apply amounts based on a budgeting procedure
5	Recommended	Using together a water use estimate based on tomato plant stage of growth, a measurement of soil moisture, determining rainfall contribution to soil moisture, having a guideline for splitting irrigation and keeping irrigation records.

TABLE 2. Summary of irrigation management guidelines for tomato.

Irrigation management component	Irrigation system[z]	
	Seepage[y]	Drip[x]
1- Target water application rate	Keep water table between 18 and 24 inch depth	Historical weather data or crop evapotranspiration (ETc) calculated from reference ET or Class A pan evaporation
2- Fine tune application with soil moisture measurement	Monitor water table depth with observation wells	Maintain soil water tension in the root zone between 8 and 15 cbar
3- Determine the contribution of rainfall	Typically, 1 inch rainfall raises the water table by 1 foot	Poor lateral water movement on sandy and rocky soils limits the contribution of rainfall to crop water needs to (1) foliar absorption and cooling of foliage and (2) water funneled by the canopy through the plan hole.
4- Rule for splitting irrigation	Not applicable	Irrigations greater than 12 and 50 gal/100ft (or 30 min and 2 hrs for medium flow rate) when plants are small and fully grown, respectively are likely to push the water front being below the root zone
5-Record keeping	Irrigation amount applied and total rainfall received [w] Days of system operation	Irrigation amount applied and total rainfall received[w] Daily irrigation schedule

[z] Efficient irrigation scheduling also requires a properly designed and maintained irrigation systems
[y] Practical only when a spodic layer is present in the field
[x] On deep sandy soils
[w] Required by the BMPs

the ET_{gage} (ETg) was well correlated to ETo except on rainy days, but overall, the ET_{gage} tended to underestimate ETo (Irmak et al., 2005). On days with rainfall less than 0.2 inch/day, ETo can be estimated from ETg as: ETo = 1.19 ETg. When rainfall exceeds 0.2 inch/day, rain water wets the canvas which interferes with the flow of water out of the atmometers, and decreases the reliability of the measurement.

TOMATO IRRIGATION REQUIREMENT

Irrigation systems are generally rated with respect to application efficiency (Ea), which is the fraction of the water that has been applied by the irrigation system and that is available to the plant for use. In general, Ea is 20% to 70% for seepage irrigation and 90% to 95% for drip irrigation. Applied water that is not available to the plant may have been lost from the crop root zone through evaporation, leaks in the pipe system, surface runoff, subsurface runoff, or deep percolation within the irrigated area. When dual drip/seepage irrigation systems are used, the contribution of the seepage system needs to be subtracted from the tomato irrigation requirement to calculate the drip irrigation need. Otherwise, excessive water volume will be systematically applied. Tomato irrigation requirement are determined by dividing the desired amount of water to provide to the plant (ETc), by Ea as a decimal fraction (Eq. [3]).

Eq. [3] Irrigation requirement = Crop water requirement / Application efficiency
IR = ETc/Ea

TABLE 3. Crop coefficient estimates (Kc) for tomato [z].

Tomato Growth Stage	Corresponding weeks after transplanting[y]	Kc for drip-irrigated crops
1	1-2	0.30
2	3-4	0.40
3	5-11	0.90
4	12	0.90
5	13	0.75

[z] Actual values will vary with time of planting, length of growing season and other site-specific factors. Kc values should be used with ETo values in Table 2 to estimated crop evapotranspiration (ETc)
[y] For a typical 13-week-long growing season.

IRRIGATION SCHEDULING FOR TOMATO

For seepage-irrigated crops, irrigation scheduling recommendations consist of maintaining the water table near the 18-inch depth shortly after transplanting and near the 24- inch depth thereafter (Stanley and Clark, 2003). The actual depth of the water table may be monitored with shallow observation wells (Smajstrla, 1997).

Irrigation scheduling for drip irrigated tomato typically consists in daily applications of ETc, estimated from Eq. [1] or [2] above. In areas where real-time weather information is not available, growers use the "1,000 gal/acre/day/string" rule for drip-irrigated tomato production. As the tomato plants grow from 1 to 4 strings, the daily irrigation volumes increase from 1,000 gal/acre/day to 4,000 gal/acre/day. On 6-ft centers, this corresponds to 15 gal/100lbf/day and 60 gal/100lbf/day for 1 and 4 strings, respectively.

SOILS MOISTURE MEASUREMENT

Soil water tension (SWT) represents the magnitude of the suction (negative pressure) the plant roots have to create to free soil water from the attraction of the soil particles, and move it into its root cells. The dryer the soil, the higher the suction needed, hence, the higher SWT. SWT is commonly expressed in centibars (cb) or kiloPascals (kPa; 1cb = 1kPa). For tomatoes grown on the sandy soils of Florida, SWT in the rooting zone should be maintained between 6 (field capacity) and 15 cb.

The two most common tools available to measure SWT in the field are tensiometers and time domain reflectometry (TDR) probes, although other types of probes are now available (Muñoz-Carpena, 2004). Tensiometers have been used for several years in tomato production. A porous cup is saturated with water, and placed under vacuum. As the soil water content changes, water comes in or out of the porous cup, and affects the amount of vacuum inside the tensiometer. Tensiometer readings have been successfully used to monitor SWT and schedule irrigation for tomatoes. However, because they are fragile and easily broken by field equipment, many growers have renounced to use them. In addition, readings are not reliable when the tensiometer dries, or when the contact between the cup and the soil is lost. Depending on the length of the access tube, tensiometers cost between $40 and $80 each. Tensiometers can be reused as long as they are maintained properly and remain undamaged.

It is necessary to monitor SWT at two soil depths when tensiometers are used. A shallow 6-inch depth is useful at the beginning of the season when tomato roots are near that depth. A deeper 12-inch depth is used to monitor SWT during the rest of the season. Comparing SWT at both depths is useful to understand the dynamics of soil moisture. When both SWT are within the 4-8 cb range (close to field capacity), this means that moisture is plentiful in the rooting zone. This may happen after a large rain, or when tomato water use is less than the irrigation applied. When the 6-inch-depth SWT increases (from 4-8 cb to 10-15cb) while SWT at 12-inch-depth remains within 4-8 cb, the upper part of the soil is drying, and it is time to irrigate. If the 6-inch-depth SWT continues to rise above 25cb, a water stress will result; plants will wilt, and yields will be reduced. This should not happen under adequate water management.

A SWT at the 6-inch depth remaining with the 4-8 cb range, but the 12-inch-depth reading showing a SWT of 20-25cb suggest that deficit irrigation has been made: irrigation has been applied to re-wet the upper part of the profile only. The amount of water applied was not enough to wet the entire profile. If SWT at the 12-inch depth continues to increase, then water stress will become more severe and it will become increasingly difficult to re-wet the soil profile. The sandy soils of Florida have a low water holding capacity. Therefore, SWT should be monitored daily and irrigation applied at least once daily. Scheduling irrigation with SWT only can be difficult at times. Therefore, SWT data should be used together with an estimate of tomato water requirement.

Times domain reflectometry (TDR) is another method for measuring soil moisture.

TABLE 4. Historical Penman-method reference ET (ETo) for four Florida locations (gallons/acre/day).

Month	Tallahassee	Tampa	West Palm Beach	Miami
January	1,630	2,440	2,720	2,720
February	2,440	3,260	3,530	3,530
March	3,260	3,800	4,340	4,340
April	4,340	5,160	5,160	5,160
May	4,890	5,430	5,160	5,160
June	4,890	5,430	4,890	4,890
July	4,620	4,890	4,890	4,890
August	4,340	4,620	4,890	4,620
September	3,800	4,340	4,340	4,070
October	2,990	3,800	3,800	3,800
November	2,170	2,990	3,260	2,990
December	1,630	2,170	2,720	2,720

[z] Assuming water application over the entire area with 100% efficiency

TABLE 5. Estimated maximum water application (in gallons per acre and in gallons/100 lft) in one irrigation event for tomato grown on 6-ft centers (7,260 linear bed feet per acre) on sandy soil (available water holding capacity 0.75 in/ft and 50% soil water depletion). Split irrigations may be required during peak water requirement.

Wetting width (ft)	Gal/100 ft to wet depth (ft)			Gal/acre to wet depth (ft)		
	1	1.5	2	1	1.5	2
1.0	24	36	48	1,700	2,600	3,500
1.5	36	54	72	2,600	3,900	5,200

The availability of inexpensive equipment ($400 to $550/unit) has recently increased the potential of this method to become practical for tomato growers. A TDR unit is comprised of three parts: a display unit, a sensor, and two rods. Rods may be 4 inches or 8 inches in length based on the depth of the soil. Long rods may be used in all the sandy soils of Florida, while the short rods may be used with the shallow soils of Miami-Dade county.

The advantage of TDR is that probes need not being buried permanently, and readings are available instantaneously. This means that, unlike tensiometers, TDR can be used as a hand-held, portable tool.

TDR actually determines percent soil moisture (volume of water per volume of soil). In theory, a soil water release curve has to be used to convert soil moisture in to SWT. However, because TDR provides an average soil moisture reading over the entire length of the rod (as opposed to the specific depth used for tensiometers), it is not practical to simply convert SWT into soil moisture to compare readings from both methods. Tests with TDR probes have shown that best soil monitoring may be achieved by placing the probe vertically, approximately 6 inches away from the drip tape on the opposite side of the tomato plants. For fine sandy soils, 9% to 15% appears to be the adequate moisture range. Tomato plants are exposed to water stress when soil moisture is below 8%. Excessive irrigation may result in soil moisture above 16%.

GUIDELINES FOR SPLITTING IRRIGATION

For sandy soils, a one square foot vertical section of a 100-ft long raised bed can hold approximately 24 to 30 gallons of water (Table 5). When drip irrigation is used, lateral water movement seldom exceeds 6 to 8 inches on each side of the drip tape (12 to 16 inches wetted width). When the irrigation volume exceeds the values in Table 5, irrigation should be split into 2 or 3 applications. Splitting will not only reduce nutrient leaching, but it will also increase tomato quality by ensuring a more continuous water supply. Uneven water supply may result in fruit cracking.

UNITS FOR MEASURING IRRIGATION WATER

When overhead and seepage irrigation were the dominant methods of irrigation, acre-inches or vertical amounts of water were used as units for irrigations recommendations. There are 27,150 gallons in 1 acre-inch; thus, total volume was calculated by multiplying the recommendation expressed in acre-inch by 27,150. This unit reflected quite well the fact that the entire field surface was wetted.

Acre-inches are still used for drip irrigation, although the entire field is not wetted. This section is intended to clarify the conventions used in measuring water amounts for drip irrigation. In short, water amounts are handled similarly to fertilizer amounts, i.e., on an acre basis. When an irrigation amount expressed in acre-inch is recommended for plasticulture, it means that the recommended volume of water needs to be delivered to the row length present in a one-acre field planted at the standard bed spacing. So in this case, it is necessary to know the bed spacing to determine the exact amount of water to apply. In addition, drip tape flow rates are reported in gallons/hour/emitter or in gallons/hour/100 ft of row. Consequently, tomato growers tend to think in terms of multiples of 100 linear feet of bed, and ultimately convert irrigation amounts into duration of irrigation. It is important to correctly understand the units of the irrigation recommendation in order to implement it correctly.

EXAMPLE

How long does an irrigation event need to last if a tomato grower needs to apply 0.20 acre-inch to a 2-acre tomato field? Rows are on 6-ft centers and a 12-ft spray alley is left unplanted every six rows; the drip tape flow rate is 0.30 gallons/hour/emitter and emitters are spaced 1 foot apart.

1. In the 2-acre field, there are 14,520 feet of bed (2 x 43,560/6). Because of the alleys, only 6/8 of the field is actually planted. So, the field actually contains 10,890 feet of bed (14,520x 6/8).
2. A 0.20 acre-inch irrigation corresponds to 5,430 gallons applied to 7,260 feet of row, which is equivalent to 75gallons/100feet (5,430/72.6).
3. The drip tape flow rate is 0.30 gallons/hr/emitter which is equivalent to 30 gallons/hr/100feet. It will take 1 hour to apply 30 gallons/100ft, 2 hours to apply 60gallons/100ft, and 2 2 hours to apply 75 gallons. The total volume applied will be 8,168 gallons/2-acre (75 x 108.9).

IRRIGATION AND BEST MANAGEMENT PRACTICES

As an effort to clean impaired water bodies, federal legislation in the 70's, followed by state legislation in the 90's and state rules since 2000 have progressively shaped the Best Management Practices (BMP) program for vegetable production in Florida. Section 303(d) of the Federal Clean Water Act of 1972 required states to identify impaired water bodies and establish Total Maximum Daily Loads (TMDL) for pollutants entering these water bodies. In 1987, the Florida legislature passed the Surface Water Improvement and Management Act requiring the five Florida water management districts to develop plans to clean up and preserve Florida lakes, bays, estuaries, and rivers. In 1999, the Florida Watershed Restoration Act defined a process for the development of TMDLs. The "*Water Quality/quantity Best Management Practices for Florida Vegetable and Agronomic Crops"* manual was adopted by reference and by rule 5M-8 in the Florida Administrative Code on Feb. 8, 2006 (FDACS, 2005). The manual (available at www.floridaagwaterpolicy.com) provides background on the state-wide BMP program for vegetables, lists all the possible BMPs, provides a selection mechanism for building a customized BMP plan, outlines record-keeping requirements, and explains how to participate in the BMP program. By definition, BMPs are specific cultural practices that aim at reducing nutrient load while maintaining or increasing productivity. Hence, BMPs are tools to achieve the TMDL. Vegetable growers who elect to participate in the BMP program receive three statutory benefits: (1) a waiver of liability from reimbursement of cost and damages associated with the evaluation, assessment, or remediation of contamination of ground water (Florida Statutes 376.307); (2) a presumption of compliance with water quality standards (F.S. 403.067 (7)(d)), and (3); an eligibility for cost-share programs (F.S. 570.085 (1)).

BMPs cover all aspects of tomato production: pesticide management, conservation practices and buffers, erosion control and sediment management, nutrient and irrigation management, water resources management, and seasonal or temporary farming operations. The main water quality parameters of importance to tomato and pepper production and targeted by the BMPs are nitrate, phosphate and total dissolved solids concentration in surface or ground water. All BMPs have some effect on water quality, but nutrient and irrigation management BMPs have a direct effect on it.

ADDITIONAL READINGS:

Cantliffe, D., P. Gilreath, D. Haman, C. Hutchinson, Y. Li, G. McAvoy, K. Migliaccio, T. Olczyk, S. Olson, D. Parmenter, B. Santos, S. Shukla, E. Simonne, C. Stanley, and A. Whidden. 2009. Review of nutrient management systems for Florida vegetable producers. EDIS HS1156, http://edis.ifas.ufl.edu/HS1156

FDACS. 2005. Florida Vegetable and Agronomic Crop Water Quality and Quantity BMP Manual. Florida Department of Agriculture and Consumer Services

http://www.floridaagwaterpolicy.com/PDFs/BMPs/vegetable&agronomicCrops.pdf

Irmak, S., M. Asce, M.D. Dukes, and J.M. Jacobs. 2005. Using modified Bellani plate evapotranspiration gauges to estimate short canopy reference evapotranspiration. J. Irr. Drainage Eng. (2):164-175.

Locascio, S.J. and A.G. Smajstrla. 1996. Water application scheduling by pan evaporation for drip-irrigated tomato. J. Amer. Soc. Hort. Sci. 121(1):63-68

Muñoz-Carpena, R. 2004. Field devices for monitoring soil water content. EDIS Bul. 343. http://edis.ifas.ufl.edu/AE266

Simonne, E.H., D.W. Studstill, R.C. Hochmuth, G. McAvoy, M.D. Dukes and S.M. Olson. 2003. Visualization of water movement in mulched beds with injections of dye with drip irrigation. Proc. Fla. State Hort. Soc. 116:88-91.

Simonne, E.H., D.W. Studstill, T.W. Olczyk, and R. Munoz-Carpena. 2004. Water movement in mulched beds in a rocky soil of Miami-Dade County. Proc. Fla. State Hort. Soc 117:68-70.

Simonne, E. and B. Morgan. 2005. Denitrification in seepage irrigated vegetable fields in South Florida, EDIS, HS 1004, http://edis.ifas.ufl.edu/HS248

Simonne, E.H., D.W. Studstill, R.C. Hochmuth, J.T. Jones and C.W. Starling. 2005. On-farm demonstration of soil water movement in vegetables grown with plasticulture, EDIS, HS 1008, http://edis.ifas.ufl.edu/HS251

Smajstrla, A.G. 1997. Simple water level indicator for seepage irrigation. EDIS Circ. 1188, http://edis.ifas.ufl.edu/AE085

Stanley, C.D. and G.A. Clark. 2003. Effect of reduced water table and fertility levels on subirrigated tomato production in Southwest Florida. EDIS SL-210, http://edis.ifas.ufl.edu/pdffiles/SS/SS42900.pdf

Weed Control in Tomato

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WEED CONTROL IN TOMATO

Labels change frequently. Be sure to read a current product label before applying any chemical.

Active ingredient lb. a.i./acre	Trade name product/acre	MOA Code	Weeds controlled / remarks
			*** PREPLANT / PREEMERGENCE ***
Carfentrazone up to 0.031	(Aim) 1.9 EW or (Aim) 2.0 EC up to 2 fl. oz.	14	Apply as a pre-plant burndown for emerged broadleaves up to 4 inches tall or rosettes less than 3 inches across. Good coverage is essential. A nonionic surfactant, methylated seed oil, or crop oil concentrate is recommended. No pre-transplant interval.
EPTC 2.6	(Eptam) 7 E 3 pt.	8	Annual broadleaves, annual grasses and suppression of yellow/purple nutsedge. Labeled for transplanted tomatoes grown on low density mulch. Do not use under high density, VIF, TIF, or metalized mulches. A 24(c) special local needs label in Florida. 14 day pre-transplant interval.
Flumioxazin up to 0.128	(Chateau) 51 WDG up to 4 oz.	14	Annual broadleaves and grasses. Apply to row middles of raised plastic mulched beds that are at least 4 in. higher than the treated row middle and 24 in. bed width. Label is a Third-Party registration (TPR, Inc.). Use without a signed authorization and waiver of liability is a misuse of the product. Tank mix with a burndown herbicide to control emerged weeds. 0 day pre-transplant interval.
Fomesafen 0.25 - 0.38	(Reflex) 2 EC 1.0 - 1.5 pt.	14	Broadleaves and suppression of yellow/purple nutsedge. Suppression of some annual and perennial grasses. Label is a 24(C) local indemnified label and a waiver of liability must be signed for use. Transplanted crop only. May be applied to bareground production or to plastic mulched beds following bed formation but prior to laying plastic. Use shields or hooded sprayers if applying to row middles and prevent contact with the plastic mulch. 7 and 0 day pre-transplant interval on bare ground and plastic mulch, respectively. 70 day PHI.
Glyphosate	(various formulations) consult labels	9	Emerged broadleaves, grasses, and nutsedge. Apply as a preplant burndown. Consult label for individual product directions.
Halosulfuron 0.024 - 0.05	(Sandea, Profine) 75 DF 0.5 - 1.0 oz.	2	Broadleaf weeds and yellow/purple nutsedge. Do not exceed 2 applications of halosulfuron per 12 month period. 7 day pre-transplant interval. 30 day PHI.
Imazosulfuron 0.19-0.3	(League) 4.0-6.4 oz	2	Broadleaves and suppression of yellow/purple nutsedge. Apply pre-transplant just prior to installation of plastic mulch. 1 day pre-transplant interval. 21 day PHI.
Lactofen 0.25 - 0.5	(Cobra) 2 EC 16 - 32 fl. oz.	14	Broadleaves. Label is a Third-Party registration (TPR, Inc.). Use without a signed authorization and waiver of liability is a misuse of the product. Apply to row middles only with shielded or hooded sprayers. Contact with green foliage or fruit may cause excessive injury. Drift of Cobra treated soil particles onto plant can cause contact injury. Limit of 1 PRE and 1 POST application per growing season. 30 day PHI.
***S*-metolachlor** 1.0 - 1.3	(Brawl, Dual Magnum, Medal) 7.62 EC 1.0 - 1.33 pt. if organic matter less then 3%	15	Annual broadleaves and grasses. Suppression of yellow/purple nutsedge. Apply to bed tops pre-transplant just prior to laying the plastic. May also be used in row middles. Research has shown that the 1.33 pt. may be too high in some Florida soils except in row middles. 30 day PHI. 90 day PHI if rate exceeds 1.33 pt./A.
Metribuzin 0.25 - 0.5	(Sencor DF, TriCor DF) 75 WDG 0.33 - 0.67 lb. (Sencor 4, Metri) 4 F 0.5 - 1.0 pt.	5	Small emerged weeds less than 1 in. tall. Apply preplant in transplanted tomatoes only. Incorporate to a depth of 2-4 inches. Maximum of 1.0 lb. a.i./A within a season. Avoid application for 3 days following cool, wet, or cloudy weather to reduce possible crop injury. 7 day PHI.

WEED CONTROL IN TOMATO (continued)

Labels change frequently. Be sure to read a current product label before applying any chemical.

