The Florida 2018 TOMATO PROCEEDINGS

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UF UNIVERSITY of FLORIDA IFAS

MEISTERMEDIA WORLDWIDE

2018 FLORIDA TOMATO INSTITUTE PROGRAM

The Ritz-Carlton, Naples, Florida | September 5, 2018

9:00 a.m. **Welcome and Opening Remarks**, Kelly Morgan, Center Director, UF/IFAS, SWFREC, Immokalee.

MODERATOR: Matt Krug, State Specialized Agent, Food Science SWFREC, Immokalee.

9:10 a.m. **State of the Industry** – Michael Schadler, Florida Tomato Committee & Florida Tomato Exchange, Maitland.

9:20 a.m. **Taking a Closer Look at Fusarium Wilt Resistance in Tomato** - Samuel Hutton, UF/IFAS, GCREC, Wimauma. Page 4

9:40 a.m. **Advancing New Fumigant and Nonfumigant Tactics for Soilborne Pest and Disease Control in Florida** – Joe Noling, UF/IFAS, CREC, Lake Alfred.

10:10 a.m. **Using Resistance to Combat Root-knot Disease in Tomato** – Donald Dickson, UF/IFAS, Department of Entomology and Nematology, Gainesville. Page 6

10:40 a.m. **What's Next after NAFTA Renegotiation**?– Zhengfei Guan, UF/IFAS, GCREC, Wimauma. Page 10

11:00 a.m. **New Product Presentations** – MODERATOR: Gene McAvoy, Hendry County Extension Service, LaBelle.

11:30 a.m. Lunch (on your own)

MODERATOR: Christian Miller, Palm Beach County Extension, West Palm Beach.

1:00 p.m. **Competitive Potential of B and Q Biotypes of *Bemisia tabaci* on Florida 91 Tomato** - Hugh Smith, UF/IFAS, GCREC, Wimauma. Page 13

1:20 p.m. **Prediction and Possible Remedy in Managing Thrips (Thysanoptera: Thripidae) and MEAM1 Whitefly (Hemiptera: Aleyrodidae) in Tomato** - Dakshina Seal, UF/IFAS, TREC, Homestead. Page 14

1:40 p.m. **Managing Bacterial Spot of Tomato by Application of Novel Compounds** – Shouan Zhang, UF/IFAS, TREC, Homestead. Page 21

2:00 p.m. **Field Performance of Nano Magnesium Oxide, a New Antibacterial Compound A gainst Bacterial Spot of Tomato** - Mathews Paret, UF/IFAS, NFREC, Quincy. Page 24

2:20 p.m. **Herbicide Phytotoxicity in Tomatoes Prevention and Rescue** – Ramdas Kanissery, UF/IFAS, SWFREC, Immokalee. Page 25

2:40 p.m. **The Electronic Logging Devices (ELDs) Mandate and Hours of Service (HOS) for Produce Haulers** – Tara Wade, UF/IFAS, SWFREC, Immokalee. Page 27

3:00 p.m. **Adjourn** (Continuing Education Units will be provided to applicable participants)

PRODUCTION GUIDES

Vegetable Production Handbook of Florida, 2017-2018. Chapter 18. Tomato Production
http://edis.ifas.ufl.edu/pdffiles/cv/cv13700.pdf

Insecticides Labeled for Management of Arthropod Pests on Tomato – Hugh A. Smith, Page 30

Herbicides Labeled for Weed Management in Tomato – Ramdas Kanissery, Page 47

Nematicides Registered for Use on Florida Tomato – Joseph W. Noling, Page 50

Tomato Fungicides– Gary E. Vallad, Page 51

Tomato Biopesticides and Other Disease Control Products – Gary E. Vallad, Page 69