Active ingredient lb. a.i./acre	Trade name product/acre	MOA Code	Weeds controlled / remarks
Napropamide **1.0 - 2.0**	(Devrinol DF XT) 50 DF 2.0 - 4.0 lb.	15	Annual broadleaves and grasses. For direct-seed or transplanted tomatoes. Apply to well worked soil that is moist enough to permit thorough incorporation to a depth of 2 in. Incorporate same day as applied.
Oxyfluorfen **0.25 - 0.5**	(Goal 2 XL) 2 EC 1.0 - 2.0 pt. (GoalTender) 4 E	14	Broadleaves. Apply pre-transplant just prior to installation of plastic mulch. 30 day pre-transplant interval. Mulch may be applied any time during the 30-day interval.
Paraquat **0.5 - 1.0**	(Gramoxone) 2 SL 2.0 - 4.0 pt. (Firestorm) 3 SL 1.3 - 2.7 pt.	22	Emerged broadleaves and grasses. Apply as a preplant burndown treatment. Surfactant recommended.
Pelargonic acid	(Scythe) 4.2 EC 3 - 10% v/v		Emerged broadleaves and grasses. Apply as a preplant burndown treatment or post transplant with shielded or hooded sprayers. Product is a contact, nonselective, foliar applied herbicide with no residual control.
Pendimethalin **0.48 - 0.72**	(Prowl H_20) 3.8 1.0 - 1.5 pt.	3	May be applied pretransplant to bed tops just prior to laying the plastic mulch or to row middles. Do not exceed 3.0 pt./A per year. 70 day PHI.
Pyraflufen **0.001 - 0.003**	(ETX Herbicide) 0.208 EC 0.3 - 1.25 fl. oz.	14	Emerged broadleaves less than 4 in. tall or rosttes less than 3 in. diameter. Apply as a preplant burndown treatment. Nonionic surfactant or crop oil concentrate recommended.
Rimsulfuron **0.03 - 0.06**	(Matrix FNV, Matrix SG, Pruvin) 25 WDG 2.0 - 4.0 oz.	2	Annual broadleaves and grasses. Suppression of yellow nutsedge. Requires 0.5-1 in. of rainfall or irrigation within 5 days of application for activation. May be applied as a sequential treatment with a PRE and POST application not exceeding 0.06 lb. a.i./A in a single season. 45 day PHI
Tifluralin **0.5**	(Treflan, Trifluralin) 4 EC 1 pt. (Treflan, Trifluralin) 10 G 5 lb.	3	Annual broadleaves and grasses. Do not apply in Dade County. Incorporate 4 in. or less within 8 hr. of application. Results in Florida are erratic on soils with low organic matter and clay contents. Note label precautions against planting noncrop within 5 months. Do not apply after transplanting.
			*** **POSTTRANSPLANT** ***
Carfentrazone **up to 0.031**	(Aim) 1.9 EW or (Aim) 2.0 EC up to 2 fl. oz.	14	Emerged broadleaf weeds. Apply as a hooded application to row middles only. Good coverage is essential. May be tank mixed with other herbicides. A nonionic surfactant, methylated seed oil, or crop oil concentrate is recommended. 0 day PHI.
Clethodim **0.09 - 0.25** **0.07 - 0.25**	(Arrow, Select) 2 EC 6 - 16 fl. oz. (Select Max) 1 EC 9 - 32 fl. oz.	1	Perennial and annual grasses. Use higher rates under heavy grass pressure or larger weeds. Surfactant or crop oil concentrate recommended. Consult label. 20 day PHI.
DCPA **6.0 - 7.5**	(Dacthal) W-75 8 - 10 lb. (Dacthal) 6 F 8 - 10 pt.	3	Annual grasses and select broadleaves. Apply to weed-free soil 6-8 wk. after crop is established and growing rapidly or to moist soil in row middles after crop establishment. Note label precautions against replanting non-registered crops within 8 months.
Diquat **0.5**	(Reglone Dessiccant) 1 qt.	22	Broadleaves and grasses. Apply to row middles only. Maximum of 2 applications per season. Prevent drift to crop. Nonionic surfactant recommended. 30 day PHI.
Halosulfuron **0.024 - 0.05**	(Sandea, Profine) 75 DF 0.5 - 1.0 oz.	2	Broadleaf weeds and yellow/purple nutsedge. Apply 14 days after transplant but before first bloom. Following first bloom apply with shielded or hooded applicator. May be applied to row middles with shielded or hooded sprayer. Do not exceed 2 oz per 12 month period. Surfactant recommended. 30 day PHI.
Imazosulfuron **0.19-0.3**	(League) 4.0-6.4 oz	2	Apply post emergence 3 to 5 days after transplant through early bloom. Only apply if no pre-transplant application was made. Surfactant recommended. PHI 21 days.
Lactofen **0.25 - 0.5**	(Cobra) 2 EC 16 - 32 fl. oz.	14	Broadleaf weeds. Apply to row middles only with shielded or hooded sprayers. Contact with green foliage or fruit can cause excessive injury. Drift of Cobra treated soil particles onto plants can cause contact injury. Limit of 1 PRE and 1 POST application per growing season. Do not apply within 18 days of transplant. Surfactant recommended. PHI 30 days.
***S*-metolachlor** **1.0 - 1.3**	(Brawl, Dual Magnum, Medal) 7.62 EC 1.0 - 1.33 pt.	15	Annual broadleaf, grasses, and yellow/purple nutsedge. Apply to row middles. Label rates are 1.0-1.33 pt./A if organic matter is less than 3%. Use on a trial basis. Surfactant not recommended. 90 day PHI for rates above 1.33 pt./A. 30 day PHI for rates 1.33 pt./acre or less.
Metribuzin **0.25 - 0.5**	(Sencor DF, TriCor DF) 75 WDG 0.33 - 0.67 lb. (Sencor 4, Metri) 4 F 0.5 - 1.0 pt.	5	Small emerged weeds. Apply after transplants or seedlings are well established. Apply in single or multiple applications with a minimum of 14 days between treatments. Maximum of 1.0 lb. a.i./A within a season. Avoid application for 3 days following cool, wet, or cloudy weather to reduce possible crop injury. 7 day PHI.
Paraquat **0.5**	(Gramoxone) 2 SL 2 pt. (Firestorm) 3 SL 1.3 pt.	22	Emerged broadleaf and grass weeds. Direct spray over emerged weeds 1-6 in. tall in row middles between mulched beds. Use low pressure and shields to control drift. Do not apply more than 3 times per season. Nonionic surfactant recommended. 30 day PHI.
Pelargonic acid	(Scythe) 4.2 EC 3 - 10% v/v		Emerged broadleaf and grass weeds. Direct spray to row middles. Product is a contact, nonselective, foliar applied herbicide with no residual control. May be tank mixed with several soil residual compounds.
Pendimethalin **0.48 - 0.72**	(Prowl H_20) 3.8 1.0 - 1.5 pt.	3	Broadleaf and grass weeds. May be applied post transplant to row middles if previously untreated. Do not exceed 3.0 pt./A per year. 70 day PHI.

WEED CONTROL IN TOMATO (continued)			
Labels change frequently. Be sure to read a current product label before applying any chemical.			
Active ingredient lb. a.i./acre	**Trade name product/acre**	**MOA Code**	**Weeds controlled / remarks**
Rimsulfuron **0.02 - 0.03**	(Matrix FNV, Matrix SG, Pruvin) 25 WDG 1.0 - 2.0 oz.	2	Broadleaves and grasses. May be applied as a sequential treatment with a PRE and POST application not exceeding 0.06 lb. a.i./A in a single season. Requires 0.5-1.0 in. of rainfall or irrigation within 5 days of application for activation. Nonionic surfactant or crop oil concentrate recommended. PHI 45 days.
Sethoxydim **0.19 - 0.28**	(Poast) 1.5 EC 1.0 - 1.5 pt.	1	Actively growing grasses. A total of 4.5 pt./A applied in one season. Unsatisfactory results may occur if applied to grasses under stress. Crop oil concentrate recommended. 20 day PHI.
Trifloxysulfuron **0.005 - 0.009**	(Envoke) 75 DG 0.1 - 0.2 oz.	2	Broadleaves and yellow/purple nutsedge. Direct spray solution to the base of transplanted tomato plants. Apply at least 14 days after transplanting and before fruit set. 45 day PHI.
			***** POSTHARVEST *****
Diquat **0.5**	(Reglone Dessiccant) 2.0 pt.	22	Minimum of 35 gal./A. Thorough coverage is required. Nonionic surfactant recommended.
Paraquat **0.62 - 0.94**	(Gramoxone) 2 SL 2.4 - 3.75 pt. (Firestorm) 3 SL 1.6 - 2.5 pt.	22	Broadcast spray over the top of the plants after the last harvest. Thorough coverage is required to ensure maximum herbicide burndown. Do not use treated crop for human or animal consumption. Nonionic surfactant recommended.

Tomato Fungicides

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TOMATO FUNGICIDES

Products sorted by disease and then in order by FRAC group corresponding to the mode of action.

Biopesticides and other alternative products labeled for disease management are listed in a separe table for convenience. (Updated June 2014).

Labels change frequently. Be sure to read a current product label before applying any chemical.
Refer to Table XX for biopesticide and other alternative products labeled for disease management.

Pertinent Diseases or Pathogens	Fungicide Group[1]	Chemical (active ingredients)	Max. Rate/acre Applic.	Max. Rate/acre Season	Min. Days to Harvest	Min. Days to Reentry	Remarks[2]
Anthracnose	M1	**(copper compounds)** **Many brands available:** Badge SC, Badge X2, Basic Copper 50W HB, Basic Copper 53, C-O-C-S WDG, Champ DP, Champ F2 FL, Champ WG, Champion WP, C-O-C DF, C-O-C WP, Copper Count N, Cuprofix Ultra 40D, Cueva, Kentan DF, Kocide 3000, Kocide 2000, Kocide DF, Nordox, Nordox 75WG, Nu Cop 50WP, Nu Cop 3L, Nu Cop 50DF, Nu Cop HB	**SEE INDIVIDUAL LABELS**		1	Varies from 4 hr to 2 days.	Mancozeb enhances bactericidal effect of fix copper compounds.
	M3	**(mancozeb)** **Many brands available:** Dithane DF, Dithane F45, Dithane M45, Koverall, Manzate FL, Manzate Pro-Stik, Penncozeb 4FL, Penncozeb 75DF, Penncozeb 80WP	**SEE INDIVIDUAL LABELS**		5	1	
	M3	Ziram 76DF (ziram)	4 lb	23.7 lb	7	2	Do not use on cherry tomatoes.
	M3 & M1	ManKocide (mancozeb + copper hydroxide)	5 lb	112 lb	5	2	
	M5	**(chlorothalonil)** **Many brands available:** Bravo Ultrex, Bravo Weather Stik, Bravo Zn, Chloronil 720, Echo 720, Echo 90 DF, Echo Zn, Equus 500 Zn, Equus 720 SST, Equus DF, Initiate 720, Orondis Opti B	SEE INDIVIDUAL LABELS		0	0.5	Use higher rates at fruit set and lower rates before fruit set.

TOMATO FUNGICIDES (continued)

Products sorted by disease and then in order by FRAC group corresponding to the mode of action.

Biopesticides and other alternative products labeled for disease management are listed in a separe table for convenience. (Updated June 2014).

Labels change frequently. Be sure to read a current product label before applying any chemical.
Refer to Table XX for biopesticide and other alternative products labeled for disease management.

Pertinent Diseases or Pathogens	Fungicide Group[1]	Chemical (active ingredients)	Max. Rate/acre		Min. Days to		Remarks[2]
			Applic.	Season	Harvest	Reentry	
(suppression)	7	Fontelis (penthiopyrad)	24 fl oz	72 fl oz	0	0.5	For Disease suppression only. No more than 2 sequential applications before rotating with another effective fungicide from a different FRAC group. See label for additional instructions pertaining to greenhouse useage.
	9 & 3	Inspire Super (cyprodinil + difenoconazole)	20 fl oz	47 fl oz	0	0.5	Limit is 5 apps per season with no more than 2 sequential apps. Must tank mix or alternate with another effective fungicide from another FRAC group. Has up to a 8 month plant back restriction with off label crops.
(suppression)	7 & 11	Luna Sensation (fluopyram + trifloxystrobin)	7.6 fl oz	27.3 fl oz	3	0.5	No more than 2 sequential applications before rotating with another effective fungicide from a different FRAC group. Limit of 5 apps per a year.
	11	Equation Heritage Quadris FL Satori (azoxystrobin)	6.2 fl oz 3.2 oz 6.2 fl oz 6.2 fl oz	37 fl oz 1.6 lb 37 fl oz 37 fl oz	0 0 0 0	4 hr 4 hr 4 hr 4 hr	Must alternate or tank mix with a fungicide from a different FRAC group; use of an adjuvant or tank mixing with EC products may cause phytotoxicity.
	11	Flint Gem 500 SC (trifloxystrobin)	4 oz 3.8 floz	16 oz 16 fl oz	3 3	0.5 0.5	Limit is 5 apps/crop. Must alternate or tank mix with a fungicide from a different FRAC group.
	11 & M5	Quadris Opti (azoxystrobin + chlorothalonil)	1.6 pt	8 pt	0	0.5	Must alternate with a non-FRAC code 11 fungicide; use of an adjuvant may cause phytotoxicity.
	11 & 3	Quadris Top (azoxystrobin + difenoconazole)	8 fl oz	47 fl oz	0	0.5	Limit is 4 apps per season with no more than 2 sequential apps. Must tank mix or alternate with another effective fungicide from another FRAC group.
	11 & 7	Priaxor (pyraclostrobin + fluxapyroxad)	8 fl oz	24 fl oz	0	0.5	Limit is 3 apps per season; no more than 2 sequential apps. See label about compatibility with other formulated products and adjuvants.
	11 & 27	Tanos (famoxadone + cymoxanil)	8 oz	72 oz	3	0.5	Do not alternate or tank mix with other FRAC group 11 fungicides.
	27 & M5	Ariston (cymoxanil + chlorothalonil)	1.9 pt	30.2 pt	3	0.5	Check copper manufacturer's label for specific precautions and limitations for mixing with this product.
(suppression)	19	Ph-D WDG Oso 5% SC (polyoxin D zinc salt)	6.2 oz 13 fl oz	31.0 oz 78 fl oz	0 0	4 hr 4 hr	Alternate with a non-FRAC code 19 fungicide.
	40 & 3	Revus Top (mandipropamid + difenoconazole)	7 fl oz	28 fl oz	1	0.5	Limit is 4 apps per season; no more than 2 sequential apps. Not labeled for transplants.
Bacterial canker	M1	**(copper compounds)** **Many brands available:** Badge SC, Badge X2, Basic Copper 50W HB, Basic Copper 53, C-O-C-S WDG, Champ DP, Champ F2 FL, Champ WG, Champion WP, C-O-C DF, C-O-C WP, Copper Count N, Cuprofix Ultra 40D, Cueva, Kentan DF, Kocide 3000, Kocide 2000, Kocide DF, Nordox, Nordox 75WG, Nu Cop 50WP, Nu Cop 3L, Nu Cop 50DF, Nu Cop HB	**SEE INDIVIDUAL LABELS**		1	Varies by product from 4 hr to 2 days.	Mancozeb enhances the bactericidal effect of fix copper compounds.
(suppression)	11 & 27	Tanos (famoxadone + cymoxanil)	8 oz	72 oz	3	0.5	Do not alternate or tank mix with other FRAC group 11 fungicides.
Bacterial spot and **Bacterial speck**	M1	**(copper compounds)** **Many brands available:** Badge SC, Badge X2, Basic Copper 50W HB, Basic Copper 53, C-O-C-S WDG, Champ DP, Champ F2 FL, Champ WG, Champion WP, C-O-C DF, C-O-C WP, Copper Count N, Cuprofix Ultra 40D, Cueva, Kentan DF, Kocide 3000, Kocide 2000, Kocide DF, Nordox, Nordox 75WG, Nu Cop 50WP, Nu Cop 3L, Nu Cop 50DF, Nu Cop HB	**SEE INDIVIDUAL LABELS**		1	Varies by product from 4 hr to 2 days.	Mancozeb enhances the bactericidal effect of fix copper compounds.

TOMATO FUNGICIDES (continued)

Products sorted by disease and then in order by FRAC group corresponding to the mode of action.

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Refer to Table XX for biopesticide and other alternative products labeled for disease management.

Pertinent Diseases or Pathogens	Fungicide Group[1]	Chemical (active ingredients)	Max. Rate/acre		Min. Days to		Remarks[2]
			Applic.	Season	Harvest	Reentry	
	M3	**(mancozeb)** **Many brands available:** Dithane DF, Dithane F45, Dithane M45, Koverall, Manzate FL, Manzate Pro-Stik, Penncozeb 4FL, Penncozeb 75DF, Penncozeb 80WP	**SEE INDIVIDUAL LABELS**		5	1	Bacterial spot control only when tank mixed with a copper fungicide.
	M3 & M1	ManKocide (mancozeb + copper hydroxide)	5 lb	112 lb	5	2	
(suppression)	11 & 27	Tanos (famoxadone + cymoxanil)	8 oz	72 oz	3	0.5	Do not alternate or tank mix with other FRAC group 11 fungicides.
	25	Agri-mycin 17 Ag Streptomycin Bac-Master (streptomycin sulfate)	200 ppm	-	-	0.5	See label for details. For transplant production only. Many isolates are resistant to streptomycin.
	P	Actigard (acibenzolar-S-methyl)	0.75 oz	4.75 oz	14	0.5	Begin applications within one week of transplanting or emergence. Make up to 8 weekly, sequential applications.
Black mold **(*Alternaria* spp.)**	3	Mentor (propiconazole)	8 oz /100 gal or / 50,000 lb of fruit	-	-	-	Apply as a post-harvest dip, drench, or high-volume spray for the post-harvest control of certain rots. See label for details.
	3 & 9	Chairman (propiconazole + fludioxonil)	32 floz / 100 gal or / 50,000 lb of fruit	-	-	-	Apply as a post-harvest dip, drench, or high-volume spray for the post-harvest control of certain rots. Lower rates for small diameter fruit. See label for details.
	7	Endura (boscalid)	12.5 oz	25 oz	0	0.5	Alternate with non-FRAC code 7 fungicides, see label
	7	Fontelis (penthiopyrad)	24 fl oz	72 fl oz	0	0.5	No more than 2 sequential applications before rotating with another effective fungicide from a different FRAC group. See label for additional instructions pertaining to greenhouse useage.
	7 & 9	Luna Tranquility (fluopyram + pyrimethanil)	11.2 fl oz	54.7 fl oz	1	0.5	No more than 2 sequential applications before rotating with another effective fungicide from a different FRAC group. See label for additional instructions pertaining to greenhouse useage.
	7 & 11	Luna Sensation (fluopyram + trifloxystrobin)	7.6 fl oz	27.3 fl oz	3	0.5	No more than 2 sequential applications before rotating with another effective fungicide from a different FRAC group. Limit of 5 apps per a year.
	9 & 3	Inspire Super (cyprodinil + difenoconazole)	20 fl oz	47 fl oz	0	0.5	Limit is 5 apps per season with no more than 2 sequential apps. Must tank mix or alternate with another effective fungicide from another FRAC group. Has up to a 8 month plant back restriction with off label crops.
	11	Heritage Quadris FL Equation Satori (azoxystrobin)	3.2 oz 6.2 fl oz 6.2 fl oz 6.2 fl oz	1.6 lb 37 fl oz 37 fl oz 37 fl oz	0 0 0 0	4 hr 4 hr 4 hr 4 hr	Must alternate or tank mix with a fungicide from a different FRAC group; use of an adjuvant or tank mixing with EC products may cause phytotoxicity.
	11 & M5	Quadris Opti (azoxystrobin + chlorothalonil)	1.6 pt	8 pt	0	0.5	Must alternate with a non-FRAC code 11 fungicide; use of an adjuvant may cause phytotoxicity.
	11 & 3	Quadris Top (azoxystrobin + difenoconazole)	8 fl oz	47 fl oz	0	0.5	Limit is 4 apps per season with no more than 2 sequential apps. Must tank mix or alternate with another effective fungicide from another FRAC group. Has up to a 1 year plant back restriction for certain off label crops.
	11 & 7	Priaxor (pyraclostrobin + fluxapyroxad)	8 fl oz	24 fl oz	0	0.5	Limit is 3 apps per season; no more than 2 sequential apps. See label about compatibility with other formulated products and adjuvants.

TOMATO FUNGICIDES (continued)

Products sorted by disease and then in order by FRAC group corresponding to the mode of action.

Biopesticides and other alternative products labeled for disease management are listed in a separe table for convenience. (Updated June 2014).

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Pertinent Diseases or Pathogens	Fungicide Group[1]	Chemical (active ingredients)	Max. Rate/acre		Min. Days to		Remarks[2]
			Applic.	Season	Harvest	Reentry	
	27 & M5	Ariston (cymoxanil + chlorothalonil)	1.9 pt	30.2 pt	3	0.5	Check copper manufacturer's label for specific precautions and limitations for mixing with this product.
	40 & 3	Revus Top (mandipropamid + difenoconazole)	7 fl oz	28 fl oz	1	0.5	4 apps per season; no more than 2 sequential apps. Not labeled for transplants.
Botrytis, Gray Mold	M5	**(chlorothalonil)** Many brands available: Bravo Ultrex, Bravo Weather Stik, Bravo Zn, Chloronil 720, Echo 720, Echo 90 DF, Echo Zn, Equus 500 Zn, Equus 720 SST, Equus DF, Initiate 720, Orondis Opti B	**SEE INDIVIDUAL LABELS**		0	0.5	Use higher rates at fruit set and lower rates before fruit set.
	3 & 9	Chairman (propiconazole + fludioxonil)	32 floz / 100 gal or /50,000 lb of fruit	-	-	-	Apply as a post-harvest dip, drench, or high-volume spray for the post-harvest control of certain rots. Lower rates for small diameter fruit. See label for details.
	7	Fontelis (penthiopyrad)	24 fl oz	72 fl oz	0	0.5	No more than 2 sequential applications before switching to another effective fungicide with a different mode of action. See label for additional instructions pertaining to greenhouse useage.
(*suppression*)	7	Endura (boscalid)	12.5 oz	25 oz	0	0.5	Alternate with non-FRAC code 7 fungicides.
	7 & 9	Luna Tranquility (fluopyram + pyrimethanil)	11.2 fl oz	54.7 fl oz	1	0.5	No more than 2 sequential applications before rotating with another effective fungicide from a different FRAC group. See label for additional instructions pertaining to greenhouse useage.
	7 & 11	Luna Sensation (fluopyram + trifloxystrobin)	7.6 fl oz	27.3 fl oz	3	0.5	No more than 2 sequential applications before rotating with another effective fungicide from a different FRAC group. Limit of 5 apps per a year.
	9	Scala SC (pyrimethanil)	7 fl oz	35 fl oz	1	0.5	Use only in a tank mix with another effective non-FRAC code 9 fungicide; Has a 30 day plant back with off label crops.
	9 & 12	Switch 62.5WG (cyprodinil + fludioxonil)	14 oz	56 oz per year	0	0.5	After 2 appl. Alternate with non-FRAC code 9 or 12 fungicides for next 2 applications. Has a 30 day plant back with off label crops.
(suppression)	11	Cabrio 2.09 F (pyraclostrobin)	16 fl oz	96 fl oz	0	0.5	Only 2 sequential appl. Allowed. Limit is 6 appl/crop. Must alternate or tank mix with a fungicide from a different FRAC group.
(suppression)	11 & 7	Priaxor (pyraclostrobin + fluxapyroxad)	8 fl oz	24 fl oz	0	0.5	Limit is 3 apps per season; no more than 2 sequential apps. See label about compatibility with other formulated products and adjuvants.
	14	Botran 75 W (dichloran)	1 lbs per 100 gal.	5.33 lb	10	0.5	Greenhouse use only. Limit is 4 applications. Seedlings or newly set transplants may be injured.
	19	Ph-D WDG Oso 5% SC (polyoxin D zinc salt)	6.2 oz 13 fl oz	31.0 oz 78 fl oz	0 0	4 hr 4 hr	Alternate with a non-FRAC code 19 fungicide.
	27 & M5	Ariston (cymoxanil + chlorothalonil)	1.9 pt	30.2 pt	3	0.5	Check copper manufacturer's label for specific precautions and limitations for mixing with this product.
Buckeye rot **Phytophthora fruit rot** **(*Phytophthora* spp.)**	4	Orondis Gold B (mefenoxam)	1 pt	3 pt	28	0	Do not apply more than 1.5 lb mefenoxam/A per crop to the soil.
	M1 + 4	Ridomil Gold Copper (copper hydroxide + mefenoxam)	2 lb	6 lb	14	2	Limited to 3 apps per season. Tankmix with mancozeb.
	11	Heritage Quadris FL Equation Satori (azoxystrobin)	3.2 oz 6.2 fl oz 6.2 fl oz 6.2 fl oz	1.6 lb 37 fl oz 37 fl oz 37 fl oz	0 0 0 0	4 hr 4 hr 4 hr 4 hr	Must alternate or tank mix with a fungicide from a different FRAC group; use of an adjuvant or tank mixing with EC products may cause phytotoxicity.

TOMATO FUNGICIDES (continued)

Products sorted by disease and then in order by FRAC group corresponding to the mode of action.

Biopesticides and other alternative products labeled for disease management are listed in a separe table for convenience. (Updated June 2014).

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Pertinent Diseases or Pathogens	Fungicide Group[1]	Chemical (active ingredients)	Max. Rate/acre		Min. Days to		Remarks[2]
			Applic.	Season	Harvest	Reentry	
	11	Cabrio 2.09 F (pyraclostrobin)	16 fl oz	96 fl oz	0	0.5	Only 2 sequential appl. Allowed. Limit is 6 appl/crop. Must alternate or tank mix with a fungicide from a different FRAC group, see label.
	11 & M5	Quadris Opti (azoxystrobin + chlorothalonil)	1.6 pt	8 pt	0	0.5	Must alternate with a non-FRAC code 11 fungicide; use of an adjuvant may cause phytotoxicity.
(suppression)	11 & 27	Tanos (famoxadone + cymoxanil)	8 oz	72 oz	3	0.5	Do not alternate or tank mix with other FRAC group 11 fungicides.
	22 & M3	Gavel 75DF (zoaximide + mancozeb)	2.0 lb	16 lb	5	2	See label
	U15	Orondis Opti A Orondis Ultra A (oxathiapiprolin)	4.8 fl oz 4.8 fl oz	19.2 fl oz 19.2 fl oz	0 0	4 hr 4 hr	Do not combine foliar apps of Orondis with soil apps of Orondis for disease control. 6 apps per season; no more than 2 sequential apps. 5 day minimum app. interval; Applications should not exceed more than 33% of the total foliar fungicide apps. See Orondis Ultra A label for greenhouse use.
Early blight	M1	**(copper compounds)** **Many brands available:** Badge SC, Badge X2, Basic Copper 50W HB, Basic Copper 53, C-O-C-S WDG, Champ DP, Champ F2 FL, Champ WG, Champion WP, C-O-C DF, C-O-C WP, Copper Count N, Cuprofix Ultra 40D, Cueva, Kentan DF, Kocide 3000, Kocide 2000, Kocide DF, Nordox, Nordox 75WG, Nu Cop 50WP, Nu Cop 3L, Nu Cop 50DF, Nu Cop HB	SEE INDIVIDUAL LABELS		1	Varies by product from 4 hr to 2 days.	Mancozeb or maneb enhances bactericidal effect of fix copper compounds. **See label for details.**
	M3	(mancozeb) **Many brands available:** Dithane DF, Dithane F45, Dithane M45, Koverall, Manzate FL, Manzate Pro-Stik, Penncozeb 4FL, Penncozeb 75DF, Penncozeb 80WP	**SEE INDIVIDUAL LABELS**		5	1	
	M3	Ziram 76DF (ziram)	4 lbs	23.7 lb	7	2	Do not use on cherry tomatoes.
	M3 & M1	ManKocide (mancozeb + copper hydroxide)	5 lb	112 lb	5	2	
	M5	**(chlorothalonil)** **Many brands available:** Bravo Ultrex, Bravo Weather Stik, Bravo Zn, Chloronil 720, Echo 720, Echo 90 DF, Echo Zn, Equus 500 Zn, Equus 720 SST, Equus DF, Initiate 720, Orondis Opti B	**SEE INDIVIDUAL LABELS**		0	0.5	Use higher rates at fruit set and lower rates before fruit set.
	3	Tebuzol 3.6F (tebuconazole)	8 fl oz	48 fl oz	7	0.5	Limit is 6 appl./crop. Minimum appl. interval of 7 days.
	4 & M5	Ridomil Gold Bravo 76.4 W (chlorothalonil + mefenoxam)	3 lb	12 lb	14	2	Limit is 4 appl./crop.
	7	Endura (boscalid)	12.5 oz	25 oz	0	0.5	Alternate with non-FRAC code 7 fungicides.
	7	Fontelis (penthiopyrad)	24 fl oz	72 fl oz	0	0.5	No more than 2 sequential applications before switching to another effective fungicide with a different mode of action. See label for additional instructions pertaining to greenhouse useage.
	7 & 9	Luna Tranquility (fluopyram + pyrimethanil)	11.2 fl oz	54.7 fl oz	1	0.5	No more than 2 sequential applications before rotating with another effective fungicide from a different FRAC group. See label for additional instructions pertaining to greenhouse useage.
	7 & 11	Luna Sensation (fluopyram + trifloxystrobin)	7.6 fl oz	27.3 fl oz	3	0.5	No more than 2 sequential applications before rotating with another effective fungicide from a different FRAC group. Limit of 5 apps per a year.
	9	Scala SC (pyrimethanil)	7 fl oz	35 fl oz	1	0.5	Use only in a tank mix with another effective non-FRAC code 9 fungicide ; Has a 30 day plant back with off label crops.

TOMATO FUNGICIDES (continued)

Products sorted by disease and then in order by FRAC group corresponding to the mode of action.

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Pertinent Diseases or Pathogens	Fungicide Group[1]	Chemical (active ingredients)	Max. Rate/acre		Min. Days to		Remarks[2]
			Applic.	Season	Harvest	Reentry	
	9 & 3	Inspire Super (cyprodinil + difenoconazole)	20 fl oz	47 fl oz	0	0.5	Limit is 5 apps per season with no more than 2 sequential apps. Must tank mix or alternate with another effective fungicide from another FRAC group. Has up to a 8 month plant back restriction with off label crops.
	9 & 12	Switch 62.5WG (cyprodinil + fludioxonil)	14 oz	56 oz per year	0	0.5	After 2 apps. alternate with non-FRAC code 9 or 12 fungicides for next 2 applications. Has a 30 day plant back with off label crops.
	11	Heritage Quadris FL Equation Satori (azoxystrobin)	3.2 oz 6.2 fl oz 6.2 fl oz 6.2 fl oz	1.6 lb 37 fl oz 37 fl oz 37 fl oz	0 0 0 0	4 hr 4 hr 4 hr 4 hr	Must alternate or tank mix with a fungicide from a different FRAC group; use of an adjuvant or tank mixing with EC products may cause phytotoxicity.
	11	Cabrio 2.09 F (pyraclostrobin)	16 fl oz	96 fl oz	0	0.5	Only 2 sequential apps. allowed. Limit is 6 apps/crop. Must alternate or tank mix with a fungicide from a different FRAC group.
	11	Flint Gem 500 SC (trifloxystrobin)	4 oz 3 floz	16 oz 16 fl oz	3 3	0.5 0.5	Limit is 5 apps/crop. Must alternate or tank mix with a fungicide from a different FRAC group.
	11	Evito Aftershock (fluoxastrobin)	5.7 fl oz	22.8 fl oz	3	0.5	Limit is 4 apps/crop. Must alternate or tank mix with a fungicide from a different FRAC group.
	11	Reason 500 SC (fenamidone)	8.2 oz	24.6 lb	14	0.5	Must alternate with a fungicide from a different FRAC group. See supplemental label for restrictions and details.
	11 & M5	Quadris Opti (azoxystrobin + chlorothalonil)	1.6 pt	8 pt	0	0.5	Must alternate with a non-FRAC code 11 fungicide; use of an adjuvant may cause phytotoxicity.
	11 & 3	Quadris Top (azoxystrobin + difenoconazole)	8 fl oz	47 fl oz	0	0.5	Limit is 4 apps per season with no more than 2 sequential apps. Must tank mix or alternate with another effective fungicide from another FRAC group. Has up to a 1 year plant back restriction for certain off label crops.
	11 & 7	Priaxor (pyraclostrobin + fluxapyroxad)	8 fl oz	24 fl oz	0	0.5	Limit is 3 apps per season; no more than 2 sequential apps. See label about compatibility with other formulated products and adjuvants.
	11 & 27	Tanos (famoxadone + cymoxanil)	8 oz	72 oz	3	0.5	Do not alternate or tank mix with other FRAC group 11 fungicides.
	19	Ph-D WDG Oso 5% SC (polyoxin D zinc salt)	6.2 oz 13 fl oz	31.0 oz 78 fl oz	0 0	4 hr 4 hr	Alternate with a non-FRAC code 19 fungicide.
	22 & M3	Gavel 75DF Zing! (zoaximide + mancozeb)	2.0 lb 34 fl oz	16 lb 272 fl oz	5	2	
	27 & M5	Ariston (cymoxanil + chlorothalonil)	3.0 pt	30.2 pt	3	0.5	Check copper manufacturer's label for specific precautions and limitations for mixing with this product.
	28	Previcur Flex (propamocarb hydrochloride)	1.5 pt	7.5 pt	5	0.5	Must tank mix with chlorothalonil or mancozeb.
	28	Promess (propamocarb hydrochloride)	1.5 pt	7.5 pt	5	0.5	Must tank mix with chlorothalonil or mancozeb.
	40 & 3	Revus Top (mandipropamid + difenoconazole)	7 fl oz	28 fl oz	1	0.5	Limit is 4 apps per season; no more than 2 sequential apps. Not labeled for transplants.
Late blight	M1	**(copper compounds)** **Many brands available:** Badge SC, Badge X2, Basic Copper 50W HB, Basic Copper 53, C-O-C-S WDG, Champ DP, Champ F2 FL, Champ WG, Champion WP, C-O-C DF, C-O-C WP, Copper Count N, Cuprofix Ultra 40D, Cueva, Kentan DF, Kocide 3000, Kocide 2000, Kocide DF, Nordox, Nordox 75WG, Nu Cop 50WP, Nu Cop 3L, Nu Cop 50DF, Nu Cop HB	**SEE INDIVIDUAL LABELS**		1	Varies by product from 4 hr to 2 days.	

TOMATO FUNGICIDES (continued)

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Pertinent Diseases or Pathogens	Fungicide Group[1]	Chemical (active ingredients)	Max. Rate/acre		Min. Days to		Remarks[2]
			Applic.	Season	Harvest	Reentry	
	M3	**(mancozeb)** **Many brands available:** Dithane DF, Dithane F45, Dithane M45, Kover-all, Manzate, Manzate Pro-Stik, Penncozeb 4FL, Penncozeb 75DF, Penncozeb 80WP	**SEE INDIVIDUAL LABELS**		5	1	
	M3 & M1	ManKocide (mancozeb + copper hydroxide)	5 lb	112 lb	5	2	
	M5	(chlorothalonil) **Many brands available:** Bravo Ultrex, Bravo Weather Stik, Bravo Zn, Chloronil 720, Echo 720, Echo 90 DF, Echo Zn, Equus 500 Zn, Equus 720 SST, Equus DF, Initiate 720, Orondis Opti B	**SEE INDIVIDUAL LABELS**		0	0.5	Use higher rates at fruit set and lower rates before fruit set.
	4 & M3	Ridomil MZ 68 WP (mefenoxam + mancozeb)	2.5 lb	7.5 lb	5	2	Limit is 3 apps./crop.
	4 & M1	Ridomil Gold Copper 64.8 W (mefenoxam + copper hydroxide)	2 lb	6 lb	14	2	Limit is 3 apps./crop. Tank mix with mancozeb fungicide.
	4 & M5	Ridomil Gold Bravo 76.4 W (chlorothalonil + mefenoxam)	3 lb	12 lb	14	2	Limit is 4 apps./crop.
	11	Heritage Quadris FL Equation Satori (azoxystrobin)	3.2 oz 6.2 fl oz 6.2 fl oz 6.2 fl oz	1.6 lb 37 fl oz 37 fl oz 37 fl oz	0 0 0 0	4 hr 4 hr 4 hr 4 hr	Must alternate or tank mix with a fungicide from a different FRAC group; use of an adjuvant or tank mixing with EC products may cause phytotoxicity.
	11	Cabrio 2.09 F (pyraclostrobin)	16 fl oz	96 fl oz	0	0.5	Only 2 sequential appl. Allowed. Limit is 6 appl/crop. Must alternate or tank mix with a fungicide from a different FRAC group.
	11	Flint Gem 500 SC (trifloxystrobin)	4 oz 3.8 floz	16 oz 16 fl oz	3 3	0.5 0.5	Limit is 5 appl/crop. Must alternate or tank mix with a fungicide from a different FRAC group.
	11	Evito Aftershock (fluoxastrobin)	5.7 fl oz	22.8 fl oz	3	0.5	Limit is 4 appl/crop. Must alternate or tank mix with a fungicide from a different FRAC group.
	11	Reason 500 SC (fenamidone)	8.2 oz	24.6 lb	14	0.5	Must alternate with a fungicide from a different FRAC group.
	11 & M5	Quadris Opti (azoxystrobin + chlorothalonil)	1.6 pt	8 pt	0	0.5	Must alternate with a non-FRAC code 11 fungicide; use of an adjuvant may cause phytotoxicity.
(suppression)	11 & 7	Priaxor (pyraclostrobin + fluxapyroxad)	8 fl oz	24 fl oz	7	0.5	Limit is 3 apps per season; no more than 2 sequential apps. See label about compatibility with other formulated products and adjuvants.
	11 & 27	Tanos (famoxadone + cymoxanil)	8 oz	72 oz	3	0.5	Do not alternate or tank mix with other FRAC group 11 fungicides.
	19	Oso 5% SC (polyoxin D zinc salt)	13 fl oz	78 fl oz	0	4 hr	Alternate with a non-FRAC code 19 fungicide.
	21	Ranman (cyazofamid)	2.75 oz	16oz	0	0.5	Limit is 6 apps./crop.
	22 & M3	Gavel 75DF Zing! (zoaximide + mancozeb)	2.0 lb 34 fl oz	16 lb 272 fl oz	5	2	
	27	Curzate 60DF (cymoxanil)	5 oz	30 oz per year	3	0.5	Must tank mix with another effective product.
	27 & M5	Ariston (cymoxanil + chlorothalonil)	3.0 pt	30.2 pt	3	0.5	Check copper manufacturer's label for specific precautions and limitations for mixing with this product.
	28	Previcur Flex (propamocarb hydrochloride)	1.5 pt	7.5 pt	5	0.5	Must tank mix with Chlorothalonil or mancozeb.
	28	Promess (propamocarb hydrochloride)	1.5 pt	7.5 pt	5	0.5	Must tank mix with Chlorothalonil or mancozeb.
	33	Aliette 80 WDG (fosetyl-al)	5 lb	20lb	14	0.5	See label for warnings concerning the use of copper compounds.

TOMATO FUNGICIDES (continued)

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			Applic.	Season	Harvest	Reentry	
	33	Alude (mono- and di-potassium salts of phosphorous acid)	1.5 qt/ acre/ 25 gal	-	-	4 hr	For transplants only.
	40	Forum (dimethomorph)	6 oz	30 oz	4	0.5	Only 2 sequential appl. See label for details
	40	Orondis Ultra B Revus (mandipropamid) Micora (mandipropamid)	8 fl oz 8 fl oz 8 fl oz/ 5,000 sq ft	32 fl oz 32 fl oz 16 fl oz/ 5,000 sq ft	1 1 n.a.	4 hr 4 hr 4 hr	No more than 2 sequential appl. Rotate with another effective fungicide; See label. Micora is only labeled for transplant and retail sale to consumers.
	40 & 3	Revus Top (mandipropamid + difenoconazole)	7 fl oz	28 fl oz	1	0.5	4 apps per season; no more than 2 sequential apps. Not labeled for transplants. See label
	43	Presidio (Fluopicolide)	4 fl oz	12 fl oz/per season	2	0.5	4 apps per season; no more than 2 sequential apps. 10 day spray interval; Tank mix with another labeled non-FRAC code 43 fungicide; 18 month rotation with off label crops; see label.
	45 & 40	Zampro (ametoctradin + dimethomorph)	14 fl oz	42 fl oz	4	0.5	Addition of a spreading or penetrating adjuvant is recommended to improve performance. Limit of 3 applications per season.
	U15	Orondis Opti A Orondis Ultra A (oxathiapiprolin)	4.8 fl oz 4.8 fl oz	19.2 fl oz 19.2 fl oz	0 0	4 hr 4 hr	Do not combine foliar apps of Orondis with soil apps of Orondis for disease control. 6 apps per season; no more than 2 sequential apps. 5 day minimum app. interval; Applications should not exceed more than 33% of the total foliar fungicide apps. See Orondis Ultra A label for greenhouse use.
Leaf mold	M3	**(mancozeb)** **Many brands available:** Dithane DF, Dithane F45, Dithane M45, Koverall, Manzate, Manzate Pro-Stik, Penncozeb 4FL, Penncozeb 75DF, Penncozeb 80WP	SEE INDIVIDUAL LABELS		5		
	M5	**(chlorothalonil)** **Many brands available:** Bravo Ultrex, Bravo Weather Stik, Bravo Zn, Chloronil 720, Echo 720, Echo 90 DF, Echo Zn, Equus 500 Zn, Equus 720 SST, Equus DF, Initiate 720, Orondis Opti B	**SEE INDIVIDUAL LABELS**		0	0.5	Use higher rates at fruit set and lower rates before fruit set.
	9 & 3	Inspire Super (cyprodinil + difenoconazole)	20 fl oz	47 fl oz	0	0.5	Limit is 5 apps per season with no more than 2 sequential apps. Must tank mix or alternate with another effective fungicide from another FRAC group. Has up to a 8 month plant back restriction with off label crops.
	11 & 3	Quadris Top (azoxystrobin + difenoconazole)	8 fl oz	47 fl oz	0	0.5	Limit is 4 apps per season with no more than 2 sequential apps. Must tank mix or alternate with another effective fungicide from another FRAC group.
	11 & 27	Tanos (famoxadone + cymoxanil)	8 oz	72 oz	3	0.5	Do not alternate or tank mix with other FRAC group 11 fungicides.
	19	Oso 5% SC (polyoxin D zinc salt)	13 fl oz	78 fl oz	0	4 hr	Alternate with a non-FRAC code 19 fungicide.
	22 & M3	Gavel 75DF (zoaximide + mancozeb)	2.0 lb	16 lb	5	2	
	40 & 3	Revus Top (mandipropamid + difenoconazole)	7 fl oz	28 fl oz	1	0.5	4 apps per season; no more than 2 sequential apps. Not labeled for transplants.
Grey leaf spot (*Stemphyllium* spp.)	M1	**(copper compounds)** **Many brands available:** Badge SC, Badge X2, Basic Copper 50W HB, Basic Copper 53, C-O-C-S WDG, Champ DP, Champ F2 FL, Champ WG, Champion WP, C-O-C DF, C-O-C WP, Copper Count N, Cuprofix Ultra 40D, Cueva, Kentan DF, Kocide 3000, Kocide 2000, Kocide DF, Nordox, Nordox 75WG, Nu Cop 50WP, Nu Cop 3L, Nu Cop 50DF, Nu Cop HB	**SEE INDIVIDUAL LABELS**		1	Varies by product from 4 hr to 2 days.	Mancozeb or maneb enhances bactericidal effect of fix copper compounds.

TOMATO FUNGICIDES (continued)

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			Applic.	Season	Harvest	Reentry	
	M3	**(mancozeb)** **Many brands available:** Dithane DF, Dithane F45, Dithane M45, Kover-all, Manzate, Manzate Pro-Stik, Penncozeb 4FL, Penncozeb 75DF, Penncozeb 80WP	**SEE INDIVIDUAL LABELS**		5	1	
	M3 & M1	ManKocide (mancozeb + copper hydroxide)	5 lb	112 lb	5	2	
	M5	**(chlorothalonil)** **Many brands available:** Bravo Ultrex, Bravo Weather Stik, Bravo Zn, Chloronil 720, Echo 720, Echo 90 DF, Echo Zn, Equus 500 Zn, Equus 720 SST, Equus DF, Initiate 720, Orondis Opti B	**SEE INDIVIDUAL LABELS**		0	0.5	Use higher rates at fruit set and lower rates before fruit set.
	4 & M5	Ridomil Gold Bravo 76.4 W (chlorothalonil + mefenoxam)	3 lb	12 lb	14	2	Limit is 4 apps./crop.
	7 & 9	Luna Tranquility (fluopyram + pyrimethanil)	11.2 fl oz	54.7 fl oz	1	0.5	No more than 2 sequential applications before rotating with another effective fungicide from a different FRAC group. See label for additional instructions pertaining to greenhouse useage.
	7 & 11	Luna Sensation (fluopyram + trifloxystrobin)	7.6 fl oz	27.3 fl oz	3	0.5	No more than 2 sequential applications before rotating with another effective fungicide from a different FRAC group. Limit of 5 apps per a year.
	9 & 3	Inspire Super (cyprodinil + difenoconazole)	20 fl oz	47 fl oz	0	0.5	Limit is 5 apps per season with no more than 2 sequential apps. Must tank mix or alternate with another effective fungicide from another FRAC group. Has up to a 8 month plant back restriction with off label crops.
	11	Flint Gem 500 SC (trifloxystrobin)	4 oz 3.8 floz	16 oz 16 fl oz	3 3	0.5 0.5	Limit is 5 apps/crop. Must alternate or tank mix with a fungicide from a different FRAC group.
	11 & 3	Quadris Top (azoxystrobin + difenoconazole)	8 fl oz	47 fl oz	0	0.5	Limit is 4 apps per season with no more than 2 sequential apps. Must tank mix or alternate with another effective fungicide from another FRAC group. Has up to a 1 year plant back restriction for certain off label crops.
	22 & M3	Gavel 75DF (zoaximide + mancozeb)	2.0 lb	16 lb	5	2	
	27 & M5	Ariston (cymoxanil + chlorothalonil)	3.0 pt	30.2 pt	3	0.5	Check copper manufacturer's label for specific precautions and limitations for mixing with this product.
	40 & 3	Revus Top (mandipropamid + difenoconazole)	7 fl oz	28 fl oz	1	0.5	4 apps per season; no more than 2 sequential apps. Not labeled for transplants.
Phytophthora crown rot, Phytophthora root rot (*Phytophthora* spp.)	4	Orondis Gold B Ridomil Gold SL Ultra Flourish (mefenoxam)	1 pt 1 pt 2 pt	3 pt 3 pt 6 pt	28 28 7	0* 2* 2*	Do not apply more than 1.5 lb mefenoxam/A per crop to the soil. *There is a reentry interval exemption if material is soil-injected or soil-incorporated.
	4	Metastar 2E (metalaxyl)	2 qt	6 qt	2	28	Soil applied by drip injection.
	11	Reason 500 SC (fenamidone)	8.2 oz	24.6 lb	14	0.5	Must alternate with a fungicide from a different FRAC group. *(Phytophthora capsici-* suppression only)
	14	Terramaster 4EC (etridiazole)	7 fl oz	27.4 fl oz	3	0.5	Greenhouse use only.
	21	Ranman (cyazofamid)	2.75 fl oz	16.5 fl oz	0		Apply to the base of plant at the time of transplanting. Make additional applications on a 7 to 10 day schedule if conditions are favorable for disease.
	28	Previcur Flex (propamocarb hydrochloride)	**SEE LABEL**		5	0.5	GREENHOUSE APPLICATION: 6 apps/crop cycle. Do not mix with other products. Can cause phytotoxicity if applied in intense sunlight.

TOMATO FUNGICIDES (continued)

Products sorted by disease and then in order by FRAC group corresponding to the mode of action.

Biopesticides and other alternative products labeled for disease management are listed in a separe table for convenience. (Updated June 2014).