Taking a Closer Look at Fusarium Wilt Resistance in Tomato

Jessica Chitwood-Brown, Gary Vallad, Tong Geon Lee, and Samuel F. Hutton*

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INTRODUCTION

Fusarium wilt, caused by the soilborne fungus *Fusarium oxysporum* f.sp. *lycopersici* (*Fol*), is a major disease of field-grown tomatoes in Florida and in other warm production regions worldwide. The fungus penetrates the roots and colonizes the vascular tissue of plants, causing yellowing, wilting, stunting, and plant death. Once introduced into a field, *Fol* is almost impossible to eliminate, as it can survive nearly indefinitely in soil as either chlamydospores or as a common root epiphyte/saprophyte on numerous weeds without causing disease (Katan, 1971). Since the 1970s, much of the eastern US fresh-market tomato industry has heavily relied on the fumigant, methyl bromide, to help manage many soil-borne diseases—including Fusarium wilt. However, the phase-out of methyl bromide left the industry less effective replacements (Vallad et al., 2014). Host resistance continues to be the primary control strategy for this disease.

Resistance to race 3 (*Fol3*), conferred by the *I*-3 gene, was introgressed from accession LA716 of the wild tomato relative *Solanum pennellii* by Scott and Jones (1989). Although cultivars containing *I-3* have been commercially available since the early 1990's, breeders who have utilized *I-3* have experienced difficulty developing commercially acceptable hybrids due to the association with negative traits including bacterial spot sensitivity and reduced fruit size. Hutton et al. (2014) demonstrated in segregating populations that plants homozygous for the *I-3* introgression had as much as 20% increased infection to bacterial spot (*Xanthomonas perforans*) race T4 relative to *I-3* susceptible genotypes. It was recently shown that the association of bacterial spot is due to linkage drag within the *I-3* introgression and not due to *I-3* itself (Li et al. (2018).

Reduced fruit size is also associated with *I-3*. Scott (1999) reported that in early *I-3* breeding materials, plants homozygous for *I-3* had smaller fruit size compared to plants that were heterozygous for the gene. Yet despite nearly 20 additional years of breeding progress with *I-3*, this effect is still observed in elite breeding materials. We recently compared near isogenic lines (NILs) differing for *I-3* in two advanced UF/IFAS breeding lines, and we saw that average fruit size decreased when *I-3* was present.

We are using a dual strategy to address these challenges and produce *Fol3* resistance that is free from the association of these negative traits. With regard to *I-3*, materials that contain a reduced introgression are being tested for the effects on bacterial spot sensitivity and fruit size. Additionally, we are introgressing alternative *Fol3* resistance alleles from wild *S. pennellii* accessions into a cultivated background with the goal of expanding the toolkit for resistance for use in cultivar development efforts.

MATERIALS AND METHODS

Recombinant inbred lines (RILs) from Li et al. (2018) were used to develop a minimal *I-3* introgression from Fla. 7228, which contains an approximately 5 Mb introgression. Recombinants R12 and R18 were crossed, and the resulting F_2 was screened with molecular markers for the desirable product of homologous recombination (Fig 1). Fla. 8978 was then selected as an F_3 breeding line that is homozygous for the minimal *I-3* introgression. Using additional markers, we determined that the size of this introgression is between 70 and 160 Kb, and it contains no more than 20 annotated genes besides *I-3*. Fla. 8978 was used as the donor for backcrossing the minimal *I-3* introgression into a panel of elite UF/IFAS breeding lines, including Fla. 7946 and Fla. 8059.

Fla. 7946 is an *Fol3*-resistant breeding line, and a backcross F2 population segregated for the original (large) and minimal introgressions. Fla. 8059 is an *Fol3* susceptible parent, and the backcross F2 population segregates only for the minimal *I-3* introgression. Both backcross populations were genotyped with molecular markers for the *I-3* locus to identify which plants contained which introgression; and these plants were then planted to the field to be evaluated for bacterial spot and fruit size. Plots were inoculated approximately three weeks after transplanting with *X. perforans* race T4 at a concentration of 2 to 5×10^8 colony forming units per ml. Inoculum was applied to plants by misting the foliage with a backpack sprayer. Three vine-ripe harvests were done, and fruit were sized according to USDA standards. Fruit numbers and weight were recorded for each size category (S, M, L, XL), and average fruit size was calculated.