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Pertinent Diseases or Pathogens	Fungicide Group[1]	Chemical (active ingredients)	Max. Rate/acre		Min. Days to		Remarks[2]
			Applic.	Season	Harvest	Reentry	
	33	Aliette 80 WDG Linebacker WDG (fosetyl-aluminum)	5 lb	2 lb	14	0.5	See label for warnings concerning the use of copper compounds.
	33	Alude (mono- and di-potassium salts of phosphorous acid)	1.5 qt/ acre/ 25 gal	-	-	4 hr	For transplants only.
	43	Presidio (fluopicolide)	4 fl oz	12 fl oz	2	0.5	4 apps per season; no more than 2 sequential apps. 10 day spray interval; Tank mix with another labeled non-FRAC code 43 fungicide; 18 month rotation with off label crops.
	45 & 40	Zampro (ametoctradin + dimethomorph)	14 fl oz	42 fl oz	4	0.5	Addition of a spreading or penetrating adjuvant is recommended to improve performance. Limit of 3 applications per season.
	U15	Orondis Gold 200 (oxathiapiprolin)	19.2 fl oz	38.6 fl oz	0	4 hr	Soil applications cannot be combined with foliar applications of Orondis Opti A or Orondis Ultra A. 4 apps per season; no more than 2 sequential apps. 7 day minimum app. interval; Applications should not exceed more than 33% of the total soil fungicide apps. See label for soil application instructions.
	U15	Orondis Opti A Orondis Ultra A (oxathiapiprolin)	4.8 fl oz 4.8 fl oz	19.2 fl oz 19.2 fl oz	0 0	4 hr 4 hr	Do not combine foliar apps of Orondis with soil apps of Orondis for disease control. 6 apps per season; no more than 2 sequential apps. 5 day minimum app. interval; Applications should not exceed more than 33% of the total foliar fungicide apps. See Orondis Ultra A label for greenhouse use.
Powdery mildew	M2	**(sulfur)** **Many brands available:** Cosavet DF, Kumulus DF, Micro Sulf, Microfine Sulfur, Microthiol Disperss, Sulfur 6L, Sulfur 90W, Super Six, That Flowable Sulfur, Tiolux Jet, Thiosperse 80%, Wettable Sulfur, Wettable Sulfur 92, Yellow Jacket Dusting Sulfur, Yellow Jacket Wettable Sulfur	**SEE INDIVIDUAL LABELS**		1	1	Follow label closely, may cause leaf burn if applied during high temperatures.
	3	Rally 40WSP Nova 40 W Sonoma 40WSP (myclobutanil)	4 oz	1.25 lb	0	1	Note that a 30 day plant back restriction exists.
	7	Fontelis (penthiopyrad)	24 fl oz	72 fl oz	0	0.5	No more than 2 sequential applications before switching to another effective fungicide with a different mode of action. See label for additional instructions pertaining to greenhouse useage.
(suppression)	7 & 9	Luna Tranquility (fluopyram + pyrimethanil)	11.2 fl oz	54.7 fl oz	1	0.5	No more than 2 sequential applications before rotating with another effective fungicide from a different FRAC group. See label for additional instructions pertaining to greenhouse useage.
	7 & 11	Luna Sensation (fluopyram + trifloxystrobin)	7.6 fl oz	27.3 fl oz	3	0.5	No more than 2 sequential applications before rotating with another effective fungicide from a different FRAC group. Limit of 5 apps per a year.
	9 & 3	Inspire Super (cyprodinil + difenoconazole)	20 fl oz	47 fl oz	0	0.5	Limit is 5 apps per season with no more than 2 sequential apps. Must tank mix or alternate with another effective fungicide from another FRAC group. Has up to a 8 month plant back restriction with off label crops.
	9 & 12	Switch 62.5WG (cyprodinil + fludioxonil)	14 oz	56 oz per year	0	0.5	After 2 apps alternate with non-FRAC code 9 or 12 fungicides for next 2 applications. Has a 30 day plant back with off label crops.
	11	Heritage Quadris FL Equation Satori (azoxystrobin)	3.2 oz 6.2 fl oz 6.2 fl oz 6.2 fl oz	1.6 lb 37 fl oz 37 fl oz 37 fl oz	0 0 0 0	4 hr 4 hr 4 hr 4 hr	Must alternate or tank mix with a fungicide from a different FRAC group; use of an adjuvant or tank mixing with EC products may cause phytotoxicity.

TOMATO FUNGICIDES (continued)

Products sorted by disease and then in order by FRAC group corresponding to the mode of action.

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Pertinent Diseases or Pathogens	Fungicide Group[1]	Chemical (active ingredients)	Max. Rate/acre		Min. Days to		Remarks[2]
			Applic.	Season	Harvest	Reentry	
	11	Cabrio 2.09 F (pyraclostrobin)	16 fl oz	96 fl oz	0	0.5	Only 2 sequential apps. allowed. Limit is 6 appl/crop. Must alternate or tank mix with a fungicide from a different FRAC group.
	11	Flint Gem 500 SC (trifloxystrobin)	4 oz 3.8 floz	16 oz 16 fl oz	3 3	0.5 0.5	Limit is 5 apps/crop; must alternate or tank mix with a fungicide from a different FRAC group.
	11 & M5	Quadris Opti (azoxystrobin + chlorothalonil)	1.6 pt	8 pt	0	0.5	Must alternate with a non-FRAC code 11 fungicide; use of an adjuvant may cause phytotoxicity.
	11 & 3	Quadris Top (azoxystrobin + difenoconazole)	8 fl oz	47 fl oz	0	0.5	Limit is 4 apps per season with no more than 2 sequential apps. Must tank mix or alternate with another effective fungicide from another FRAC group. Has up to a 1 year plant back restriction for certain off label crops.
	11 & 7	Priaxor (pyraclostrobin + fluxapyroxad)	8 fl oz	24 fl oz	0	0.5	Limit is 3 apps per season; no more than 2 sequential apps. See label about compatibility with other formulated products and adjuvants.
	19	Ph-D WDG Oso 5% SC (polyoxin D zinc salt)	6.2 oz 13 fl oz	31.0 oz 78 fl oz	0 0	4 hr 4 hr	Alternate with a non-FRAC code 19 fungicide.
	40 & 3	Revus Top (mandipropamid + difenoconazole)	7 fl oz	28 fl oz	1	0.5	4 apps per season; no more than 2 sequential apps. Not labeled for transplants.
	U8	Vivando (metrafenone)	15.4 fl oz	46.2 fl oz	0	0.5	3 apps per season; no more than 2 sequential apps. Do not mix with horticultural oils.
Pythium diseases (*Pythium spp.*)	4	Orondis Gold B Ridomil Gold GR Ridomil Gold SL Ultra Flourish (mefenoxam)	1 pt 20 lb 2 pt 2 pt	3 pt 40 lb 3 pt 6 pt	28 28 7 7	0* 2* 2* 2	Do not apply more than 1.5 lb mefenoxam/A per crop to the soil. *There is a reentry interval exemption if material is soil-injected or soil-incorporated.
	4	Metastar 2E (metalaxyl)	2 qt	6 qt	28	2	Soil applied by drip injection.
	14	Terramaster 4EC (etridiazole)	7 fl oz	27.4 fl oz	3	0.5	Greenhouse use only.
	21	Ranman (cyazofamid)	3 fl oz/ 100 gal	-	0	-	For greenhouse transplant production; make a single application to the seedling tray 1 week prior up to the time of transplanting. Do not use any surfactant.
	28	Previcur Flex (propamocarb hydrochloride)	**SEE INDIVIDUAL LABELS**		5	0.5	GREENHOUSE APPLICATION: 6 apps/crop cycle. Do not mix with other products. Can cause phytotoxicity if applied in intense sunlight.
	28	Previcur Flex (propamocarb hydrochloride)	1.5 pts/ treated acre	7.5 pt/ treated acre	5	0.5	(Root rots and seedling diseases) Applied to lower portion of plant and soil, or as a soil drench or drip irrigation.
	28	Promess (propamocarb hydrochloride)	1.5 pt	7.5 pt	5	0.5	Must tank mix with chlorothalonil or mancozeb.
	33	Alude (mono- and di-potassium salts of phosphorous acid)	1.5 qt/ acre/ 25 gal	-	-	4 hr	For transplants only.
Rhizoctonia root rot, Rhizoctonia fruit rot (*Rhizoctonia solani*)	M5	**(chlorothalonil)** **Many brands available:** Bravo Ultrex, Bravo Weather Stik, Bravo Zn, Chloronil 720, Echo 720, Echo 90 DF, Echo Zn, Equus 500 Zn, Equus 720 SST, Equus DF, Initiate 720, Orondis Opti B	**SEE INDIVIDUAL LABELS**		0	0.5	Use higher rates at fruit set and lower rates before fruit set.
	7	Fontelis (penthiopyrad)	1.0 - 1.6 fl oz / 1000 row-ft	24 fl oz	0	0.5	Apply at-plant, pre-plant incorporated, in-furrow, as a transplant drench, or by drip irrigation.
(*suppression*)	11	Cabrio (pyraclostrobin)	16 oz	96 oz	0	0.5	Limit is 2 sequential applications before alternating to another effective fungicide from a different FRAC group.
(*suppression*)	11 & 7	Priaxor (pyraclostrobin + fluxapyroxad)	8 fl oz	24 fl oz	7	0.5	Limit is 3 apps per season; no more than 2 sequential apps. See label about compatibility with other formulated products and adjuvants.

TOMATO FUNGICIDES (continued)

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			Applic.	Season	Harvest	Reentry	
	14	Blocker 4F Terraclor 75 WP (PCNB)	**SEE INDIVIDUAL LABELS**		Soil treat-ment at planting	0.5	See label for application type and restric-tions
	14	Par-Flo 4F (PCNB)	12 fl oz per 100 gal.	2 app.	Soil drench	0.5	Limited to only container-grown plants in nurseries or greenhouse.
	27 & M5	Ariston (cymoxanil + chlorothalonil)	1.9 pt	30.2 pt	3	0.5	Check copper manufacturer's label for spe-cific precautions and limitations for mixing with this product.
Rhizopus rot	3 & 9	Chairman (propiconazole + fludioxonil)	32 floz /100 gal or /50,000 lb of fruit	-	-	-	Apply as a post-harvest dip, drench, or high-volume spray for the post-harvest control of certain rots. Lower rates for small diameter fruit. See label for details.
Septoria leaf spot	M1	**(copper compounds)** **Many brands available:** Badge SC, Badge X2, Basic Copper 50W HB, Ba-sic Copper 53, C-O-C-S WDG, Champ DP, Champ F2 FL, Champ WG, Champion WP, C-O-C DF, C-O-C WP, Copper Count N, Cuprofix Ultra 40D, Cueva, Kentan DF, Kocide 3000, Kocide 2000, Kocide DF, Nordox, Nordox 75WG, Nu Cop 50WP, Nu Cop 3L, Nu Cop 50DF, Nu Cop HB	**SEE INDIVIDUAL LABELS**		1	Varies by product from 4 hr to 2 days.	
	M3	**(mancozeb)** **Many brands available:** Dithane DF, Dithane F45, Dithane M45, Kover-all, Manzate, Manzate Pro-Stik, Penncozeb 4FL, Penncozeb 75DF, Penncozeb 80WP	**SEE INDIVIDUAL LABELS**		5		
	M3	Ziram 76DF (ziram)	4 lbs	23.7 lb	7	2	Do not use on cherry tomatoes.
	M3 & M1	ManKocide (mancozeb + copper hydroxide)	5 lbs	112 lb	5	2	
	M5	(chlorothalonil) **Many brands available:** Bravo Ultrex, Bravo Weather Stik, Bravo Zn, Chloronil 720, Echo 720, Echo 90 DF, Echo Zn, Equus 500 Zn, Equus 720 SST, Equus DF, Initiate 720, Orondis Opti B	**SEE INDIVIDUAL LABELS**		0	0.5	Use higher rates at fruit set and lower rates before fruit set.
	4 & M5	Ridomil Gold Bravo 76.4 W (chlorothalonil + mefenoxam)	3 lb	12 lb	14	2	Limit is 4 apps./crop.
	7	Fontelis (penthiopyrad)	24 fl oz	72 fl oz	0	0.5	No more than 2 sequential apps. before switching to another effective fungicide with a different mode of action. See label for additional instructions pertaining to greenhouse useage.
	7 & 9	Luna Tranquility (fluopyram + pyrimethanil)	11.2 fl oz	54.7 fl oz	1	0.5	No more than 2 sequential applications before rotating with another effective fungicide from a different FRAC group. See label for additional instructions pertaining to greenhouse useage.
	7 & 11	Luna Sensation (fluopyram + trifloxystrobin)	7.6 fl oz	27.3 fl oz	3	0.5	No more than 2 sequential applications before rotating with another effective fun-gicide from a different FRAC group. Limit of 5 apps per a year.
	9 & 3	Inspire Super (cyprodinil + difenoconazole)	20 fl oz	47 fl oz	0	0.5	Limit is 5 apps per season with no more than 2 sequential apps. Must tank mix or alternate with another effective fungicide from another FRAC group. Has up to a 8 month plant back restriction with off label crops.
	11	Heritage Quadris FL Equation Satori (azoxystrobin)	3.2 oz 6.2 fl oz 6.2 fl oz 6.2 fl oz	1.6 lb 37 fl oz 37 fl oz 37 fl oz	0 0 0 0	4 hr 4 hr 4 hr 4 hr	Must alternate or tank mix with a fungicide from a different FRAC group; use of an adjuvant or tank mixing with EC products may cause phytotoxicity.
	11	Cabrio 2.09 F (pyraclostrobin)	16 fl oz	96 fl oz	0	0.5	Only 2 sequential appl. Allowed. Limit is 6 apps/crop. Must alternate or tank mix with a fungicide from a different FRAC group.

TOMATO FUNGICIDES (continued)

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Pertinent Diseases or Pathogens	Fungicide Group[1]	Chemical (active ingredients)	Max. Rate/acre		Min. Days to		Remarks[2]
			Applic.	Season	Harvest	Reentry	
	11	Flint (trifloxystrobin)	4 oz	16 oz	3	0.5	Limit is 5 apps/crop. Must alternate or tank mix with a fungicide from a different FRAC group.
	11	Reason 500 SC (fenamidone)	8.2 oz	24.6 lb	14	0.5	Must alternate with a fungicide from a different FRAC group.
	11 & M5	Quadris Opti (azoxystrobin + chlorothalonil)	1.6 pt	8 pt	0	0.5	Must alternate with a non-FRAC code 11 fungicide; use of an adjuvant may cause phytotoxicity.
	11 & 3	Quadris Top (azoxystrobin + difenoconazole)	8 fl oz	47 fl oz	0	0.5	Limit is 4 apps per season with no more than 2 sequential apps. Must tank mix or alternate with another effective fungicide from another FRAC group. Up to a 1 year plant back restriction for certain off label crops.
	11 & 7	Priaxor (pyraclostrobin + fluxapyroxad)	8 fl oz	24 fl oz	0	0.5	Limit is 3 apps per season; no more than 2 sequential apps. See label about compatibility with other formulated products and adjuvants.
	11 & 27	Tanos (famoxadone + cymoxanil)	8 oz	72 oz	3	0.5	Do not alternate or tank mix with other FRAC group 11 fungicides.
	22 & M3	Gavel 75DF Zing! (zoaximide + mancozeb)	2.0 lb 34 fl oz	16 lb 272 fl oz	5	2	
	27 & M5	Ariston (cymoxanil + chlorothalonil)	3.0 pt	30.2 pt	3	0.5	Check copper manufacturer's label for specific precautions and limitations for mixing with this product.
	40 & 3	Revus Top (mandipropamid + difenoconazole)	7 fl oz	28 fl oz	1	0.5	4 apps per season; no more than 2 sequential apps. Not labeled for transplants.
Sour Rot **(*Geotrichum candidum*)**	3	Mentor (propiconazole)	8 oz /100 gal or /50,000 lb of fruit	-	-	-	Apply as a post-harvest dip, drench, or high-volume spray for the post-harvest control of certain rots. See label for details.
	3 & 9	Chairman (propiconazole + fludioxonil)	32 floz /100 gal or /50,000 lb of fruit	-	-	-	Apply as a post-harvest dip, drench, or high-volume spray for the post-harvest control of certain rots. Lower rates for small diameter fruit. See label for details.
Southern blight	7	Fontelis (penthiopyrad)	1.0 - 1.6 fl oz/ 1000 row-ft	24 fl oz	0	0.5	Apply at-plant, pre-plant incorporated, in-furrow, as a transplant drench, or by drip irrigation.
	11	Evito Aftershock (fluoxastrobin)	5.7 fl oz	22.8 fl oz	3	0.5	Limit is 4 appl/crop. Must alternate or tank mix with a fungicide from a different FRAC group.
(*suppression*)	11	Cabrio (pyraclostrobin)	16 oz	96 oz	0	0.5	Limit is 2 sequential applications before alternating to another effective fungicide from a different FRAC group.
(suppression)	11 & 7	Priaxor (pyraclostrobin + fluxapyroxad)	8 fl oz	24 fl oz	0	0.5	Limit is 3 apps per season; no more than 2 sequential apps. See label about compatibility with other formulated products and adjuvants.
	14	Blocker 4F Terraclor 75 WP (PCNB)	**SEE INDIVIDUAL LABELS**		Soil treatment at planting	0.5	See label for application type and restrictions.
(suppression)	19	Oso 5% SC (polyoxin D zinc salt)	13 fl oz	78 fl oz	0	4 hr	Alternate with a non-FRAC code 19 fungicide.
Target spot	M5	**(chlorothalonil)** **Many brands available:** Bravo Ultrex, Bravo Weather Stik, Bravo Zn, Chloronil 720, Echo 720, Echo 90 DF, Echo Zn, Equus 500 Zn, Equus 720 SST, Equus DF, Initiate 720, Orondis Opti B	**SEE INDIVIDUAL LABELS**		0	0.5	Use higher rates at fruit set and lower rates before fruit set.
	4 & M5	Ridomil Gold Bravo 76.4 W (chlorothalonil + mefenoxam)	3 lb	12 lb	14	2	Limit is 4 appl./crop.
	7	Endura (boscalid)	12.5 oz	25 oz	0	0.5	Alternate with non-FRAC code 7 fungicides.

TOMATO FUNGICIDES (continued)

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			Applic.	Season	Harvest	Reentry	
	7	Fontelis (penthiopyrad)	24 fl oz	72 fl oz	0	0.5	No more than 2 sequential apps. before switching to another effective fungicide with a different mode of action. See label for additional instructions pertaining to greenhouse useage.
	7 & 9	Luna Tranquility (fluopyram + pyrimethanil)	11.2 fl oz	54.7 fl oz	1	0.5	No more than 2 sequential applications before rotating with another effective fungicide from a different FRAC group. See label for additional instructions pertaining to greenhouse useage.
	7 & 11	Luna Sensation (fluopyram + trifloxystrobin)	7.6 fl oz	27.3 fl oz	3	0.5	No more than 2 sequential applications before rotating with another effective fungicide from a different FRAC group. Limit of 5 apps per a year.
	9	Scala SC (pyrimethanil)	7 fl oz	35 fl oz	1	0.5	Use only in a tank mix with another effective non-FRAC code 9 fungicide; has a 30 day plant back with off label crops.
	9 & 3	Inspire Super (cyprodinil + difenoconazole)	20 fl oz	47 fl oz	0	0.5	Limit is 5 apps./season with no more than 2 sequential apps. Must tank mix or alternate with another effective fungicide from another FRAC group. Has up to a 8 month plant back restriction with off label crops.
	9 & 12	Switch 62.5WG (cyprodinil + fludioxonil)	14 oz	56 oz per year	0	0.5	See 2 (ee) label. After 2 apps. alternate with non-FRAC code 9 or 12 fungicides for next 2 applications. Has a 30 day plant back with off label crops.
	11	Heritage Quadris FL Equation Satori (azoxystrobin)	3.2 oz 6.2 fl oz 6.2 fl oz 6.2 fl oz	1.6 lb 37 fl oz 37 fl oz 37 fl oz	0 0 0 0	4 hr 4 hr 4 hr 4 hr	Must alternate or tank mix with a fungicide from a different FRAC group; use of an adjuvant or tank mixing with EC products may cause phytotoxicity.
	11	Cabrio 2.09 F (pyraclostrobin)	16 fl oz	96 fl oz	0	0.5	Only 2 sequential appl. Allowed. Limit is 6 appl/crop. Must alternate or tank mix with a fungicide from a different FRAC group.
	11	Evito Aftershock (fluoxastrobin)	5.7 fl oz	22.8 fl oz	3	0.5	Limit is 4 appl/crop. Must alternate or tank mix with a fungicide from a different FRAC group.
	11 & M5	Quadris Opti (azoxystrobin + chlorothalonil)	1.6 pt	8 pt	0	0.5	Must alternate with a non-FRAC code 11 fungicide; use of an adjuvant may cause phytotoxicity.
	11 & 3	Quadris Top (azoxystrobin + difenoconazole)	8 fl oz	47 fl oz	0	0.5	Limit is 4 apps per season with no more than 2 sequential apps. Must tank mix or alternate with another effective fungicide from another FRAC group. Has up to a 1 year plant back restriction for certain off label crops.
	11 & 7	Priaxor (pyraclostrobin + fluxapyroxad)	8 fl oz	24 fl oz	0	0.5	Limit is 3 apps per season; no more than 2 sequential apps. See label about compatibility with other formulated products and adjuvants.
	11 & 27	Tanos (famoxadone + cymoxanil)	8 oz	72 oz	3	0.5	Do not alternate or tank mix with other FRAC group 11 fungicides.
	27 & M5	Ariston (cymoxanil + chlorothalonil)	3.0 pt	30.2 pt	3	0.5	Check copper manufacturer's label for specific precautions and limitations for mixing with this product.
	40 & 3	Revus Top (mandipropamid + difenoconazole)	7 fl oz	28 fl oz	1	0.5	4 apps per season; no more than 2 sequential apps. Not labeled for transplants.
Timber Rot, Sclerotinia stem rot, or White mold (*Sclerotinia sclerotiorum*) *(suppression)*	7 & 11	Luna Sensation (fluopyram + trifloxystrobin)	7.6 fl oz	27.3 fl oz	3	0.5	No more than 2 sequential applications before rotating with another effective fungicide from a different FRAC group. Limit of 5 apps per a year.
	11	Heritage Quadris FL (azoxystrobin)	3.2 oz 6.2 fl oz	1.6 lb 37 fl oz	0	4 hr	Must alternate or tank mix with a fungicide from a different FRAC group; use of an adjuvant or tank mixing with EC products may cause phytotoxicity.

TOMATO FUNGICIDES (continued)

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			Applic.	Season	Harvest	Reentry	
(*suppression*)	11	Cabrio 2.09 F (pyraclostrobin)	16 fl oz	96 fl oz	0	0.5	Only 2 sequential apps. allowed. Limit is 6 apps/crop. Must alternate or tank mix with a fungicide from a different FRAC group.
(suppression)	11 & 7	Priaxor (pyraclostrobin + fluxapyroxad)	8 fl oz	24 fl oz	0	0.5	Limit is 3 apps per season; no more than 2 sequential apps. See label about compatibility with other formulated products and adjuvants.

[1] FRAC code (fungicide group): Number (1 through 46) and letters (U and P) are used to distinguish the fungicide mode of action groups. All fungicides within the same group (with same number or letter) indicate same active ingredient or similar mode of action. This information must be considered for the fungicide resistance management decisions. U = unknown, or a mode of action that has not been classified yet and is typically associated with another number; P = host plant defense inducers. Source: FRAC Code List 2013; http://www.frac.info/ (FRAC = Fungicide Resistance Action Committee).

[2] Information provided in this table applies only to Florida. Be sure to read a current product label before applying any chemical. The use of brand names and any mention or listing of commercial products or services in the publication does not imply endorsement by the University of Florida Cooperative Extension Service nor discrimination against similar products or services not mentioned.

Tomato Biopesticides And Other Disease Control Products

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TOMATO BIOPESTICIDES AND OTHER DISEASE CONTROL PRODUCTS

BE SURE TO READ A CURRENT LABEL BEFORE APPLYING ANY PRODUCT.

Product (active ingredient), Fungicide Group[1]	Pertinent Diseases or Pathogens	Minimum Days to:		OMRI	Remarks[2]
		Harvest	Reentry	Listed	
Actinovate, ActinoGrow (*Streptomyces lydicus* WYEC 108), NC	*Alternaria* spp., Anthracnose, *Aphanomyces*, Botrytis, Charcoal Rot (*Macrophomina phaseolina*), Club root (*Plasmodiophora brassicae*), Downy Mildew, *Erwinia* spp., *Fusarium* spp., *Gaeumannomyces*, Powdery Mildew, Pseudomonas spp., *Phytophthora* spp., *Pythium* spp., *Rhizoctonia* spp., *Sclerotinia* spp., Southern Blight, Verticillium spp., *Xanthomonas* spp.	0	1 hr	Yes	See label for specific rates and application recommendations.
AgriPhage (bacteriophage), NC	Bacterial spot, Bacterial speck	0	0	No	Bacterial strains must be characterized preiodically by manufacturer to correctly formulate the bacteriophage mixture.
Armicarb 100 **Eco-mate Armicarb "O"** (potassium bicarbonate), NC	Anthracnose, Botrytis, Downy mildew, Phoma, Powdery mildew, Septoria leaf spot	0	4 hr	No	See label for specific rates and application recommendations.
BioCover (Oil, petroleum)	Powdery mildew, Rust	0	4 hr	No	See label for specific rates, application recommendations, and precautions regarding use with other pesticides.