RESULTS AND DISCUSSION

Data from fall 2017 suggests the minimal introgression results in significantly less bacterial spot and larger fruit size than the original introgression, and it has no effect compared with Fol3 susceptibility (Table 1). In the Fla. 7946 background, disease severity increased according to dosage effect of the large I-3 introgression compared to the plants homozygous for the minimal introgression, while heterozygous plants were intermediate. In contrast, the minimal introgression had no effect on bacterial spot sensitivity in the Fla. 8059 background.

Data for average fruit size reflected a similar result (Table 1). In the Fla. 7946 background, the large introgression also had a dosage effect on fruit size, where heterozygosity resulted in intermediate fruit size relative to homozygous large or minimal introgressions, and plants homozygous for the large introgression had the smallest average fruit size. Again, there was no significant effect of the minimal introgression in the Fla. 8059 background.

The minimal introgression will continue to be evaluated and will also be tested in additional backgrounds.

An alternative solution to the challenges with producing *Fol3* resistant cultivars using *I-3* may be to utilize novel resistance genes from wild tomato accessions that are not associated with negative traits. The wild tomato relative *S. pennellii* is highly resistant to all races of Fusarium wilt and may be a source for such genes. We subjected 42 *S. pennellii* accessions to disease screens to identify resistance. Molecular markers were used to select against known resistance loci (such as *I-3*) as *Fol3* resistance was backcrossed into an elite, susceptible tomato background. Backcross populations are currently being evaluated to identify and characterize novel *Fol3* resistance genes and to utilize these for cultivar improvement.

ACKNOWLEDGEMENTS

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Hutton, S.F., J.W. Scott, and G.E. Vallad, 2014. Association of the Fusarium wilt race 3 resistance gene, I-3, on chromosome 7 with increased susceptibility to bacterial spot race T4 in tomato. *Journal of the American Society for Horticultural Science* 139:282-289.

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Scott, J. 1999. Tomato plants heterozygous for fusarium wilt race 3 resistance develop larger fruit than homozygous resistant plants. *Proc. Fla. State Hort. Soc.* 112:305-307).

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Vallad, G.E., Boyd N., and Noling, J. 2014. A comparison of alternative fumigants to methyl bromide for Florida tomato. Proceedings from the 2014 Annual International Research Conference on Methyl Bromide Alternatives and Emissions Reductions, p 6-1 to 6-4.

Table 1. Effects of the large and minimal introgressions on bacterial spot severity and fruit size.

Background	Introgression	Bacterial Spot Rating		Average Fruit Size (g)	
Fla. 7946	Lg/Lg	5.8 [z]	a	132 [y]	a
	Lg/Min	5.6	ab	149	ab
	Min/Min	5.2	bc	154	bc
Fla. 8059	-/-	4.8	ns	111	ns
	Min/-	4.9		110	
	Min/Min	4.8		115	

[z] Foliar disease severity was rated 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, and analyzed using rank-mean analysis and 95% confidence intervals with SAS 9.4.

[y] Fruit size data was analyzed with PROC GLIMMIX of SAS 9.4 with block treated as a random effect and means compared with Tukey-Kramer mean separation.

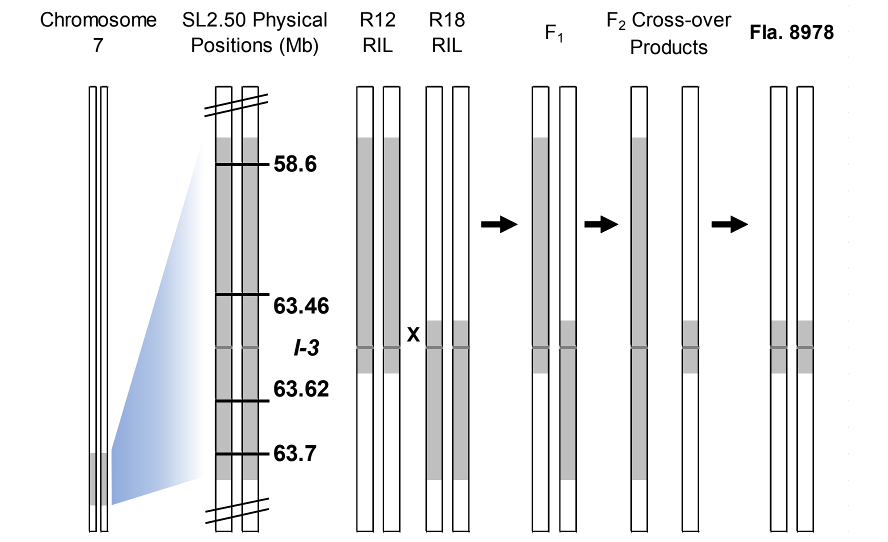

Figure 1. Breeding strategy used to obtain a minimal I-3 introgression. The original introgression size exceeded 5.0 Mb. Recombinant inbred lines (RILs; derived from R12 and R18) resulting from recombination events on either side of I-3 were intercrossed, and the F1 was self-pollinated. Flanking markers were used to screen an F2 population and identify the desirable of two possible products of crossing-over which resulted from further recombination within the overlapping homologous region. A plant containing the minimal I-3 introgression was self-pollinated to obtain a homozygous breeding line, Fla. 8978.

Using Resistance to Combat Root-Knot Disease in Tomato

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The subject presented in this brief article is about using host-plant resistance to combat root-knot disease in tomato production in Florida. Because of use of methyl bromide by Florida tomato growers for more than 45 years there has been little or no interest in using root-knot nematode resistant tomato cultivars. This is in contrast to what has occurred in California and other tomato production regions were the majority of field-grown processing tomatoes are transplanted with resistant tomato (Cook, 2004; Williamson and Roberts, 2009). Nevertheless, with the phase out of methyl bromide, it was reported that using resistant tomato cultivars in Florida was a viable alternative to fumigation and that growers may be more apt to use root-knot nematode resistant tomato cultivars in the future (Rich and Olson, 1999; 2003; Rich et al., 2003).

The question remains, however, whether using tomato cultivars that are reported as resistant to root-knot nematodes (RKN) are a good option for Florida growers. There are several important informational points about using resistant tomato that Florida producers must consider. The information contained herein is aimed to aid growers with that decision.

Why use resistance: Host plants resistant to plant-pathogenic nematodes is considered as a best management practice. Any producer in Florida who has dealt with a serious nematode disease problem can attest to the difficulty of managing nematodes. Ideally, if all a producer had to do was turn to using a nematode resistant cultivar that would solve a major production problem. Unfortunately, it is not quite that simple and the reasons are somewhat complicated.

Almost all of the vegetables that have been bred with resistance genes were developed to prevent root-knot disease and a few other specialized sedentary endoparasitic nematode genera (endoparasite = nematode developmental cycle mostly occurs within the plant roots). Relatively few plants have been bred for resistance to the ectoparasitic nematode genera (ectoparasite = nematode developmental cycle mostly occurs outside the plant roots). Not surprising, the list of resistant vegetables important for Florida growers is not very long. Furthermore, the list includes some vegetables where resistance has been identified but not yet introduced in to commercially available varieties, namely pepper (Table 1). Note that the list does not include any cucurbits or cruciferous vegetables.

Genetics of resistance to root-knot nematodes in sweet potato is poorly understood and the research is contradictory (Cordner et al., 1954; Giamalva et al., 1961; Jones and Dukes, 1980; Struble et al., 1966; Ukoskit et al., 1997).

How was tomato resistant to RKN developed: Research began in the 1940's to develop tomato resistant to RKN. A gene for RKN resistance was introduced into cultivated tomato, Solanum esculentum, from the wild species, Solanum peruvianum by embryo rescue of the interspecific cross (Smith, 1944). This gene historically became known as the Mi-1 gene. It provides resistance against most populations of the three most common RKN species - M. incognita, M. javanica, and M. arenaria (Williamson, 1998). This is an important fact to remember as reasons presented below are discussed.

When a grower looks at the tomato cultivar description the following is generally revealed under cultivar details - disease reaction – resistance to RKN listed as M, Mi, or in some cultivars Mi, Ma, Mj. The latter means the cultivar was tested against three of the most common RKN species – M. incognita, M. arenaria, and M. javanica. Otherwise, one must consider the cultivar is known to be resistant to a Meloidogyne sp., but the particular species is unknown. Below, this point will be discussed further pointing out the limitations posed by the fact Florida production fields may harbor species other than the three most common species, and, in some instances more than one species.