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Product (active ingredient), Fungicide Group[1]	Pertinent Diseases or Pathogens	Minimum Days to: Harvest	Minimum Days to: Reentry	OMRI Listed	Remarks[2]
BIO-TAM (*Trichoderma asperellum* strain ICC 012 + *Trichoderma gamsii* strain ICC 080) NC	*Fusarium* spp., *Phytophthora* spp., *Pythium* spp., *Rhizoctonia* spp., *Sclerotinia* spp., *Sclerotium rolfsii*, *Thielaviopsis basicola*, and *Verticillium* spp.	-	1 hr	Yes	See label for additional rates and recommendations for transplant production and details for specific diseases. Check label for product incompatibility with certain chemical fungicides.
Botector (*Aureobasidium pullulans* strains DSM 14940 + DSM 14941)	Botrytis	0	4 hr	Yes	See label for application recommendations, especially for compatibility to other fungicides.
Cease (*Bacillus subtilis* strain QST 713), 44	Bacterial spot, Bacterial speck, Botrytis, Early Blight, Late Blight, Powdery mildew, Target spot, Rhizoctonia spp., Pythium spp., Fusarium spp., Verticillium spp., Phytophthora spp.	0	4 hr	Yes	For foliar applications mix with copper compounds or other effective fungicides. Compatible with soil drench and in-furrow applications. See label for specific rates and application recommendations.
Contans WG (*Coniothyrium minitans* strain CON/M/91-08)	*Sclerotinia sclerotiorum* and *Sclerotinia minor*	0	4 hr	Yes	See label for specific rates and application recommendations.
Double Nickel 55 **Double Nickel LC** (*Bacillus amyloliquefaciencs* strain D747), 44	*Alternaria* spp., Anthracnose, Bacterial diseases, Botrytis, Early blight, Late blight, *Phytophthora* spp., Powdery mildew, *Pythium* spp., Rhizoctonia, Fusarium spp., Rhizoctonia, Phytophthora spp., Pythium spp.	0	4 hr	Yes	See label for additional rates and recommendations for foliar and soil application rates and details for specific diseases. Use as a soil drench at transplant and periodically throughout the season. Can also be used as a seed treatment. See label for details.
Fracture (Banda de Lupinus albus doce; BLAD), NC	Botrytis and Powdery mildew	1	4 hr	No	No more than 2 sequential applications before alternating with another effective fungicide with a different mode of action. No more than 5 applications per season. Product requires 2 to 4 hours dry time for maximum adhesion to foliage.
Glacial Spray Fluid (Oil, petroleum), NC	Powdery mildew, Rust	0	4 hr	Yes	See label for specific rates, application recommendations, and precautions regarding use with other pesticides.
JMS Stylet-Oil **Organic JMS Stylet-Oil** (paraffinic oil), NC	Potato Virus Y, Tobacco Etch Virus, Cucumber Mosaic Virus	0	4 hr	Yes, but only for one label.	See label for specific rates, application recommendations, and precautions regarding use with other pesticides.
Kaligreen (potassium bicarbonate), NC	Powdery mildew	0	4 hr	Yes	See label for specific rates and application recommendations.
Milstop (potassium bicarbonate), NC	Anthracnose, *Alternaria* spp., Botrytis, Downy mildew, Powdery mildew	0	1 hr	Yes	See label for specific rates and application recommendations.
Oxidate 2.0 (mono- and di-potassium salts of phosphorous acid + hydrogen peroxide), 33 + NC	*Alternaria* spp., Anthracnose, Bacterial diseases, Botrytis, Early blight, Late blight, *Phytophthora* spp., Powdery mildew, *Pythium* spp., Rhizoctonia, Fusarium spp., Rhizoctonia, Phytophthora spp., Pythium spp.	0	1 hr for enclosed areas; until spray dries in open field areas.	No	See label for additional rates and recommendations for transplant production and details for specific diseases. Use as a soil drench at transplant and periodically throughout the season. Can also be used as a seed treatment.
OxiPhos (hydrogen peroxide), NC	Bacterial diseases, Gummy stem blight, Late blight, *Phytophthora* spp., *Pythium* spp., Phytophthora spp., Pythium spp.	0	4 hr	No	See label for recommedations for rates, application methods, and details for specific diseases.
(potassium phosphite; mono- and di-potassium salts of phosphorous acid), 33 **Many brands available:** Alude, Appear, Confine Extra T&O, Fosphite, Fungi-Phite, Helena Prophyt, K-Phite 7LP AG, Phorcephite, Phostrol, Rampart, Reveille	*Alternaria spp., Anthracnose, Bacterial diseases,* Downy mildew, *Fusarium* spp., Late blight, Leaf blights caused by *Cercospora* and *Septoria* spp., *Phytophthora* spp., Powdery mildew, *Pythium* spp., *Rhizoctonia* spp., Root rots	0	4 hr	No	See label for details, specific recommendations, and precautions for tank mixing with copper-based fungicides.
PlantShield HC (*Trichoderma harzianum* Rifai strain KRL-AG2), NC	*Fusarium* spp., Rhizoctonia, *Pythium* spp.	0	4 hr	Yes	Can be applied to plant as a direct drench, furrow spray, chemigation, or in transplant starter solution. See label for details.
Procidic (Citric acid), NC	Broad spectrum fungicide	0	0	No	See label for specific rates, application recommendations, and precautions regarding use with other pesticides.
Purespray Green (Oil, petroleum), NC	Powdery mildew, Rust	0	4 hr	Yes	See label for specific rates, application recommendations, and precautions regarding use.

TOMATO BIOPESTICIDES AND OTHER DISEASE CONTROL PRODUCTS (continued)

BE SURE TO READ A CURRENT LABEL BEFORE APPLYING ANY PRODUCT.

Product (active ingredient), Fungicide Group[1]	Pertinent Diseases or Pathogens	Minimum Days to: Harvest	Minimum Days to: Reentry	OMRI Listed	Remarks[2]
Regalia SC (extract of *Reynoutria sachalinensis*), P	Bacterial canker , Bacterial speck, Bacterial spot, Botrytis, Early blight, Phytophthora spp., Powdery mildew, Target spot, Late blight	0	4 hr	Yes	Tank mix with other effective fungicides for improved disease control under heavy pressure. See label for details.
Rendition **ZeroTol 2.0** (Hydrogen peroxide + peroxyacetic acid), NC	Broad spectrum fungicide	0	1 hr for enclosed areas; until spray dries in open field areas.	No	See label for specific rates, application recommendations, and precautions regarding use with other pesticides. Can be used as a soil drench at transplant and periodically throughout the season. Can also be used as a seed treatment.
RootShield Granular (Trichoderma harzianum Rifai strain KRL-AG2), NC	*Fusarium* spp., Rhizoctonia, *Pythium* spp.	0	0	Yes	Granular formulation can be applied in furrow in the field, or to greenhouse planting mix. See label for details.
RootShield WP (*Trichoderma harzianum* Rifai strain KRL-AG2), NC	*Fusarium* spp., Rhizoctonia, *Pythium* spp.	0	Until spray has dried.	Yes	Can be applied as a greenhouse soil drench, or by chemigation in field and greenhouse operations. In furrow or transplant starter solution.
Serenade ASO **Serenade Max** **Serenade Opti** **Serenade Optimum** (*Bacillus subtilis* strain QST 713), 44	Bacterial speck, Bacterial spot, Botrytis, Early Blight, Late Blight, Powdery mildew, Target spot	0	4 hr	Yes	For foliar applications mix with copper compounds or other effective fungicides for improved disease control. See label for details.
Serenade Soil (Bacillus subtilis strain QST 713), 44	*Fusarium* spp., *Phytophthora* spp., *Pythium* spp., *Rhizoctonia* spp., *Verticillium* spp.	0	4 hr	Yes	Formulation compatible with soil drench, in-furrow, and chemigation applications. Mix with other effective fungicides for improved disease control. See label for details.
Serifel (*Bacillus amyloliquefaciens* strain MBI 600), NC	Anthracnose, Botrytis, Buckeye Rot, Early Blight, Late Blight, Powdery mildew	0	4 hr	Yes	Begin applications early and continue on a 5 - 10 day interval as needed. Not labelled for greenhouse or transplant production.
Sil-Matrix (potassium silicate), NC	Broad spectrum fungicide	0	4 hr	No	Must be used in a rotational program with other fungicides when conditions are conducive for disease development. See label for details.
Soilgard 12G (Gliocladium virens GI-21), NC	Fusarium root and crown rot, *Phytophthora capsici, Pythium* spp., Rhizoctonia, *Sclerotinia* spp., *Sclerotium* spp.	0	0	Yes	For best results apply to transplants or as a drench during transplanting. Subsequent applications can be made as drench, directed spray, or by chemigation. Chemical fungicides should not be mixed with or applied to soil or plant media at the same time as SoilGard 12G. See label for details.
Sonata (*Bacillus pumilus* QST 2808), NC	Early Blight, Downy mildew, Late Blight, Powdery mildew, Rust	0	4 hr	Yes	Mix or alternate with other effective fungicides for improved disease control. See label for details.
Sporatec (oils of clove, rosemary and thyme), NC	Bacterial spot, Botrytis, Early blight, Gray mold, Late blight, Powdery mildew	0	0	Yes	Exercise care when applying. Begin applications once disease is observed. Use of a spreader and/or penetrant adjuvant recommended for improved performance. Do not apply when temps are above 90ºF. See label for details. Ingredients are exempt from FIFRA.
Taegro ECO (*Bacillus amyloliquefaciencs* strain FZB24), NC	Foliar diseases: Downy mildew, Powdery mildew, Pseudomonas spp., Xanthomonas spp.; Soilborne diseases: *Fusarium* spp., *Phytophthora* spp., *Pythium* spp., *Rhizoctonia* spp., *Sclerotinia* spp.	-	1 day	No	See label for specific instructions regarding soil injected, spray, or incorporated applications. Maximum of 12 applications per season. For best efficacy, product should be applied prior to disease or disease establishment. May be applied to greenhouse produced crops.
Tenet (*Trichoderma asperellum* ICC 012; *Trichoderma gamsii* ICC 080), NC	*Fusarium* spp., *Phytophthora* spp., *Pythium* spp., *Rhizoctonia* spp., *Sclerotium rolfsii*, *Sclerotinia* spp., *Thielaviopsis basicola*, and *Verticillium* spp.	0	1 hr	Yes	For best results apply 1 week prior to planting, with 2 or more additional applications throughout the production cycle. May be applied through fertigation systems in combination with most common fertilizers. Can be applied to fumigated soil after fumigant has dissipated. Tenet has no curative activity. See label for details regarding application and fungicide incompatibility.

TOMATO BIOPESTICIDES AND OTHER DISEASE CONTROL PRODUCTS (continued)

BE SURE TO READ A CURRENT LABEL BEFORE APPLYING ANY PRODUCT.

Product (active ingredient), Fungicide Group[1]	Pertinent Diseases or Pathogens	Minimum Days to: Harvest	Minimum Days to: Reentry	OMRI Listed	Remarks[2]
Terraclean (hydrogen dioxide), NC	Soilborne plant pathogens caused by species of *Fusarium, Phytophthora, Pythium,* and *Rhizoctonia*	0	0	No	Can be applied by flood irrigation, drip irrigation, or as a soil drench. See label for application details and instructions regarding applications with liquid fertilizer mixtures.
Trilogy (clarified hydrophobic extract of neem oil), NC	*Alternaria* spp., Anthracnose, Botrytis, Early blight, Powdery mildew	0	4 hr	Yes	See label for specific rates, application recommendations, and precautions regarding use with other pesticides.
Vacciplant (laminarin), P	Anthracnose, Bacterial speck, Bacterial spot, Early blight, Phytophthora blight, Powdery mildew	0	4 hr	No	Start applications preventively, when weather conditions are favorable for disease development. Repeat applications until disease conditions end. Add a labeled copper product to VacciPlant if the disease symptoms appear.

1 FRAC code (fungicide group): Number (33 and 44) and letters (NC and P) are used to distinguish the fungicide mode of action groups. All fungicides within the same group (with same number or letter) indicate same active ingredient or similar mode of action. This information must be considered for the fungicide resistance management decisions. However, products with NC or P are considered low risk and don't require any rotation unless specifically directed on the label. NC = not classified, includes mineral oils, organic oils, potassium bicarbonate, and other materials of biological origin; P = host plant defense inducers. Source: FRAC Code List 2013; http://www.frac.info/ (FRAC = Fungicide Resistance Action Committee).

2 Information provided in this table applies only to Florida. Be sure to read a current product label before applying any product. The use of brand names and any mention or listing of commercial products or services in the publication does not imply endorsement by the University of Florida Cooperative Extension Service nor discrimination against similar products or services not mentioned.

Insecticides and Miticides for Management of Tomato Pests

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INSECTICIDES AND MITICIDES FOR MANAGEMENT OF TOMATO PESTS

Pest	MOA Code	Trade name (Active Ingredient) *Restricted	Rate (Product/acre)	Rate/Season	PHI (d)	REI (hrs)	Remarks
Aphids	1A	*Lannate LV (methomyl)	LV: 1.5-3.0 pt	Do not apply more than 21 pt LV/acre/ crop (15 for tomatillos) or 7 lb SP /acre/ crop (5 lb for tomatillos).	1	48	
		*Lannate SP (methomyl)	SP: 0.5-1.0 lb		1	48	
	1A	*Vydate L (oxamyl)	foliar: 2.0-4.0 pt	Do not apply more than 32 pts/A per season.	3	48	
	1B	Dimethoate 4 EC (dimethoate)	0.5-1.0 pt	Maximum total rate per year is 1 lb ai/A.	7	48	Minimum 6 day reapplication interval.
	1B	Malathion 5 (malathion)	1.0-2.5 pt	10 pints	1	12	8F can be used in greenhouse.
		Malathion 8 F	1.5 pt				
	3	*Asana XL (0.66EC) (esfenvalerate)	2.9-9.6 fl oz	Do not apply more than 0.5 lb ai per acre per season, or 10 applications at highest rate.	1	12	

INSECTICIDES AND MITICIDES FOR MANAGEMENT OF TOMATO PESTS (continued)							
Pest	**MOA Code**	**Trade name (Active Ingredient) *Restricted**	**Rate (Product/acre)**	**Rate/Season**	**PHI (d)**	**REI (hrs)**	**Remarks**
	3	*Baythroid XL (beta-cyfluthrin)	1.6-2.8 fl oz	Do not apply more than 16.8 fl oz per acre per season.	0	12	
	3	*Danitol 2.4 EC (fenpropathrin)	7-10.67 fl oz	Do not exceed 42.67 fl. oz. total application /A per season.	3	24	
	3	Karate with Zeon* (lambdacyhalothrin)	0.96-1.92 fl. oz.	Do not apply more than 23.04 fl. oz. /A per season.	5	24	
	3	*Mustang (zeta-cypermethrin)	2.4-4.3 oz	Do not apply more than 25.8 fl. oz./A per season.	1	12	Do not make applications less than 7 days apart.
	3	Pyganic Crop Protection EC 5.0 II (pyrethrins)	4.5-18.0 fl oz	11.25 pints.	0	12	Pyrethrins degrade rapidly in sunlight. Thorough coverage is important. OMRI-listed. Do not apply more than 10 times per season.
	3 & 4A	Leverage* 360 (beta-cyfluthrin & imidacloprid)	3.8-4.1		0	12	
	3 & 6	Gladiator* (avermectin B1 & zeta-cypermethrin)	10-19 fl. oz.	Do not apply more than 57 fl. oz./A per 12 month cropping year.	7	12	
	3 & 28	*Voliam Xpress (lambda-cyhalothrin & chlorantraniliprole)	5.0-9.0 fl oz	Do not apply more than 31.0 fl oz /A per season.	5	24	
	3A	*Brigade 2EC (bifenthrin)	2.1-5.2 fl oz	Make no more than 4 applications per season.	1	12	Do not make applications less than 10 days apart.
	3A	*Proaxis Insecticide (gamma-cyhalothrin)	1.92-3.84 fl oz	Do not apply more than 2.88 pints per acre per season.	5	24	
	3A	*Warrior II (lambdacyhalothrin)	0.96-1.92 fl oz	Do not apply more than 23.04 fl. oz/A per season.	5	24	
	3A & 4A	*Endigo ZC (lambda-cyhalothrin & thiamethoxam)	4.0-4.5 fl oz	Do not exceed a total of 19.0 fl oz per acre per season.	5	24	See label for limits on each active ingredient.
	4A	Actara (thiamethoxam)	2.0-5.5 oz	Do not exceed a total of 11.0 oz/Acre per acre per growing season.	0	12	Application restrictions exist for this product because of risk to bees and other insect pollinators. Follow application restrictions found in directions for use to protect pollinators. Minimum interval between applications is 5 days.
	4A	Admire Pro (imidacloprid)	7-10.5 fl oz	Maximum allowed on tomato is 10.5 fl. oz/A.	21	12	Application restrictions exist for this product because of risk to bees and other insect pollinators. Follow application restrictions found in directions for use to protect pollinators.
	4A	Admire Pro (imidacloprid)	0.6 fl oz per 1000 plants		0 (soil)	12	Greenhouse use: 1 application to mature plants, see label for cautions.
	4A	Admire Pro (imidacloprid)	0.44 fl oz per 10,000 plants		21	12	Planthouse: 1 application. See label.
	4A	Assail 70WP (acetamiprid)	0.6-1.7 oz	Do not exceed a total of 6.8 oz. Assail 70 WP per acre per growing season including any pretransplant applications of acetamiprid.	7	12	Do not apply to crop that has been already treated with imidacloprid or thiamethoxam at planting. Begin applications for whitefly when first adults are noticed. Do not make more than 4 applications per season. Do not apply more than once every 7 days.
	4A	Belay 50 WDG (clothianidin)	1.6-2.1 oz (foliar application)	Do not apply more than 6.4 oz per acre per season.	7	12	Do not use an adjuvant. Toxic to bees. Do not release irrigation water from the treated area.
	4A	Belay 50 WDG (clothianidin)	4.8-6.4 oz (soil application)	Do not apply more than 6.4 oz per acre per season.	Apply at planting	12	See label for application instructions. Do not release irrigation water from the treated area.
	4A	Platinum	5-11 fl oz	Do not exceed a total of 11 fl. oz. Platinum/A per growing season.	30	12	Soil application. Not for use in nurseries, plant propagation houses, greenhouses, or on plants grown for use as transplants. See label for rotational restrictions. Do not use with other neonicotinoid insecticides
	4A	Platinum 75 SG (thiamethoxam)	1.66-3.67 oz	Do not exceed a total of 3.67 Platinum 75 SG/A per growing season.	30	12	
	4A	Provado 1.6F (imidacloprid)	3.8-6.2 fl oz	Maximum per crop per season 19.2 fl oz/A.	0	12	Do not apply to crop that has been already treated with imidacloprid or thiamethoxam at planting.
	4A	Safari 20 SG (dinotefuran)	7.0-14.0 oz		1	12	For transplant production only. Can be applied as foliar spray or soil drench.
	4A	Scorpion (dinotefuran)	Soil: 9-10.5 fl. oz.; foliar: 2-7 fl. oz.	Do not apply more than 21 fl. oz/A per season as a soil application. Do not apply more than 10.5 fl. oz/A per season foliarly.	1	12	Application restrictions exist for this product because of risk to bees and other insect pollinators. Follow application restrictions found in the directions for use to protect pollinators. Do not combine soil and foliar applications. Use one method or the other.

INSECTICIDES AND MITICIDES FOR MANAGEMENT OF TOMATO PESTS (continued)

Pest	MOA Code	Trade name (Active Ingredient) *Restricted	Rate (Product/acre)	Rate/Season	PHI (d)	REI (hrs)	Remarks
	4A	Venom 20 SG (dinotefuran)	foliar:0.44-0.895 lb	Do not apply more than 1.34 lb./A per season.	1	12	Use only one application method (soil or foliar). Limited to three applications per season. Toxic to honeybees.
	4A	Venom 20 SG (dinotefuran)	soil: 1.13-1.34 lb	Do not apply more than 2.68 lb/A per season.	21	12	Use only one application method (soil or foliar). Must have supplemental label for rates over 6.0 oz/acre.
	4A & 28	Durivo (thiamethoxam & chlorantraniliprole)	10-13 fl oz	Do not exceed a total of 13.0 fl. oz./A per growing season.	30	12	Several methods of soil application – see label.
	4A & 28	Voliam Flexi (thiamethoxam & chlorantraniliprole)	4.0-7.0 oz	Do not exceed 14 oz/A per season.	1	12	Do not use in greenhouses or on transplants. Do not use if seed has been treated with thiamethoxam or if other Group 4A insecticides will be used. Highly toxic to bees.
	4D	Sivanto 200 SL (flupyradifurone)	7.0-14.0 fl. oz.	Do not apply more than 28.0 fl. oz./A per year.	1	4	Minimum interval between applications: 7 days.
	9B	Fulfill (pymetrozine)	2.75 oz	Do not apply more than 5.5 oz/acre per crop.	0	12	(FL-040006) 24(c) label for growing transplants also (FL-03004).
	9 C	Beleaf 50 SG (flonicamid)	2.0-2.8 oz	Do not apply more than 8.4 oz per acre per season.	0	12	Begin applications before pests reach damaging levels. Do not apply more than 2 applications per season. Allow a minimum of 7 days between applications.
	23	Movento (spirotetramat)	4.0-5.0 fl oz	Maximum of 10 fl oz/acre per season.	1	24	
	28	Exirel (cyantraniliprole)	7-20.5 fl. oz.	Do not apply a total of more than 0.4 lb ai/A per crop.	1	12	Application restrictions exist for this product because of risk to bees and other pollinators. Follow application restrictions found in the directions for use to protect pollinators. Minimum application interval between treatmenst is 5 days.
	28	Verimark (cyantraniliprole)	5-13.5 fl. oz.	Do not apply more than 0.4 lb ai/A per crop.	1	4	
	un	Aza-Direct (azadirachtin)	1-2 pts, up to 3.5 pts, if needed		0	4	Antifeedant, repellant, insect growth regulator. OMRI-listed.
	un	Azatin XL (azadirachtin)	5-21 fl oz		0	4	Antifeedant, repellant, insect growth regulator.
	un	Grandevo (*Chromobacterium subtsugae*)	1.0-3.0 lb		0	4	Thorough coverage is necessary for effective control.
	un	Mycotrol O (*Beauvaria bassiana* strain GHA)	0.5 quart -1 quart/100 gallons		0	4	OMRI Listed
	un	Neemix 4.5 (azadirachtin)	4.0-16.0 fl oz		0	12	IGR, feeding repellant. OMRI-listed.
	un	PFR-97 (*Isaria fumosorosea* Apopka strain 97)	1.0-2.0 lbs		0	4	Repeat applications at 3-10 days are needed to maintain control. Can be used in greenhouse for food crop transplants raised to be planted into the field. OMRI listed.
	un	Requiem 25EC (extract of Chenopodium ambrosioides)	2-4 qt	Limited to 10 applications per crop cycle.	0	4	Begin applications before pests reach damaging levels.
	un	SuffOil-X (unsulfonated residue of petroleum oil)	1-2 gallons per 100 gallons of water.			4	OMRI listed.
	-	M-Pede 49% EC (Soap, insecticidal)	1-2% V/V		0	12	OMRI-listed
	-	Ultra Fine Oil, Saf-T-Side, others JMS Stylet-Oil (oil, insecticidal)	1.0-2.0 gal/100 gal 3.0-6.0 qt/100 gal water (JMS)		0	4	Do not exceed four applications per season. Organic Stylet-Oil and Saf-T-Side are OMRI-listed.
Beetles	1A	Sevin 80S; XLR; 4F (carbaryl)	80S: 0.63-2.5 XLR; 4F: 0.5-2.0 A	Do not apply a total of more than 10 lb or 8 qt per acre per crop.	3	12	Do not apply more than seven times.
	1A	*Vydate L (oxamyl)	foliar: 2.0-4.0 pt	Do not apply more than 32 pts/A per season.	3	48	
	3	*Ambush 25W (permethrin)	3.2-12.8 oz	Do not apply more than 76.8 oz/A per season.	up to day of harvest	12	Do not use on cherry tomatoes.
	3	*Asana XL (0.66EC) (esfenvalerate)	2.9-9.6 fl oz	Do not apply more than 0.5 lb ai per acre per season, or 10 applications at highest rate.	1	12	