There has been a great deal of research on the *Mi-1* gene, especially in California, where use of resistant tomato cultivars is part of an integrated management program (Kaloshian et al., 1996; Williamson, 1998). The *Mi*-gene is comprised of several genes: *Mi-1* to *Mi-9*. From the several *Mi*-genes available only *Mi-1* gene has been incorporated in the domesticated tomato cultivars. The *Mi-1* gene is currently the best characterized nematode resistance gene among cultivated crops with nematode resistance.

How does the *Mi-1* gene work: Tomato cultivars with the resistance *MI-1* gene prevents the formation of the specialized cells that are required by the nematode for feeding. When a RKN infects a resistant tomato cultivar and tries to begin parasitism (feeding process) a hypersensitive reaction occurs in plant vascular cells near the head of the nematode. This reaction results in the collapse of cells. In the RKN infection process it is absolutely essential for the infective nematode to establish specialized feeding cells known as "giant cells". This fact is well documented in the nematode's pathogenesis process. If giant cells are not formed the nematode is unable to feed and either dies or egresses from the root (Dropkin, 1969; Paulson and Webster, 1972). The hypersensitive reaction is a fairly rapid response to the secretion of enzymes from the nematode's esophageal glands (Paulson and Webster, 1972).

Do RKN juveniles enter resistant tomato: The J2 can enter susceptible or resistance tomato plants in about equal numbers (Moura et al., 1993; Schneider, 1991; Windham and Williams, 1994), or in different numbers (Ferris et al., 1982; Lawrence and Clark, 1986; Powers et al., 1992). The fate of the juveniles once inside tomato roots is determined by resistance factors (Williamson, 1999). They either die or they egress from the root. The latter is dependent on the juvenile's reserved energy level and whether it remains mobile.

The essence of plant-host resistance is that it is supposed to have a significant impact on nematode reproduction. According with the classical definition the term resistance is used to describe the ability of the plant to inhibit reproduction of a plant parasite, namely a nematode species, relative to the rate of reproduction on a plant lacking such resistance (Cook and Evans, 1987). This implies that a resistant plant should be able to inhibit the reproduction approximately 90% or more compared with susceptible plants (Taylor and Sasser, 1983). Resistance to root-knot nematodes, however, is not always consistent. There is often contradictory research data that shows different results for fecundity of root-knot nematodes between susceptible and resistant plants.

Species of root-knot nematodes that cause disease: Root-knot disease is caused by root-knot nematodes (*Meloidogyne* spp.). In Florida, unfortunately, producers are confronted with seven known individual species, all of which are pathogens on most vegetables, including tomato. These seven species are *M. arenaria*, *M. incognita*, *M. javanica*, *M. floridensis*, *M. enterolobii*, *M. haplanaria* and *M. hapla*. It is important to recognize that it matters as to which species one is dealing with in a production field. Especially if one is choosing to depend on a resistant tomato cultivar for management. These species have different parasitic capabilities, and host ranges. And, as stated above, it is not uncommon to find fields infested with more than one species. While the exact distribution of these species is unknown it is not uncommon to find fields infested with *M. arenaria*, *M. javanica*, *M. incognita*, *M. floridensis*, and *M. enterolobii*, but probably less common to encounter *M. haplanaria* or *M. hapla*. *M. haplanaria* was only recently reported in a vegetable field in south Florida (Joseph et al., 2016). Infestations of *M. hapla* are known to occur in fields that have been transplanted with strawberries for many years. The species is introduced on strawberry seedlings imported into the state. Whether this species occurs outside the strawberry production region is unknown.

Why it matters which species of RKN infesting production fields is because the Mi-1 gene in tomato is not effective against M. hapla, M. enterolobii, M. floridensis, or M. haplanaria (Brito et al., 2007a, 2007b, Joseph et al., 2016). While all seven RKN species are known to occur in vegetable fields in Florida, little is known about their exact distribution, especially the latter four species. It is important to note that all seven of these species are pathogenic, especially on tomato, where if left untreated they have the potential to cause heavy yield suppression. It is also important to note that of these seven species M. enterolobii is known to be especially highly virulent on tomato. Reasons for its high degree of virulence remains unknown.