INSECTICIDES AND MITICIDES FOR MANAGEMENT OF TOMATO PESTS (continued)

Pest	MOA Code	Trade name (Active Ingredient) *Restricted	Rate (Product/acre)	Rate/Season	PHI (d)	REI (hrs)	Remarks
	3	*Baythroid XL (beta-cyfluthrin)	1.6-2.8 fl oz	Do not apply more than 16.8 fl oz per acre per season.	0	12	
	3	*Hero (bifenthrin & zeta-cypermethrin)	4.0-10.3 oz	Do not apply more than 43.26 fl. oz./A per season.	1	12	Do not make more than 4 applications per season. Do not make applications less than 10 days apart.
	3	Karate with Zeon* (lambdacyhalothrin)	0.96-1.92 fl. oz.	Do not apply more than 23.04 fl. oz. /A per season.	5	24	
	3	*Mustang (zeta-cypermethrin)	2.4-4.3 oz	Do not apply more than 25.8 fl. oz./A per season.	1	12	Do not make applications less than 7 days apart.
	3	*Pounce 25 WP (permethrin)	3.2-12.8 oz		0	12	Do not apply to cherry or grape tomatoes (fruit less than 1 inch in diameter). Do not apply more than 0.6 lb ai per acre per season.
	3	Pyganic Crop Protection EC 5.0 II (pyrethrins)	4.5-18.0 fl oz	11.25 pints.	0	12	Pyrethrins degrade rapidly in sunlight. Thorough coverage is important. OMRI-listed. Do not apply more than 10 times per season.
	3 & 4A	Leverage* 360 (beta-cyfluthrin & imidacloprid)	3.8-4.1		0	12	
	3 & 6	Gladiator* (avermectin B1 & zeta-cypermethrin)	10-19 fl. oz.	Do not apply more than 57 fl. oz./A per 12 month cropping year.	7	12	
	3 & 28	*Voliam Xpress (lambda-cyhalothrin & chlorantraniliprole)	5.0-9.0 fl oz	Do not apply more than 31.0 fl oz /A per season.	5	24	
	3A	*Brigade 2EC (bifenthrin)	2.1-5.2 fl oz	Make no more than 4 applications per season.	1	12	Do not make applications less than 10 days apart.
	3A	*Proaxis Insecticide (gamma-cyhalothrin)	1.92-3.84 fl oz	Do not apply more than 2.88 pints per acre per season.	5	24	
	3A	*Warrior II (lambdacyhalothrin)	0.96-1.92 fl oz	Do not apply more than 23.04 fl. oz/A per season.	5	24	
	3A & 4A	*Endigo ZC (lambda-cyhalothrin & thiamethoxam)	4.0-4.5 fl oz	Do not exceed a total of 19.0 fl oz per acre per season.	5	24	See label for limits on each active ingredient.
	4A	Actara (thiamethoxam)	2.0-5.5 oz	Do not exceed a total of 11.0 oz/Acre per acre per growing season.	0	12	Application restrictions exist for this product because of risk to bees and other insect pollinators. Follow application restrictions found in directions for use to protect pollinators. Minimum interval between applications is 5 days.
	4A	Admire Pro (imidacloprid)	7-10.5 fl oz	Maximum allowed on tomato is 10.5 fl. oz/A.	21	12	Application restrictions exist for this product because of risk to bees and other insect pollinators. Follow application restrictions found in directions for use to protect pollinators.
	4A	Assail 70WP (acetamiprid)	0.6-1.7 oz	Do not exceed a total of 6.8 oz. Assail 70 WP per acre per growing season including any pretransplant applications of acetamiprid.	7	12	Do not apply to crop that has been already treated with imidacloprid or thiamethoxam at planting. Begin applications for whitefly when first adults are noticed. Do not make more than 4 applications per season. Do not apply more than once every 7 days.
	4A	Belay 50 WDG (clothianidin)	1.6-2.1 oz (foliar application)	Do not apply more than 6.4 oz per acre per season.	7	12	Do not use an adjuvant. Toxic to bees. Do not release irrigation water from the treated area.
	4A	Belay 50 WDG (clothianidin)	4.8-6.4 oz (soil application)	Do not apply more than 6.4 oz per acre per season.	Apply at planting	12	See label for application instructions. Do not release irrigation water from the treated area.
	4A	Platinum	5-11 fl oz	Do not exceed a total of 11 fl. oz. Platinum/A per growing season.	30	12	Soil application. Not for use in nurseries, plant propagation houses, greenhouses, or on plants grown for use as transplants. See label for rotational restrictions. Do not use with other neonicotinoid insecticides
		Platinum 75 SG (thiamethoxam)	1.66-3.67 oz	Do not exceed a total of 3.67 Platinum 75 SG/A per growing season.			
	4A	Provado 1.6F (imidacloprid)	3.8-6.2 fl oz	Maximum per crop per season 19.2 fl oz/A.	0	12	Do not apply to crop that has been already treated with imidacloprid or thiamethoxam at planting.
	4A	Scorpion (dinotefuran)	Soil: 9-10.5 fl. oz.; foliar: 2-7 fl. oz.	Do not apply more than 21 fl. oz/A per season as a soil application. Do not apply more than 10.5 fl. oz/A per season foliarly.	1	12	Application restrictions exist for this product because of risk to bees and other insect pollinators. Follow application restrictions found in the directions for use to protect pollinators. Do not combine soil and foliar applications. Use one method or the other.

INSECTICIDES AND MITICIDES FOR MANAGEMENT OF TOMATO PESTS (continued)

Pest	MOA Code	Trade name (Active Ingredient) *Restricted	Rate (Product/acre)	Rate/Season	PHI (d)	REI (hrs)	Remarks
	4A	Venom 20 SG (dinotefuran)	foliar:0.44-0.895 lb	Do not apply more than 1.34 lb./A per season.	1	12	Use only one application method (soil or foliar). Limited to three applications per season. Toxic to honeybees.
		Venom 20 SG (dinotefuran)	soil: 1.13-1.34 lb	Do not apply more than 2.68 lb/A per season.	21	12	Use only one application method (soil or foliar). Must have supplemental label for rates over 6.0 oz/acre.
	4A & 28	Durivo (thiamethoxam & chlorantraniliprole)	10-13 fl oz	Do not exceed a total of 13.0 fl. oz./A per growing season.	30	12	Several methods of soil application – see label.
	4A & 28	Voliam Flexi (thiamethoxam & chlorantraniliprole)	4.0-7.0 oz	Do not exceed 14 oz/A per season.	1	12	Do not use in greenhouses or on transplants. Do not use if seed has been treated with thiamethoxam or if other Group 4A insecticides will be used. Highly toxic to bees.
	4D	Sivanto 200 SL (flupyradifurone)	7.0-14.0 fl. oz.	Do not apply more than 28.0 fl. oz./A per year.	1	4	Minimum interval between applications: 7 days.
	5	Entrust (spinosad)	0.5-2.5 oz	Do not apply more than 9 oz per acre per crop.	1	4	OMRI-listed. For thrips, rotate to other class of effective insecticide after 2 applications of a Group 5 insecticide for at least 2 applications.
	6	*Proclaim (emamectin benzoate)	2.4-4.8 oz	No more than 28.8 oz/A per season.	7	12	Do not use in greenhouses, nurseries, plant propagation houses, or on any plants grown for use as transplants.
	15	Rimon 0.83EC (novaluron)	9.0-12.0 fl oz	Do not apply more than 36 fl oz per acre per season.	1	12	Minimum of 7 days between applications.
	17	Trigard (cyromazine)	2.66 oz	Do not apply more than 15.96 oz./A per season.	0	12	No more than 6 applications per crop. Does not control CPB adults. Most effective against 1st & 2nd instar larvae.
	28	Coragen (chlorantraniliprole/ rynaxypyr)	3.5-7.5 fl oz	Do not apply more than 15.4 fl oz per acre per crop.	1	4	Can be applied by drip chemigation or as a soil application at planting. See label for details.
	28	Exirel (cyantraniliprole)	7-20.5 fl. oz.	Do not apply a total of more than 0.4 lb ai/A per crop.	1	12	Application restrictions exist for this product because of risk to bees and other pollinators. Follow application restrictions found in the directions for use to protect pollinators. Minimum application interval between treatmenst is 5 days.
	28	Verimark (cyantraniliprole)	5-13.5 fl. oz.	Do not apply more than 0.4 lb ai/A per crop.	1	4	
	un	Aza-Direct (azadirachtin)	1-2 pts, up to 3.5 pts, if needed		0	4	Antifeedant, repellant, insect growth regulator. OMRI-listed.
	un	Azatin XL (azadirachtin)	5-21 fl oz		0	4	Antifeedant, repellant, insect growth regulator.
	un	Neemix 4.5 (azadirachtin)	4.0-16.0 fl oz		0	12	IGR, feeding repellant. OMRI-listed.
	un	SuffOil-X (unsulfonated residue of petroleum oil)	1-2 gallons per 100 gallons of water.			4	OMRI listed.
	un	Surround WP (kaolin)	12.5-50 lbs		0	4	OMRI listed.
	-	Ultra Fine Oil, Saf-T-Side, others	1.0-2.0 gal/ 100 gal		0	4	Do not exceed four applications per season.
		JMS Stylet-Oil (oil, insecticidal)	3.0-6.0 qt/100 gal water (JMS)				Organic Stylet-Oil and Saf-T-Side are OMRI-listed.
Caterpillars	1A	*Lannate SP (methomyl)	SP: 0.5-1.0 lb		1	48	
	1A	Sevin 80S; XLR; 4F (carbaryl)	80S: 0.63-2.5 XLR; 4F: 0.5-2.0 A	Do not apply a total of more than 10 lb or 8 qt per acre per crop.	3	12	Do not apply more than seven times.
	1A	10% Sevin Granules (carbaryl)	20 lb		3	12	Maximum of 4 applications, not more often than once every 7 days.
	1B	*Diazinon AG500; *50 W (diazinon)	AG500: 1-4 qt 50W: 2-8 lb	Do not make more than one soil applicationper year regrardless of target pest.	preplant	48	Incorporate into soil - see label.
	3	*Ambush 25W (permethrin)	3.2-12.8 oz	Do not apply more than 76.8 oz/A per season.	up to day of harvest	12	Do not use on cherry tomatoes.
	3	*Asana XL (0.66EC) (esfenvalerate)	2.9-9.6 fl oz	Do not apply more than 0.5 lb ai per acre per season, or 10 applications at highest rate.	1	12	

INSECTICIDES AND MITICIDES FOR MANAGEMENT OF TOMATO PESTS (continued)

Pest	MOA Code	Trade name (Active Ingredient) *Restricted	Rate (Product/acre)	Rate/Season	PHI (d)	REI (hrs)	Remarks
	3	*Baythroid XL (beta-cyfluthrin)	1.6-2.8 fl oz	Do not apply more than 16.8 fl oz per acre per season.	0	12	
	3	*Danitol 2.4 EC (fenpropathrin)	7-10.67 fl oz	Do not exceed 42.67 fl. oz. total application /A per season.	3	24	
	3	*Hero (bifenthrin & zeta-cypermethrin)	4.0-10.3 oz	Do not apply more than 43.26 fl. oz./A per season.	1	12	Do not make more than 4 applications per season. Do not make applications less than 10 days apart.
	3	Karate with Zeon* (lambdacyhalothrin)	0.96-1.92 fl. oz.	Do not apply more than 23.04 fl. oz. /A per season.	5	24	
	3	*Mustang (zeta-cypermethrin)	2.4-4.3 oz	Do not apply more than 25.8 fl. oz./A per season.	1	12	Do not make applications less than 7 days apart.
	3	*Pounce 25 WP (permethrin)	3.2-12.8 oz		0	12	Do not apply to cherry or grape tomatoes (fruit less than 1 inch in diameter). Do not apply more than 0.6 lb ai per acre per season.
	3	Pyganic Crop Protection EC 5.0 II (pyrethrins)	4.5-18.0 fl oz	11.25 pints.	0	12	Pyrethrins degrade rapidly in sunlight. Thorough coverage is important. OMRI-listed. Do not apply more than 10 times per season.
	3 & 4A	Leverage* 360 (beta-cyfluthrin & imidacloprid)	3.8-4.1		0	12	
	3 & 6	Gladiator* (avermectin B1 & zeta-cypermethrin)	10-19 fl. oz.	Do not apply more than 57 fl. oz./A per 12 month cropping year.	7	12	
	3 & 28	*Voliam Xpress (lambda-cyhalothrin & chlorantraniliprole)	5.0-9.0 fl oz	Do not apply more than 31.0 fl oz /A per season.	5	24	
	3A	*Brigade 2EC (bifenthrin)	2.1-5.2 fl oz	Make no more than 4 applications per season.	1	12	Do not make applications less than 10 days apart.
	3A	*Proaxis Insecticide (gamma-cyhalothrin)	1.92-3.84 fl oz	Do not apply more than 2.88 pints per acre per season.	5	24	
	3A	*Warrior II (lambdacyhalothrin)	0.96-1.92 fl oz	Do not apply more than 23.04 fl. oz/A per season.	5	24	
	3A & 4A	*Endigo ZC (lambda-cyhalothrin & thiamethoxam)	4.0-4.5 fl oz	Do not exceed a total of 19.0 fl oz per acre per season.	5	24	See label for limits on each active ingredient.
	4A	Platinum Platinum 75 SG (thiamethoxam)	5-11 fl oz 1.66-3.67 oz	Do not exceed a total of 11 fl. oz. Platinum/A per growing season. Do not exceed a total of 3.67 Platinum 75 SG/A per growing season.	30	12	Soil application. Not for use in nurseries, plant propagation houses, greenhouses, or on plants grown for use as transplants. See label for rotational restrictions. Do not use with other neonicotinoid insecticides
	4A & 28	Durivo (thiamethoxam & chlorantraniliprole)	10-13 fl oz	Do not exceed a total of 13.0 fl. oz./A per growing season.	30	12	Several methods of soil application – see label.
	4A & 28	Voliam Flexi (thiamethoxam & chlorantraniliprole)	4.0-7.0 oz	Do not exceed 14 oz/A per season.	1	12	Do not use in greenhouses or on transplants. Do not use if seed has been treated with thiamethoxam or if other Group 4A insecticides will be used. Highly toxic to bees.
	5	Entrust (spinosad)	0.5-2.5 oz	Do not apply more than 9 oz per acre per crop.	1	4	OMRI-listed. For thrips, rotate to other class of effective insecticide after 2 applications of a Group 5 insecticide for at least 2 applications.
	5	Radiant SC (spinetoram)	5-10 fl oz.	Do not apply more than 34 fl. oz./A per calendar year.	1	4	For thrips, if additional treatment is needed after two applications, switch to an alternate mode of action (not group 5) for at least two applications.
	6	*Proclaim (emamectin benzoate)	2.4-4.8 oz	No more than 28.8 oz/A per season.	7	12	Do not use in greenhouses, nurseries, plant propagation houses, or on any plants grown for use as transplants.
	11	Agree WG (*Bacillus thuringiensis* subspecies *aizawai*)	0.5-2.0 lb		0	4	Apply when larvae are small for best control. Can be used in greenhouse. OMRI-listed.
	11	Biobit HP (*Bacillus thuringiensis* subspecies *kurstaki*)	0.5-2.0 lb		0	4	Treat when larvae are young. Good coverage is essential. Can be used in the greenhouse. OMRI-listed.
	11	Crymax WDG (*Bacillus thuringiensis* subspecies *kurstaki*)	0.5-2.0 lb		0	4	Use high rate for armyworms. Treat when larvae are young.
	11	Deliver (*Bacillus thuringiensis* subspecies *kurstaki*)	0.25-1.5 lb		0	4	Use higher rates for armyworms. OMRI-listed.

Pest	MOA Code	Trade name (Active Ingredient) *Restricted	Rate (Product/acre)	Rate/Season	PHI (d)	REI (hrs)	Remarks
	11	DiPel DF (*Bacillus thuringiensis* subspecies *kurstaki*)	0.25-2.0 lb		0	4	Treat when larvae are young. Good coverage is essential. Can be used for organic production.
	11	Javelin WG (*Bacillus thuringiensis* subspecies *kurstaki*)	0.12-1.5 lb		0	4	Treat when larvae are young. Thorough coverage is essential. OMRI-listed[2].
	11	Xentari DF (*Bacillus thuringiensis* subspecies *aizawai*)	0.5-2.0 lb		0	4	Treat when larvae are young. Thorough coverage is essential. May be used in the greenhouse. Can be used in organic production. OMRI-listed.
	15	Rimon 0.83EC (novaluron)	9.0-12.0 fl oz	Do not apply more than 36 fl oz per acre per season.	1	12	Minimum of 7 days between applications.
	18	Confirm 2F (tebufenozide)	6-16 fl oz	Do not apply more than 64 fl. oz./A per season.	7	4	Product is a slowacting IGR that will not kill larvae immediately.
	18	Intrepid 2F (methoxyfenozide)	4-16 fl oz	Do not apply more than 64 fl oz per acre per season.	1	4	Product is a slow-acting IGR that will not kill larvae immediately.
	22	Avaunt (indoxacarb)	2.5-3.5 oz	Do not apply more than 14 ounces of product per acre per crop. Minimum spray interval is 5 days.	3	12	
	28	Belt SC (flubendiamide)	1.5 fl oz	Do not apply more tha 4.5 oz per acre per crop season.	1	12	Do not apply more than 1.5 oz per acre per 3 day interval.
	28	Coragen (chlorantraniliprole/ rynaxypyr)	3.5-7.5 fl oz	Do not apply more than 15.4 fl oz per acre per crop.	1	4	Can be applied by drip chemigation or as a soil application at planting. See label for details.
	28	Exirel (cyantraniliprole)	7-20.5 fl. oz.	Do not apply a total of more than 0.4 lb ai/A per crop.	1	12	Application restrictions exist for this product because of risk to bees and other pollinators. Follow application restrictions found in the directions for use to protect pollinators. Minimum application interval between treatments is 5 days.
	28	Verimark (cyantraniliprole)	5-13.5 fl. oz.	Do not apply more than 0.4 lb ai/A per crop.	1	4	
	28 & 16	Vetica (flubendiamide & buprofezin)	12.0-17.0 fl oz	Do not apply more than 38 fl oz/A per season.	1	12	Do not apply more than 3 times per season or apply more than 38 fl oz per acre per season. Same classes of active ingredients as Belt, Synapse, Coragen (all group 28), and Courier (group 16).
	un	Aza-Direct (azadirachtin)	1-2 pts, up to 3.5 pts, if needed		0	4	Antifeedant, repellant, insect growth regulator. OMRI-listed.
	un	Azatin XL (azadirachtin)	5-21 fl oz		0	4	Antifeedant, repellant, insect growth regulator.
	un	CheckMate TPW-F (pheromone)	1.2-6.0 fl oz		0	0	For mating disruption of tomato pinworm-See label for details.
	un	Grandevo (*Chromobacterium subtsugae*)	1.0-3.0 lb		0	4	Thorough coverage is necessary for effective control.
	un	MBI-203 EP (*Chromobacterium subtsugae*)	4.0-12.0 quarts		0	4	OMRI listed. Can be used in the greenhouse.
	un	Neemix 4.5 (azadirachtin)	4.0-16.0 fl oz		0	12	IGR, feeding repellant. OMRI-listed.
Fire Ants	7A	Extinguish ((S)methoprene)	1.0-1.5 lb		0	4	Slowacting IGR (insect growth regulator). Best applied early spring and fall where crop will be grown. Colonies will be reduced after three weeks and eliminated after 8 to 10 weeks. May be applied by ground equipment or aerially.
	7C	Esteem Ant Bait (pyriproxyfen)	1.5-2.0 lb		1	12	Apply when ants are actively foraging.
Grasshoppers	1A	10% Sevin Granules (carbaryl)	20 lb		3	12	Maximum of 4 applications, not more often than once every 7 days.
	3	*Asana XL (0.66EC) (esfenvalerate)	2.9-9.6 fl oz	Do not apply more than 0.5 lb ai per acre per season, or 10 applications at highest rate.	1	12	
	3	*Hero (bifenthrin & zeta-cypermethrin)	4.0-10.3 oz	Do not apply more than 43.26 fl. oz./A per season.	1	12	Do not make more than 4 applications per season. Do not make applications less than 10 days apart.
	3	Karate with Zeon* (lambdacyhalothrin)	0.96-1.92 fl. oz.	Do not apply more than 23.04 fl. oz. /A per season.	5	24	
	3	*Mustang (zeta-cypermethrin)	2.4-4.3 oz	Do not apply more than 25.8 fl. oz./A per season.	1	12	Do not make applications less than 7 days apart.