Root-knot nematode developmental cycle: There are five developmental stages of RKN -- egg, four juveniles, and adults. Eggs quickly develop to form a first-stage juvenile inside an egg shell, which molts to form a second-stage juvenile (J2). This is the parasitic stage that hatches from the egg. They are tiny, able to move freely in the soil profile and once a suitable host plant is introduced into the soil the J2 will make a beeline to infect the plant root. Once inside the root the J2 begins the process of parasitism, whereby it forms specialized feeding cells named giant cells. Furthermore, the pathogenicity process causes cells surrounding the nematode to multiply thereby causing a swelling of root tissue. It is this process of cell increase in numbers that results in galls or knots to form on roots. These knots or galling of roots is a symptom that can be used to identify root-knot nematode disease. The number and size of galls depends on the species and the number of J2 that invade a plant root system. Once the giant cell feeding process is established the J2 will begin to grow, molts it outer cuticle three times, which allows it to grow. It passes through three more developmental juvenile stages before reaching adulthood. The common RKN mostly develop to the female stage. The female is an enlarged swollen form that resembles a pear. They are sedentary inside the galled root. The female is capable of reproducing in absence of males, a process known as parthogenesis. If males are formed they remain eelworm shaped and move freely in the soil. Most times they will move to the vulva area of a female where they are thought to copulate with the female. Regardless whether males are present, the female will begin to lay eggs that pass into a gelatinous mass formed in the vulvar area. The mass is generally found on the outside of galled tissue and may contain several hundred eggs. The eggs quickly embryonate and the process begins anew as J2 move quickly to infect roots. The disease cycle is dependent on soil temperature and moisture. Ideal temperature for the common RKN to infect and develop is between 78 to 95 F. During periods of low or high soil temperature the cycle slows down considerable. Soil moisture that benefits plant growth is ideal for RKN development. During periods of drought the nematodes become relatively inactive. They survive best at around 50 F. Because of this low temperature range for survival results in the largest densities lying deep within the soil profile. Depending on the soil type and depth large numbers of J2 may be found as deep as four feet. Higher densities are commonly found 18 to 48 inches deep in deep sandy soils. An underlying dense clay layer and high water table will also limit their movement into deeper soil depths.

Soil temperature affects *Mi-1* gene in tomato: Soil temperature studies in environmental chambers has long been reported to effect the functioning of the *Mi-1* gene (Abdul-Baki and Haroon, 1996). Some reports that the tomato *Mi-1* gene function provides resistance at temperatures up to 32 °C (Table 2); whereas others report the resistance conferred by *Mi-1* gene is lost at temperatures above 28 ˚C (Dropkin, 1969). Increase in number of galls has been shown in root-knot resistant tomato cultivars exposed to soil temperatures above 28 ˚C (Ammati et al., 1986; Araujo et al., 1982a; Devran et al., 2010; Dropkin, 1969; Haroon et al., 1993; Holtzman, 1965; Wang et al., 2009). This may be related to the number of hours (days) that temperatures are above 28 ˚C and (or) the sequence of heat and timing of inoculation. It was reported that at a constant temperature of 28 ˚C only 2% of the J2 of *M. incognita* developed within the roots of resistant tomato in contrast with 87% at 33 ˚C (Dropkin, 1969). This is often reported as a limiting factor for field tomato production and is an important question to consider.

Virulent Races of Root-Knot Nematodes: Previous field trials have demonstrated the capacity of some species or races

Table 1. Vegetable host plants reported with resistant genes to root-knot nematodes (adapted from Williamson and Roberts, 2009).

Host plant	Resistance gene or source	*Meloidogyne* species	References
Carrot	*Mj - 1*	Mi, *M. javanica* (Mj)	Boiteux et al., 2001
Common bean	*me 1, me 2, me 3*	Mh, Mi, Mj	Omwega and Roberts, 1992 Chen and Roberts, 2003
Lima bean	*Mir-1, Mig-1, Mjg-1*	Mi, Mj	Roberts et al., 2008
Pepper	*Me1, 3,4,7; Mech1,2*	Ma, Mi, Mj, *M. chitwoodi* (Mc)	Djian-Caporalino et al., 2007
Potato, sweet	*Rmc1, MfaXIIspl*	Mc, Mh, *M. fallax* (Mf), Mi	Brown et al., 1996; Janssen et al., 1997; Kouassi et al., 2006
Tomato	*Mi-1 – Mi-9*	Mi, Mj, Ma	Yaghoobi et al., 1995 Veremis and Roberts, 1996, Ammiraju et al., 2003

Genetics of resistance to root-knot nematodes in sweet potato is poorly understood and the research is contradictory (Cordner et al., 1954; Giamalva et al., 1961; Jones and Dukes, 1980; Struble et al., 1966; Ukoskit et al., 1997).

of root-knot nematodes to reproduce and inflict damage upon resistant tomato cultivars (Verdejo-Lucas et al., 2009). A race may be defined as a physiology variant of a given species. Races are identified by using a series of host plant differentials. For example, there are four host races of *M. javanica* reported. Pepper and peanut are used to identify these four races. Race 1 infects neither, race 2 infects pepper, race 3 infects peanut, and race 4 infects both peanut and pepper.

Decision on Using Resistance Tomato: Given that significant yield suppression occurs where large densities of RKN juveniles occur in soil, combined efforts to manage soil population densities to low levels before planting should be considered. If this situation develops, the combination of a nematicide and resistant cultivar may also comprise an option to reduce nematode population densities to acceptable thresholds (Roberts et al., 1986).

With the above background the following questions will be presented and summary answers provided. These relate to important considerations that must be made before deciding on using resistant tomato cultivars.

1. Will high soil temperature under polyethylene film cause the resistant gene to become nonfunctional? Based on four years of field testing at the Plant Science Research and Education Unit, Citra FL, Marion County, the answer is no, resistance consistently held in both spring and autumn growing seasons. During the autumn seasons soil temperatures were often about 90 F as deep as nine inches during the early stages of plant development, whereas in the spring season temperatures above 90 F were recorded during the latter stages of plant development, near fruit harvest. These studies confirm earlier studies done at the North Florida Research and Education Center, Quincy, FL.

2. What degree of galling (percentage) will occur on resistant tomato? Resistant cultivars Amelia, Crista, and Red Bounty were compared with susceptible BHN 602. The percentage galling averages on resistant cultivars generally ranged from zero to 15%. Relative to the amount of galling on the susceptible cultivars this degree of galling was consistently much less. The percentage galling is based on a zero to 100 scale where zero = no observable galls, 10 = 10% of root system with observable galls, … to 100 = 100% of root system with observable galls.

3. What is the yield potential of a resistant cultivar versus a susceptible cultivar without and with soil fumigation? Nontreated susceptible BHN 602 and resistant Amelia both had statistical similar yields, thus yield wise there was no advantage to growing a resistant cultivar. However, most all the Amelia plants had little to no galling thus resulting in a reduction in the population of juveniles in soil compared with the susceptible cultivar.

4. Do both resistant and susceptible cultivars responded to soil fumigation? When treated with the soil fumigant Telone II the yield of Amelia was 53% less than that of BHN 602. When a broad-spectrum fumigant Telone C35 was applied Amelia yield 12% less than BHN 602. This same trend was obtained in trials conducted in both spring and autumn seasons. In every case the resistant cultivar responded with increased yields when a broad-spectrum fumigant was applied, but apparently genetically the yield potential of resistant cultivars is less than that in susceptible cultivars. However, these trials did not assess an isogenic line.

5. What is the likelihood that fields in Florida transplanted with resistant RKN resistant cultivars result in a resistant breaking race of Meloidogyne sp.? Currently, we have no such report of resistant breaking strains of RKN but the continuous planting of a resistant cultivar would greater increase this likelihood. There are just too many instances where such has been well documented.