Pest	MOA Code	Trade name (Active Ingredient) *Restricted	Rate (Product/acre)	Rate/Season	PHI (d)	REI (hrs)	Remarks
	3	Pyganic Crop Protection EC 5.0 II (pyrethrins)	4.5-18.0 fl oz	11.25 pints.	0	12	Pyrethrins degrade rapidly in sunlight. Thorough coverage is important. OMRI-listed. Do not apply more than 10 times per season.
	3A	*Brigade 2EC (bifenthrin)	2.1-5.2 fl oz	Make no more than 4 applications per season.	1	12	Do not make applications less than 10 days apart.
	3A	*Proaxis Insecticide (gamma-cyhalothrin)	1.92-3.84 fl oz	Do not apply more than 2.88 pints per acre per season.	5	24	
	3A	*Warrior II (lambdacyhalothrin)	0.96-1.92 fl oz	Do not apply more than 23.04 fl. oz/A per season.	5	24	
	3A & 4A	*Endigo ZC (lambda-cyhalothrin & thiamethoxam)	4.0-4.5 fl oz	Do not exceed a total of 19.0 fl oz per acre per season.	5	24	See label for limits on each active ingredient.
	un	Surround WP (kaolin)	12.5-50 lbs		0	4	OMRI listed.
Lace bugs	1A	Sevin 80S; XLR; 4F (carbaryl)	80S: 0.63-2.5 XLR; 4F: 0.5-2.0 A	Do not apply a total of more than 10 lb or 8 qt per acre per crop.	3	12	Do not apply more than seven times.
Leafhoppers	1A	Sevin 80S; XLR; 4F (carbaryl)	80S: 0.63-2.5 XLR; 4F: 0.5-2.0 A	Do not apply a total of more than 10 lb or 8 qt per acre per crop.	3	12	Do not apply more than seven times.
	1B	Dimethoate 4 EC (dimethoate)	0.5-1.0 pt	Maximum total rate per year is 1 lb ai/A.	7	48	Minimum 6 day reapplication interval.
	3	*Hero (bifenthrin & zeta-cypermethrin)	4.0-10.3 oz	Do not apply more than 43.26 fl. oz./A per season.	1	12	Do not make more than 4 applications per season. Do not make applications less than 10 days apart.
	3	Karate with Zeon* (lambdacyhalothrin)	0.96-1.92 fl. oz.	Do not apply more than 23.04 fl. oz. /A per season.	5	24	
	3	*Mustang (zeta-cypermethrin)	2.4-4.3 oz	Do not apply more than 25.8 fl. oz./A per season.	1	12	Do not make applications less than 7 days apart.
	3	Pyganic Crop Protection EC 5.0 II (pyrethrins)	4.5-18.0 fl oz	11.25 pints.	0	12	Pyrethrins degrade rapidly in sunlight. Thorough coverage is important. OMRI-listed. Do not apply more than 10 times per season.
	3 & 6	Gladiator* (avermectin B1 & zeta-cypermethrin)	10-19 fl. oz.	Do not apply more than 57 fl. oz./A per 12 month cropping year.	7	12	
	3 & 28	*Voliam Xpress (lambda-cyhalothrin & chlorantraniliprole)	5.0-9.0 fl oz	Do not apply more than 31.0 fl oz /A per season.	5	24	
	3A	*Proaxis Insecticide (gamma-cyhalothrin)	1.92-3.84 fl oz	Do not apply more than 2.88 pints per acre per season.	5	24	
	3A	*Warrior II (lambdacyhalothrin)	0.96-1.92 fl oz	Do not apply more than 23.04 fl. oz/A per season.	5	24	
	3A & 4A	*Endigo ZC (lambda-cyhalothrin & thiamethoxam)	4.0-4.5 fl oz	Do not exceed a total of 19.0 fl oz per acre per season.	5	24	See label for limits on each active ingredient.
	4A	Actara (thiamethoxam)	2.0-5.5 oz	Do not exceed a total of 11.0 oz/Acre per acre per growing season.	0	12	Application restrictions exist for this product because of risk to bees and other insect pollinators. Follow application restrictions found in directions for use to protect pollinators. Minimum interval between applications is 5 days.
	4A	Admire Pro (imidacloprid)	7-10.5 fl oz	Maximum allowed on tomato is 10.5 fl. oz/A.	21	12	Application restrictions exist for this product because of risk to bees and other insect pollinators. Follow application restrictions found in directions for use to protect pollinators.
	4A	Belay 50 WDG (clothianidin)	1.6-2.1 oz (foliar application)	Do not apply more than 6.4 oz per acre per season.	7	12	Do not use an adjuvant. Toxic to bees. Do not release irrigation water from the treated area.
	4A	Belay 50 WDG (clothianidin)	4.8-6.4 oz (soil application)	Do not apply more than 6.4 oz per acre per season.	Apply at planting	12	See label for application instructions. Do not release irrigation water from the treated area.
	4A	Platinum	5-11 fl oz	Do not exceed a total of 11 fl. oz. Platinum/A per growing season.	30	12	Soil application. Not for use in nurseries, plant propagation houses, greenhouses, or on plants grown for use as transplants. See label for rotational restrictions. Do not use with other neonicotinoid insecticides
		Platinum 75 SG (thiamethoxam)	1.66-3.67 oz	Do not exceed a total of 3.67 Platinum 75 SG/A per growing season.			

INSECTICIDES AND MITICIDES FOR MANAGEMENT OF TOMATO PESTS (continued)

Pest	MOA Code	Trade name (Active Ingredient) *Restricted	Rate (Product/acre)	Rate/Season	PHI (d)	REI (hrs)	Remarks
	4A	Provado 1.6F (imidacloprid)	3.8-6.2 fl oz	Maximum per crop per season 19.2 fl oz/A.	0	12	Do not apply to crop that has been already treated with imidacloprid or thiamethoxam at planting.
	4A	Scorpion (dinotefuran)	Soil: 9-10.5 fl. oz.; foliar: 2-7 fl. oz.	Do not apply more than 21 fl. oz/A per season as a soil application. Do not apply more than 10.5 fl. oz/A per season foliarly.	1	12	Application restrictions exist for this product because of risk to bees and other insect pollinators. Follow application restrictions found in the directions for use to protect pollinators. Do not combine soil and foliar applications. Use one method or the other.
	4A	Venom 20 SG (dinotefuran)	foliar: 0.44-0.895 lb	Do not apply more than 1.34 lb./A per season.	1	12	Use only one application method (soil or foliar). Limited to three applications per season. Toxic to honeybees.
	4A	Venom 20 SG (dinotefuran)	soil: 1.13-1.34 lb	Do not apply more than 2.68 lb/A per season.	21	12	Use only one application method (soil or foliar). Must have supplemental label for rates over 6.0 oz/acre.
	4A & 28	Durivo (thiamethoxam & chlorantraniliprole)	10-13 fl oz	Do not exceed a total of 13.0 fl. oz./A per growing season.	30	12	Several methods of soil application – see label.
	4A & 28	Voliam Flexi (thiamethoxam & chlorantraniliprole)	4.0-7.0 oz	Do not exceed 14 oz/A per season.	1	12	Do not use in greenhouses or on transplants. Do not use if seed has been treated with thiamethoxam or if other Group 4A insecticides will be used. Highly toxic to bees.
	4D	Sivanto 200 SL (flupyradifurone)	7.0-14.0 fl. oz.	Do not apply more than 28.0 fl. oz./A per year.	1	4	Minimum interval between applications: 7 days.
	6	*Proclaim (emamectin benzoate)	2.4-4.8 oz	No more than 28.8 oz/A per season.	7	12	Do not use in greenhouses, nurseries, plant propagation houses, or on any plants grown for use as transplants.
	16	Courier 40SC (buprofezin)	9.0-13.6 fl oz	Do not apply more than 27.2 fl. oz./A per crop cycle.	1	12	Apply when a threshold is reached of 5 whitefly nymphs per 10 leaflets from the middle of the plant. Product is a slow-acting IGR that will not kill nymphs immediately. No more than 2 applications per season. Allow at least 5 days between applications.
	28 & 16	Vetica (flubendiamide & buprofezin)	12.0-17.0 fl oz	Do not apply more than 38 fl oz/A per season.	1	12	Do not apply more than 3 times per season or apply more than 38 fl oz per acre per season. Same classes of active ingredients as Belt, Synapse, Coragen (all group 28), and Courier (group 16).
	un	Aza-Direct (azadirachtin)	1-2 pts, up to 3.5 pts, if needed		0	4	Antifeedant, repellant, insect growth regulator. OMRI-listed.
	un	Azatin XL (azadirachtin)	5-21 fl oz		0	4	Antifeedant, repellant, insect growth regulator.
	un	SuffOil-X (unsulfonated residue of petroleum oil)	1-2 gallons per 100 gallons of water.			4	OMRI listed.
	un	Surround WP (kaolin)	12.5-50 lbs		0	4	OMRI listed.
	--	M-Pede 49% EC (Soap, insecticidal)	1-2% V/V		0	12	OMRI-listed
	--	Ultra Fine Oil, Saf-T-Side, others JMS Stylet-Oil (oil, insecticidal)	1.0-2.0 gal/100 gal 3.0-6.0 qt/100 gal water (JMS)		0	4	Do not exceed four applications per season. Organic Stylet-Oil and Saf-T-Side are OMRI-listed.
Leafminers	1A	*Vydate L (oxamyl)	foliar: 2.0-4.0 pt	Do not apply more than 32 pts/A per season.	3	48	
	3 & 6	Gladiator* (avermectin B1 & zeta-cypermethrin)	10-19 fl. oz.	Do not apply more than 57 fl. oz./A per 12 month cropping year.	7	12	
	4A	Venom 20 SG (dinotefuran)	foliar:0.44-0.895 lb	Do not apply more than 1.34 lb./A per season.	1	12	Use only one application method (soil or foliar). Limited to three applications per season. Toxic to honeybees.
		Venom 20 SG (dinotefuran)	soil: 1.13-1.34 lb	Do not apply more than 2.68 lb/A per season.	21	12	Use only one application method (soil or foliar). Must have supplemental label for rates over 6.0 oz/acre.
	5	Entrust (spinosad)	0.5-2.5 oz	Do not apply more than 9 oz per acre per crop.	1	4	OMRI-listed. For thrips, rotate to other class of effective insecticide after 2 applications of a Group 5 insecticide for at least 2 applications.
	5	Radiant SC (spinetoram)	5-10 fl oz.	Do not apply more than 34 fl. oz./A per calendar year.	1	4	

Pest	MOA Code	Trade name (Active Ingredient) *Restricted	Rate (Product/acre)	Rate/Season	PHI (d)	REI (hrs)	Remarks
	6	*AgriMek SC (abamectin)	1.75-3.5 fl oz	Do not apply more than 10.25 fl. oz./A in a growing season.	7	12	Do not make more than 2 sequential applications of Agri-Mek SC or any other foliar applied abamectin-containing product in a growing season.
		*Agri-Mek 0.15 EC	8.0-16.0 fl. oz	Do not apply more than 48 fl oz per acre per season.	7	12	Do not make more than 2 sequential applications per season.
	28	Exirel (cyantraniliprole)	7-20.5 fl. oz.	Do not apply a total of more than 0.4 lb ai/A per crop.	1	12	Application restrictions exist for this product because of risk to bees and other pollinators. Follow application restrictions found in the directions for use to protect pollinators. Minimum application interval between treatmenst is 5 days.
	28	Verimark (cyantraniliprole)	5-13.5 fl. oz.	Do not apply more than 0.4 lb ai/A per crop.	1	4	
	un	Requiem 25EC (extract of Chenopodium ambrosioides)	2-4 qt	Limited to 10 applications per crop cycle.	0	4	Begin applications before pests reach damaging levels.
Mites	1B	Malathion 5 (malathion)	1.0-2.5 pt	10 pints	1	12	8F can be used in greenhouse.
		Malathion 8 F	1.5 pt				
	3	*Danitol 2.4 EC (fenpropathrin)	7-10.67 fl oz	Do not exceed 42.67 fl. oz. total application /A per season.	3	24	
	3	*Hero (bifenthrin & zeta-cypermethrin)	4.0-10.3 oz	Do not apply more than 43.26 fl. oz./A per season.	1	12	Do not make more than 4 applications per season. Do not make applications less than 10 days apart.
	3	Karate with Zeon* (lambdacyhalothrin)	0.96-1.92 fl. oz.	Do not apply more than 23.04 fl. oz. /A per season.	5	24	
	3	Pyganic Crop Protection EC 5.0 II (pyrethrins)	4.5-18.0 fl oz	11.25 pints.	0	12	Pyrethrins degrade rapidly in sunlight. Thorough coverage is important. OMRI-listed. Do not apply more than 10 times per season.
	3A	*Brigade 2EC (bifenthrin)	2.1-5.2 fl oz	Make no more than 4 applications per season.	1	12	Do not make applications less than 10 days apart.
	3A	*Proaxis Insecticide (gamma-cyhalothrin)	1.92-3.84 fl oz	Do not apply more than 2.88 pints per acre per season.	5	24	
	3 & 6	Gladiator* (avermectin B1 & zeta-cypermethrin)	10-19 fl. oz.	Do not apply more than 57 fl. oz./A per 12 month cropping year.	7	12	
	6	*AgriMek SC (abamectin)	1.75-3.5 fl oz	Do not apply more than 10.25 fl. oz./A in a growing season.	7	12	Do not make more than 2 sequential applications of Agri-Mek SC or any other foliar applied abamectin-containing product in a growing season.
	20B	Kanemite 15 SC (acequinocyl)	31 fl oz	Do not apply more than 62 fl. oz/A per season.	1	12	Do not use less than 100 gal per acre. Make no more than 2 applications at least 21 days apart.
	21A	Portal (fenpyroximate)	2.0 pt	Do not apply more than 4.0 pints/A per crop cycle.	1	12	Do not make more than two applications per growing season. Allow 14 days between applications.
	23	Movento (spirotetramat)	4.0-5.0 fl oz	Maximum of 10 fl oz/acre per season.	1	24	
	23	Oberon 2SC (spiromesifen)	7.0-8.5 fl oz	Maximum amount per crop: 25.5 fl oz/A.	1	12	No more than 3 applications.
	un	Acramite-50WS (bifenazate)	0.75-1.0 lb	One application allowed per season.	3	12	One application per season. Field grown only. ACRAMITE-50WS is not systemic in action; therefore complete coverage of both upper and lower leaf surfaces and of fruit is necessary for effective control.
		*Agri-Mek 0.15 EC	8.0-16.0 fl. oz	Do not apply more than 48 fl oz per acre per season.	7	12	Do not make more than 2 sequential applications per season.
	un	Aza-Direct (azadirachtin)	1-2 pts, up to 3.5 pts, if needed		0	4	Antifeedant, repellant, insect growth regulator. OMRI-listed.
	un	Grandevo (*Chromobacterium subtsugae*)	1.0-3.0 lb		0	4	Thorough coverage is necessary for effective control.
	un	MET52 EC (*Metarhizium anisopliae* strain F52)	drench: 40-80 fl. oz.; foliar: 0.5 pint - 2qt		0	0	
	un	PFR-97 (*Isaria fumosorosea* Apopka strain 97)	1.0-2.0 lbs		0	4	Repeat applications at 3-10 days are needed to maintain control. Can be used in greenhouse for food crop transplants raised to be planted into the field. OMRI listed.

Pest	MOA Code	Trade name (Active Ingredient) *Restricted	Rate (Product/acre)	Rate/Season	PHI (d)	REI (hrs)	Remarks
	un	SuffOil-X (unsulfonated residue of petroleum oil)	1-2 gallons per 100 gallons of water.			4	OMRI listed.
	--	M-Pede 49% EC (Soap, insecticidal)	1-2% V/V		0	12	OMRI-listed
	--	Sulfur (many brands)				24	May burn fruit and foliage when temperature is high. Do not apply within 2 weeks of an oil spray or EC formulation.
	--	Ultra Fine Oil, Saf-T-Side, others	1.0-2.0 gal/100 gal		0	4	Do not exceed four applications per season.
		JMS Stylet-Oil (oil, insecticidal)	3.0-6.0 qt/100 gal water				
			(JMS)				Organic Stylet-Oil and Saf-T-Side are OMRI-listed.
Mole crickets	1B	*Diazinon AG500; *50 W (diazinon)	AG500: 1-4 qt 50W: 2-8 lb	Do not make more than one soil applicationper year regrardless of target pest.	preplant	48	Incorporate into soil - see label.
Plant bugs + tarnished plant bugs	1A	Sevin 80S; XLR; 4F (carbaryl)	80S: 0.63-2.5 XLR; 4F: 0.5-2.0 A	Do not apply a total of more than 10 lb or 8 qt per acre per crop.	3	12	Do not apply more than seven times.
	3	*Mustang (zeta-cypermethrin)	2.4-4.3 oz	Do not apply more than 25.8 fl. oz./A per season.	1	12	Do not make applications less than 7 days apart.
	3	Pyganic Crop Protection EC 5.0 II (pyrethrins)	4.5-18.0 fl oz	11.25 pints.	0	12	Pyrethrins degrade rapidly in sunlight. Thorough coverage is important. OMRI-listed. Do not apply more than 10 times per season.
	3A	*Brigade 2EC (bifenthrin)	2.1-5.2 fl oz	Make no more than 4 applications per season.	1	12	Do not make applications less than 10 days apart.
	3A	*Proaxis Insecticide (gamma-cyhalothrin)	1.92-3.84 fl oz	Do not apply more than 2.88 pints per acre per season.	5	24	
	3A	*Warrior II (lambdacyhalothrin)	0.96-1.92 fl oz	Do not apply more than 23.04 fl. oz/A per season.	5	24	
	3A & 4A	*Endigo ZC (lambda-cyhalothrin & thiamethoxam)	4.0-4.5 fl oz	Do not exceed a total of 19.0 fl oz per acre per season.	5	24	See label for limits on each active ingredient.
	4A	Belay 50 WDG (clothianidin)	1.6-2.1 oz (foliar application)	Do not apply more than 6.4 oz per acre per season.	7	12	Do not use an adjuvant. Toxic to bees. Do not release irrigation water from the treated area.
	4A	Belay 50 WDG (clothianidin)	4.8-6.4 oz (soil application)	Do not apply more than 6.4 oz per acre per season.	Apply at planting	12	See label for application instructions. Do not release irrigation water from the treated area.
	9 C	Beleaf 50 SG (flonicamid)	2.0-2.8 oz	Do not apply more than 8.4 oz per acre per season.	0	12	Begin applications before pests reach damaging levels. Do not apply more than 2 applications per season. Allow a minimum of 7 days between applications.
	15	Rimon 0.83EC (novaluron)	9.0-12.0 fl oz	Do not apply more than 36 fl oz per acre per season.	1	12	Minimum of 7 days between applications.
	--	M-Pede 49% EC (Soap, insecticidal)	1-2% V/V		0	12	OMRI-listed
Plant hopper	16	Courier 40SC (buprofezin)	9.0-13.6 fl oz	Do not apply more than 27.2 fl. oz./A per crop cycle.	1	12	Apply when a threshold is reached of 5 whitefly nymphs per 10 leaflets from the middle of the plant. Product is a slow-acting IGR that will not kill nymphs immediately. No more than 2 applications per season. Allow at least 5 days between applications.
Psyllids	4D	Sivanto 200 SL (flupyradifurone)	7.0-14.0 fl. oz.	Do not apply more than 28.0 fl. oz./A per year.	1	4	Minimum interval between applications: 7 days.
	23	Movento (spirotetramat)	4.0-5.0 fl oz	Maximum of 10 fl oz/acre per season.	1	24	
	un	Neemix 4.5 (azadirachtin)	4.0-16.0 fl oz		0	12	IGR, feeding repellant. OMRI-listed.
Soil insects	1A	10% Sevin Granules (carbaryl)	20 lb		3	12	Maximum of 4 applications, not more often than once every 7 days.
Stinkbugs	1A	Sevin 80S; XLR; 4F (carbaryl)	80S: 0.63-2.5 XLR; 4F: 0.5-2.0 A	Do not apply a total of more than 10 lb or 8 qt per acre per crop.	3	12	Do not apply more than seven times.
	3	*Baythroid XL (beta-cyfluthrin)	1.6-2.8 fl oz	Do not apply more than 16.8 fl oz per acre per season.	0	12	
	3	*Danitol 2.4 EC (fenpropathrin)	7-10.67 fl oz	Do not exceed 42.67 fl. oz. total application /A per season.	3	24	

Pest	MOA Code	Trade name (Active Ingredient) *Restricted	Rate (Product/acre)	Rate/Season	PHI (d)	REI (hrs)	Remarks
	3	*Hero (bifenthrin & zeta-cypermethrin)	4.0-10.3 oz	Do not apply more than 43.26 fl. oz./A per season.	1	12	Do not make more than 4 applications per season. Do not make applications less than 10 days apart.
	3	Karate with Zeon* (lambdacyhalothrin)	0.96-1.92 fl. oz.	Do not apply more than 23.04 fl. oz. /A per season.	5	24	
	3	*Mustang (zeta-cypermethrin)	2.4-4.3 oz	Do not apply more than 25.8 fl. oz./A per season.	1	12	Not recommended for vegetable leafminer in Florida. Do not make applications less than 7 days apart.
	3 & 4A	Leverage* 360 (beta-cyfluthrin & imidacloprid)	3.8-4.1		0	12	
	3 & 6	Gladiator* (avermectin B1 & zeta-cypermethrin)	10-19 fl. oz.	Do not apply more than 57 fl. oz./A per 12 month cropping year.	7	12	
	3 & 28	*Voliam Xpress (lambda-cyhalothrin & chlorantraniliprole)	5.0-9.0 fl oz	Do not apply more than 31.0 fl oz /A per season.	5	24	
	3A	*Brigade 2EC (bifenthrin)	2.1-5.2 fl oz	Make no more than 4 applications per season.	1	12	Do not make applications less than 10 days apart.
	3A	*Proaxis Insecticide (gamma-cyhalothrin)	1.92-3.84 fl oz	Do not apply more than 2.88 pints per acre per season.	5	24	
	3A	*Warrior II (lambdacyhalothrin)	0.96-1.92 fl oz	Do not apply more than 23.04 fl. oz/A per season.	5	24	
	3A & 4A	*Endigo ZC (lambda-cyhalothrin & thiamethoxam)	4.0-4.5 fl oz	Do not exceed a total of 19.0 fl oz per acre per season.	5	24	See label for limits on each active ingredient.
	4A	Actara (thiamethoxam)	2.0-5.5 oz	Do not exceed a total of 11.0 oz/Acre per acre per growing season.	0	12	Application restrictions exist for this product because of risk to bees and other insect pollinators. Follow application restrictions found in directions for use to protect pollinators. Minimum interval between applications is 5 days.
	4A	Belay 50 WDG (clothianidin)	1.6-2.1 oz (foliar application)	Do not apply more than 6.4 oz per acre per season.	7	12	Do not use an adjuvant. Toxic to bees. Do not release irrigation water from the treated area.
	4A	Scorpion (dinotefuran)	Soil: 9-10.5 fl. oz.; foliar: 2-7 fl. oz.	Do not apply more than 21 fl. oz/A per season as a soil application. Do not apply more than 10.5 fl. oz/A per season foliarly.	1	12	Application restrictions exist for this product because of risk to bees and other insect pollinators. Follow application restrictions found in the directions for use to protect pollinators. Do not combine soil and foliar applications. Use one method or the other.
	4A & 28	Voliam Flexi (thiamethoxam & chlorantraniliprole)	4.0-7.0 oz	Do not exceed 14 oz/A per season.	1	12	Do not use in greenhouses or on transplants. Do not use if seed has been treated with thiamethoxam or if other Group 4A insecticides will be used. Highly toxic to bees.
	15	Rimon 0.83EC (novaluron)	9.0-12.0 fl oz	Do not apply more than 36 fl oz per acre per season.	1	12	Minimum of 7 days between applications.
	un	Aza-Direct (azadirachtin)	1-2 pts, up to 3.5 pts, if needed		0	4	Antifeedant, repellant, insect growth regulator. OMRI-listed.
Thrips: check label for species controlled	1A	Sevin 80S; XLR; 4F (carbaryl)	80S: 0.63-2.5 XLR; 4F: 0.5-2.0 A	Do not apply a total of more than 10 lb or 8 qt per acre per crop.	3	12	Do not apply more than seven times.
	3	*Baythroid XL (beta-cyfluthrin)	1.6-2.8 fl oz	Do not apply more than 16.8 fl oz per acre per season.	0	12	
	3	*Hero (bifenthrin & zeta-cypermethrin)	4.0-10.3 oz	Do not apply more than 43.26 fl. oz./A per season.	1	12	Do not make more than 4 applications per season. Do not make applications less than 10 days apart.
	3	Karate with Zeon* (lambdacyhalothrin)	0.96-1.92 fl. oz.	Do not apply more than 23.04 fl. oz. /A per season.	5	24	
	3	*Mustang (zeta-cypermethrin)	2.4-4.3 oz	Do not apply more than 25.8 fl. oz./A per season.	1	12	Not recommended for vegetable leafminer in Florida. Do not make applications less than 7 days apart.
	3	Pyganic Crop Protection EC 5.0 II (pyrethrins)	4.5-18.0 fl oz	11.25 pints.	0	12	Pyrethrins degrade rapidly in sunlight. Thorough coverage is important. OMRI-listed. Do not apply more than 10 times per season.
	3 & 4A	Leverage* 360 (beta-cyfluthrin & imidacloprid)	3.8-4.1		0	12	
	3 & 6	Gladiator* (avermectin B1 & zeta-cypermethrin)	10-19 fl. oz.	Do not apply more than 57 fl. oz./A per 12 month cropping year.	7	12	

INSECTICIDES AND MITICIDES FOR MANAGEMENT OF TOMATO PESTS (continued)

Pest	MOA Code	Trade name (Active Ingredient) *Restricted	Rate (Product/acre)	Rate/Season	PHI (d)	REI (hrs)	Remarks
	3 & 28	*Voliam Xpress (lambda-cyhalothrin & chlorantraniliprole)	5.0-9.0 fl oz	Do not apply more than 31.0 fl oz /A per season.	5	24	
	3A	*Brigade 2EC (bifenthrin)	2.1-5.2 fl oz	Make no more than 4 applications per season.	1	12	Do not make applications less than 10 days apart.
	3A	*Proaxis Insecticide (gamma-cyhalothrin)	1.92-3.84 fl oz	Do not apply more than 2.88 pints per acre per season.	5	24	
	3A	*Warrior II (lambdacyhalothrin)	0.96-1.92 fl oz	Do not apply more than 23.04 fl. oz/A per season.	5	24	
	4A	Admire Pro (imidacloprid)	7-10.5 fl oz	Maximum allowed on tomato is 10.5 fl. oz/A.	21	12	Application restrictions exist for this product because of risk to bees and other insect pollinators. Follow application restrictions found in directions for use to protect pollinators.
	4A	Assail 70WP (acetamiprid)	0.6-1.7 oz	Do not exceed a total of 6.8 oz. Assail 70 WP per acre per growing season including any pretransplant applications of acetamiprid.	7	12	Do not apply to crop that has been already treated with imidacloprid or thiamethoxam at planting. Begin applications for whitefly when first adults are noticed. Do not make more than 4 applications per season. Do not apply more than once every 7 days.
	4A	Platinum	5-11 fl oz	Do not exceed a total of 11 fl. oz. Platinum/A per growing season.	30	12	Soil application. Not for use in nurseries, plant propagation houses, greenhouses, or on plants grown for use as transplants. See label for rotational restrictions. Do not use with other neonicotinoid insecticides
		Platinum 75 SG (thiamethoxam)	1.66-3.67 oz	Do not exceed a total of 3.67 Platinum 75 SG/A per growing season.			
	4A	Scorpion (dinotefuran)	Soil: 9-10.5 fl. oz.; foliar: 2-7 fl. oz.	Do not apply more than 21 fl. oz/A per season as a soil application. Do not apply more than 10.5 fl. oz/A per season foliarly.	1	12	Application restrictions exist for this product because of risk to bees and other insect pollinators. Follow application restrictions found in the directions for use to protect pollinators. Do not combine soil and foliar applications. Use one method or the other.
	4A	Venom 20 SG (dinotefuran)	foliar:0.44-0.895 lb	Do not apply more than 1.34 lb./A per season.	1	12	Use only one application method (soil or foliar). Limited to three applications per season. Toxic to honeybees.
		Venom 20 SG (dinotefuran)	soil: 1.13-1.34 lb	Do not apply more than 2.68 lb/A per season.	21	12	Use only one application method (soil or foliar). Must have supplemental label for rates over 6.0 oz/acre.
	4A & 28	Durivo (thiamethoxam & chlorantraniliprole)	10-13 fl oz	Do not exceed a total of 13.0 fl. oz./A per growing season.	30	12	Several methods of soil application – see label.
	5	Entrust (spinosad)	0.5-2.5 oz	Do not apply more than 9 oz per acre per crop.	1	4	OMRI-listed2. For thrips, rotate to other class of effective insecticide after 2 applications of a Group 5 insecticide for at least 2 applications.
	5	Radiant SC (spinetoram)	5-10 fl oz.	Do not apply more than 34 fl. oz./A per calendar year.	1	4	For thrips, if additional treatment is needed after two applications, switch to an alternate mode of action (not group 5) for at least two applications.
	6	*AgriMek SC (abamectin)	1.75-3.5 fl oz	Do not apply more than 10.25 fl. oz./A in a growing season.	7	12	Do not make more than 2 sequential applications of Agri-Mek SC or any other foliar applied abamectin-containing product in a growing season.
		*Agri-Mek 0.15 EC	8.0-16.0 fl. oz	Do not apply more than 48 fl oz per acre per season.	7	12	Do not make more than 2 sequential applications per season.
	9C	Beleaf 50 SG (flonicamid)	4.2 oz.	Do not apply more than 8.4 oz per acre per season.	0		Begin applications before pests reach damaging levels. Do not apply more than 2 applications per season. Allow a minimum of 7 days between applications.
	15	Rimon 0.83EC (novaluron)	9.0-12.0 fl oz	Do not apply more than 36 fl oz per acre per season.	1	12	Minimum of 7 days between applications.
	23	Movento (spirotetramat)	4.0-5.0 fl oz	Maximum of 10 fl oz/acre per season.	1	24	
	28	Exirel (cyantraniliprole)	7-20.5 fl. oz.	Do not apply a total of more than 0.4 lb ai/A per crop.	1	12	Application restrictions exist for this product because of risk to bees and other pollinators. Follow application restrictions found in the directions for use to protect pollinators. Minimum application interval between treatmenst is 5 days.
	28	Verimark (cyantraniliprole)	5-13.5 fl. oz.	Do not apply more than 0.4 lb ai/A per crop.	1	4	

INSECTICIDES AND MITICIDES FOR MANAGEMENT OF TOMATO PESTS (continued)

Pest	MOA Code	Trade name (Active Ingredient) *Restricted	Rate (Product/acre)	Rate/Season	PHI (d)	REI (hrs)	Remarks
	un	Aza-Direct (azadirachtin)	1-2 pts, up to 3.5 pts, if needed		0	4	Antifeedant, repellant, insect growth regulator. OMRI-listed.
	un	Azatin XL (azadirachtin)	5-21 fl oz		0	4	Antifeedant, repellant, insect growth regulator.
	un	Grandevo (*Chromobacterium subtsugae*)	1.0-3.0 lb		0	4	Thorough coverage is necessary for effective control.
	un	MET52 EC (*Metarhizium anispoliae* strain F52)	drench: 40-80 fl. oz.; foliar: 0.5 pint - 2qt		0	0	
	un	Mycotrol O (*Beauvaria bassiana* strain GHA)	0.5 quart -1 quart/100 gallons		0	4	OMRI Listed
	un	PFR-97 (*Isaria fumosorosea* Apopka strain 97)	1.0-2.0 lbs		0	4	Repeat applications at 3-10 days are needed to maintain control. Can be used in greenhouse for food crop transplants raised to be planted into the field. OMRI listed.
	un	Requiem 25EC (extract of Chenopodium ambrosioides)	2-4 qt	Limited to 10 applications per crop cycle.	0	4	Begin applications before pests reach damaging levels.
	un	Surround WP (kaolin)	12.5-50 lbs		0	4	OMRI listed.
	--	M-Pede 49% EC (Soap, insecticidal)	1-2% V/V		0	12	OMRI-listed
	--	Ultra Fine Oil, Saf-T-Side, others JMS Stylet-Oil (oil, insecticidal)	1.0-2.0 gal/100 gal 3.0-6.0 qt/100 gal water (JMS)		0	4	Do not exceed four applications per season. Organic Stylet-Oil and Saf-T-Side are OMRI-listed.
Weevils	3A	*Proaxis Insecticide (gamma-cyhalothrin)	1.92-3.84 fl oz	Do not apply more than 2.88 pints per acre per season.	5	24	
	3A	*Warrior II (lambdacyhalothrin)	0.96-1.92 fl oz	Do not apply more than 23.04 fl. oz/A per season.	5	24	
	3A, 4A	*Endigo ZC (lambda-cyhalothrin & thiamethoxam)	4.0-4.5 fl oz	Do not exceed a total of 19.0 fl oz per acre per season.	5	24	See label for limits on each active ingredient.
	un	Aza-Direct (azadirachtin)	1-2 pts, up to 3.5 pts, if needed		0	4	Antifeedant, repellant, insect growth regulator. OMRI-listed.
	un	Azatin XL (azadirachtin)	5-21 fl oz		0	4	Antifeedant, repellant, insect growth regulator.
Whiteflies	1A	*Vydate L (oxamyl)	foliar: 2.0-4.0 pt	Do not apply more than 32 pts/A per season.	3	48	
	3	*Asana XL (0.66EC) (esfenvalerate)	2.9-9.6 fl oz	Do not apply more than 0.5 lb ai per acre per season, or 10 applications at highest rate.	1	12	Not recommended for control of vegetable leafminer in Florida.
	3	*Baythroid XL (beta-cyfluthrin)	1.6-2.8 fl oz	Do not apply more than 16.8 fl oz per acre per season.	0	12	
	3	*Danitol 2.4 EC (fenpropathrin)	7-10.67 fl oz	Do not exceed 42.67 fl. oz. total application /A per season.	3	24	
	3	*Hero (bifenthrin & zeta-cypermethrin)	4.0-10.3 oz	Do not apply more than 43.26 fl. oz./A per season.	1	12	Do not make more than 4 applications per season. Do not make applications less than 10 days apart.
	3	Karate with Zeon* (lambdacyhalothrin)	0.96-1.92 fl. oz.	Do not apply more than 23.04 fl. oz. /A per season.	5	24	
	3	*Mustang (zeta-cypermethrin)	2.4-4.3 oz	Do not apply more than 25.8 fl. oz./A per season.	1	12	Not recommended for vegetable leafminer in Florida. Do not make applications less than 7 days apart.
	3	Pyganic Crop Protection EC 5.0 II (pyrethrins)	4.5-18.0 fl oz	11.25 pints.	0	12	Pyrethrins degrade rapidly in sunlight. Thorough coverage is important. OMRI-listed. Do not apply more than 10 times per season.
	3 & 28	*Voliam Xpress (lambda-cyhalothrin & chlorantraniliprole)	5.0-9.0 fl oz	Do not apply more than 31.0 fl oz /A per season.	5	24	
	3A	*Brigade 2EC (bifenthrin)	2.1-5.2 fl oz	Make no more than 4 applications per season.	1	12	Do not make applications less than 10 days apart.
	3A	*Proaxis Insecticide (gamma-cyhalothrin)	1.92-3.84 fl oz	Do not apply more than 2.88 pints per acre per season.	5	24	
	3A	*Warrior II (lambdacyhalothrin)	0.96-1.92 fl oz	Do not apply more than 23.04 fl. oz/A per season.	5	24	

INSECTICIDES AND MITICIDES FOR MANAGEMENT OF TOMATO PESTS (continued)

Pest	MOA Code	Trade name (Active Ingredient) *Restricted	Rate (Product/acre)	Rate/Season	PHI (d)	REI (hrs)	Remarks
	4A	Actara (thiamethoxam)	2.0-5.5 oz	Do not exceed a total of 11.0 oz/Acre per acre per growing season.	0	12	Application restrictions exist for this product because of risk to bees and other insect pollinators. Follow application restrictions found in directions for use to protect pollinators. Minimum interval between applications is 5 days.
	4A	Admire Pro (imidacloprid)	7-10.5 fl oz	Maximum allowed on tomato is 10.5 fl. oz/A.	21	12	Application restrictions exist for this product because of risk to bees and other insect pollinators. Follow application restrictions found in directions for use to protect pollinators.
	4A	Admire Pro (imidacloprid)	0.6 fl oz per 1000 plants		0 (soil)	12	Greenhouse use: 1 application to mature plants, see label for cautions.
	4A	Admire Pro (imidacloprid)	0.44 fl oz per 10,000 plants		21	12	Planthouse: 1 application. See label.
	4A	Assail 70WP (acetamiprid)	0.6-1.7 oz	Do not exceed a total of 6.8 oz. Assail 70 WP per acre per growing season including any pretransplant applications of acetamiprid.	7	12	Do not apply to crop that has been already treated with imidacloprid or thiamethoxam at planting. Begin applications for whitefly when first adults are noticed. Do not make more than 4 applications per season. Do not apply more than once every 7 days.
	4A	Belay 50 WDG (clothianidin)	1.6-2.1 oz (foliar application)	Do not apply more than 6.4 oz per acre per season.	7	12	Do not use an adjuvant. Toxic to bees. Do not release irrigation water from the treated area.
	4A	Belay 50 WDG (clothianidin)	4.8-6.4 oz (soil application)	Do not apply more than 6.4 oz per acre per season.	Apply at planting	12	See label for application instructions. Do not release irrigation water from the treated area.
	4A	Platinum	5-11 fl oz	Do not exceed a total of 11 fl. oz. Platinum/A per growing season.	30	12	Soil application. Not for use in nurseries, plant propagation houses, greenhouses, or on plants grown for use as transplants. See label for rotational restrictions. Do not use with other neonicotinoid insecticides
		Platinum 75 SG (thiamethoxam)	1.66-3.67 oz	Do not exceed a total of 3.67 Platinum 75 SG/A per growing season.			
	4A	Provado 1.6F (imidacloprid)	3.8-6.2 fl oz	Maximum per crop per season 19.2 fl oz/A.	0	12	Do not apply to crop that has been already treated with imidacloprid or thiamethoxam at planting.
	4A	Safari 20 SG (dinotefuran)	7.0-14.0 oz		1	12	For transplant production only. Can be applied as foliar spray or soil drench.
	4A	Scorpion (dinotefuran)	Soil: 9-10.5 fl. oz.; foliar: 2-7 fl. oz.	Do not apply more than 21 fl. oz/A per season as a soil application. Do not apply more than 10.5 fl. oz/A per season foliarly.	1	12	Application restrictions exist for this product because of risk to bees and other insect pollinators. Follow application restrictions found in the directions for use to protect pollinators. Do not combine soil and foliar applications. Use one method or the other.
	4A	Venom 20 SG (dinotefuran)	foliar:0.44-0.895 lb	Do not apply more than 1.34 lb./A per season.	1	12	Use only one application method (soil or foliar). Limited to three applications per season. Toxic to honeybees.
		Venom 20 SG (dinotefuran)	soil: 1.13-1.34 lb	Do not apply more than 2.68 lb/A per season.	21	12	Use only one application method (soil or foliar). Must have supplemental label for rates over 6.0 oz/acre.
	4A & 28	Durivo (thiamethoxam & chlorantraniliprole)	10-13 fl oz	Do not exceed a total of 13.0 fl. oz./A per growing season.	30	12	Several methods of soil application – see label.
	4A & 28	Voliam Flexi (thiamethoxam & chlorantraniliprole)	4.0-7.0 oz	Do not exceed 14 oz/A per season.	1	12	Do not use in greenhouses or on transplants. Do not use if seed has been treated with thiamethoxam or if other Group 4A insecticides will be used. Highly toxic to bees.
	7C	Knack IGR (pyriproxyfen)	8-10 fl oz	Do not exceed 20 fl. oz./A per season.	14	12	Immatures only. Apply when nymphs first appear. Apply when a threshold is reached of 5 nymphs per 10 leaflets from the middle of the plant. Product is a slow-acting IGR that will not kill nymphs immediately. Make no more than two applications per season. Treat whole fields.
	9B	Fulfill (pymetrozine)	2.75 oz	Do not apply more than 5.5 oz/acre per crop.	0	12	(FL-040006) 24(c) label for growing transplants also (FL-03004).
	9C	Beleaf 50 SG (flonicamid)	4.2 oz.	Do not apply more than 8.4 oz per acre per season.	0		Begin applications before pests reach damaging levels. Do not apply more than 2 applications per season. Allow a minimum of 7 days between applications.
	15	Rimon 0.83EC (novaluron)	9.0-12.0 fl oz	Do not apply more than 36 fl oz per acre per season.	1	12	Minimum of 7 days between applications.

Pest	MOA Code	Trade name (Active Ingredient) *Restricted	Rate (Product/acre)	Rate/Season	PHI (d)	REI (hrs)	Remarks
	16	Courier 40SC (buprofezin)	9.0-13.6 fl oz	Do not apply more than 27.2 fl. oz./A per crop cycle.	1	12	Immatures only. Apply when a threshold is reached of 5 whitefly nymphs per 10 leaflets from the middle of the plant. Product is a slow-acting IGR that will not kill nymphs immediately. No more than 2 applications per season. Allow at least 5 days between applications.
	21A	Portal (fenpyroximate)	2.0 pt	Do not apply more than 4.0 pints/A per crop cycle.	1	12	Do not make more than two applications per growing season. Allow 14 days between applications.
	23	Movento (spirotetramat)	4.0-5.0 fl oz	Maximum of 10 fl oz/acre per season.	1	24	
	23	Oberon 2SC (spiromesifen)	7.0-8.5 fl oz	Maximum amount per crop: 25.5 fl oz/A.	1	12	No more than 3 applications.
	28	Exirel (cyantraniliprole)	7-20.5 fl. oz.	Do not apply a total of more than 0.4 lb ai/A per crop.	1	12	Application restrictions exist for this product because of risk to bees and other pollinators. Follow application restrictions found in the directions for use to protect pollinators. Minimum application interval between treatmenst is 5 days.
	28	Verimark (cyantraniliprole)	5-13.5 fl. oz.	Do not apply more than 0.4 lb ai/A per crop.	1	4	
	28 & 16	Vetica (flubendiamide & buprofezin)	12.0-17.0 fl oz	Do not apply more than 38 fl oz/A per season.	1	12	Do not apply more than 3 times per season or apply more than 38 fl oz per acre per season. Same classes of active ingredients as Belt, Synapse, Coragen (all group 28), and Courier (group 16).
	un	Aza-Direct (azadirachtin)	1-2 pts, up to 3.5 pts, if needed		0	4	Antifeedant, repellant, insect growth regulator. OMRI-listed.
	un	Azatin XL (azadirachtin)	5-21 fl oz		0	4	Antifeedant, repellant, insect growth regulator.
	un	Grandevo (*Chromobacterium subtsugae*)	1.0-3.0 lb		0	4	Thorough coverage is necessary for effective control.
	un	MET52 EC (*Metarhizium anisopliae* strain F52)	drench: 40-80 fl. oz.; foliar: 0.5 pint - 2qt		0	0	
	un	Mycotrol O (*Beauvaria bassiana* strain GHA)	0.5 quart -1 quart/100 gallons		0	4	OMRI Listed
	un	Neemix 4.5 (azadirachtin)	4.0-16.0 fl oz		0	12	IGR, feeding repellant. OMRI-listed.
	un	PFR-97 (*Isaria fumosorosea* Apopka strain 97)	1.0-2.0 lbs		0	4	Repeat applications at 3-10 days are needed to maintain control. Can be used in greenhouse for food crop transplants raised to be planted into the field. OMRI listed.
	un	Requiem 25EC (extract of Chenopodium ambrosioides)	2-4 qt	Limited to 10 applications per crop cycle.	0	4	Begin applications before pests reach damaging levels.
	un	SuffOil-X (unsulfonated residue of petroleum oil)	1-2 gallons per 100 gallons of water.			4	OMRI listed.
	--	M-Pede 49% EC (Soap, insecticidal)	1-2% V/V		0	12	OMRI-listed
	--	Ultra Fine Oil, Saf-T-Side, others JMS Stylet-Oil (oil, insecticidal)	1.0-2.0 gal/100 gal 3.0-6.0 qt/100 gal water (JMS)		0	4	Do not exceed four applications per season. Organic Stylet-Oil and Saf-T-Side are OMRI-listed.
Wireworms	1B	*Diazinon AG500; *50 W (diazinon)	AG500: 1-4 qt 50W: 2-8 lb	Do not make more than one soil applicationper year regardless of target pest.	preplant	48	Incorporate into soil - see label.

Nematicides Registered for Use on Florida Tomato

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		Row Application (6' row spacing - 36" bed)[4]			
Product	**Broadcast (Rate)**	**Recommended Chisel Spacing**	**Chisels (per Row)**	**Rate/acre**	**Rate/1000 Ft/Chisel**
FUMIGANT NEMATICIDES					
Methyl Bromide[1,3] 50-50	300-480 lb	12"	3	250 lb	6.8-11.0 lb
Chloropicrin EC[1]	300-500 lb	Drip applied	See label for use guidelines and additional considerations		
Chloropicrin[1]	300-500 lb	12"	3	150-200 lb	6.9-11.5 lb
Dimethyl Disulfide[1]	35-51 gal	12"	3	17.5 – 25.5	102-149 fl oz
PIC Clor 60[1]	19.5 – 31.5 gal	12"	3	20-25 gal 250-300 lb	117- 147 fl oz
Telone II[2]	9 -18 gal	12"	3	6 -9.0 gal	35-53 fl oz
Telone EC[2]	9 -18 gal	Drip applied	See label for use guidelines and additional considerations		
Telone C-17[2]	10.8-17.1 gal	12"	3	10.8-17.1 gal	63-100 fl oz
Telone C-35[2]	13-20.5 gal	12"	3	13-20.5 gal	76-120 fl oz
Telone Inline[2]	13-20.5 gal	Drip applied	See label for use guideline and additional considerations		
Metam sodium	50-75 gal	5"	6	25-37.5 gal	73-110 fl oz
Metam potassium	30-62 gal	5"	6	15-31.0 gal	44-91 fl oz
Dominus (AITC[5])	10-40 gal	Drip applied	See label for use guidelines and additional considerations		
NON-FUMIGANT NEMATICIDES					
Vydate L – is currently not available for purchase within commercial markets. Dupont production of the product will not resume until government agencies and DuPont complete investigations into the fire which destroyed the manufacturing facility and obtains government approval on how to safely restart the production process. For users holding Vydate, treat soil before or at planting with any other appropriate nematicide 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.					
Nimitz - All applications to tomato must be incorporated either physically or via drip or overhead irrigation. Make preplant applications at a rate of 3.5 to 5 pints, (56.0 to 80.0 fl. oz.) per acre, a minimum of seven days before planting. Do not plant any unlisted crops into treated land for 365 days after application of the product. Do not apply more than one application per crop, and no more than 112 fl. oz. of product per acre, per year (365 days). Provides control only for nematodes and does not provide residual control. Product is commercially available but is still actively under assessment in field trial evaluations. This product is not as consistently effective against root-knot nematodes as the fumigants, but is registered as indicated.					

1. If treated area is tarped with impermeable film, dosage may be reduced by 40-50%. All crop and Florida county uses of Dimethyl Disulfide (DMDS) now mandatorily required totally impermeable mulch film (TIF).
2. The manufacturer of Telone II, Telone EC, Telone C-17, Telone C-35, and Telone Inline has restricted use only on soils that have a relatively shallow hard pan or soil layer restrictive to downward water movement (such as a spodic horizon) within six feet of the ground surface and are capable of supporting seepage irrigation regardless of irrigation method employed. Crop use of Telone products do not apply to the Homestead, Dade county production regions of south Florida. Higher label application rates are possible for fields with cyst-forming nematodes. Consult manufacturers label for personal protective equipment and other use restrictions which might apply.
3. As a grandfather clause, it is still possible to continue to use methyl bromide on any previous labeled crop as long as the methyl bromide used comes from existing supplies produced prior to January 1, 2005. A critical use exemption (CUE) for continuing use of methyl bromide was not awarded for tomato, pepper and eggplant for calendar year during 2014 or for 2015. As of January 1, 2014, **all of the prior approved CUE uses of methyl bromide for these crops finally came to an end in FloridaL.** Specific, certified uses and labeling requirements for any methyl bromide acquired for field use must now be certified and labeled as coming from existing stock from distributors prior to grower purchase and use in these crops. Methyl bromide products purchased and farm delivered as CUE stock before December 31, 2013 are still available for future use. Product formulations are subject to change and availability.
4. Rate/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. Reduced rates are possible with use of gas impermeable mulches.
5. Allyl isothiocyanate (AITC)

Rates are believed to be correct for products listed when applied to mineral soils. Higher rates may be required for muck (organic) soils. Growers have the final responsibility to guarantee that each product is used in a manner consistent with the label. The information was compiled by the author as of June 18, 2016 as a reference for the commercial Florida tomato grower. The mentioning of a chemical or proprietary product in this publication does not constitute a written recommendation or an endorsement for its use by the University of Florida, Institute of Food and Agricultural Sciences, and does not imply its approval to the exclusion of other products that may be suitable. Products mentioned in this publication are subject to changing Environmental Protection Agency (EPA) rules, regulations, and restrictions such as requirements for buffer zones, fumigant management plans (FMP), post application summary reports, mandatory good agricultural practices, and EPA approved certified applicator fumigant product training. Additional products may become available or approved for use.

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