6. What RKN species may be present in grower tomato production fields and why is this important if a producer chooses to use a RKN resistant cultivar? There is little or no data on the distribution of the seven RKN species known to occur in Florida production fields. We do know, however, that there is a greater likelihood of fields being infested with the more common species, *M. arenaria*, *M. incognita*, and *M. javanica*. Any field transplanted with a resistant tomato cultivar that has significant galling should have the nematode identified. There are two possibilities why this would happen. One, it is a resistant breaking strain of one of the common RKN, and second, it is a population of *M. enterolobii*, *M. floridensis*, or *M. haplanaria* all of which are capable of infecting tomato.

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What is Next after NAFTA Renegotiation?

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INTRODUCTION

Fresh-market tomatoes are an important vegetable crop in the United States. California and Florida are the two leading tomato-producing states, producing more than 70% of all U.S. tomatoes. However, U.S. tomato production has significantly declined over the past decade (Figure 1). The total production of fresh tomatoes decreased by 48% between 2000 and 2017, from 3.96 to 2.04 billion pounds. Over this same period, the Florida tomato industry has experienced a similar downward trend, with a decrease in fresh tomato production of 47%, from 1.58 to 0.84 billion pounds (Figure 2).

Increased competition from Mexico has been the primary cause of the decline in Florida and overall U.S. production of fresh tomatoes in the last decade. Since 2000, Mexican tomato imports have significantly increased, accounting for more than 90% of total imported tomatoes (Figure 3). Up until 2016, Florida produced 728 million pounds of tomatoes, equivalent to only 20% of tomato imports from Mexico (Figure 4).

The North American Free Trade Agreement (NAFTA) has been criticized as one cause of the large tomato influx from Mexico. When the renegotiation of NAFTA began, U.S. growers (particularly Florida growers) sought seasonal trade protection from imports. That is, growers proposed using seasonal data to trigger anti-dumping charges. However, this proposal has been withdrawn due to opposition from Mexico, Canada, and the rest of the U.S. producers. Without a trade solution that would bring relief to Florida growers, what comes next for them? Below we will illustrate several areas that Florida growers could work on to improve the viability of the industry.

SUSPENSION AGREEMENTS

In 1996, there was a tomato trade dispute between the United States and Mexico, resulting in an antidumping investigation against the Mexican tomato industry. That November, the U.S. Department of Commerce (USDC) negotiated an antidumping investigation suspension agreement that set a mandatory reference (floor) price for imported Mexican tomatoes. This price was amended in 1998, and the USDC and Mexico signed new agreements in November 2003, 2008, and 2013. The 2013 agreement significantly increased reference prices for imported Mexican tomatoes by 43%.

These suspension agreements are intended to ensure that there is no undercutting or suppressing of fresh market tomato prices in the United States, thus addressing the concerns of the U.S. tomato industry. However, these agreements' ability to effectively remedy the

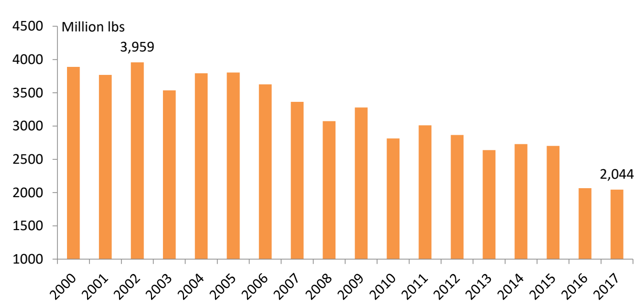

Figure 1. US Fresh Tomato Production.
Source: USDA, NASS.

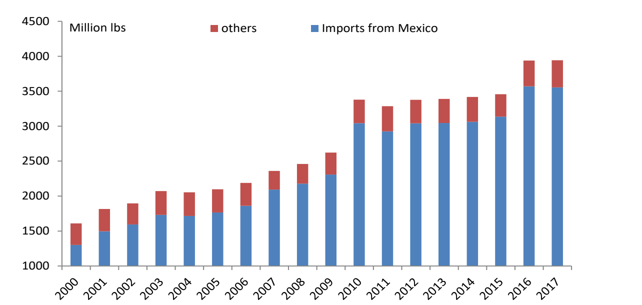

Figure 3. Mexican Tomato Imports .
Source: US Department of Commerce.

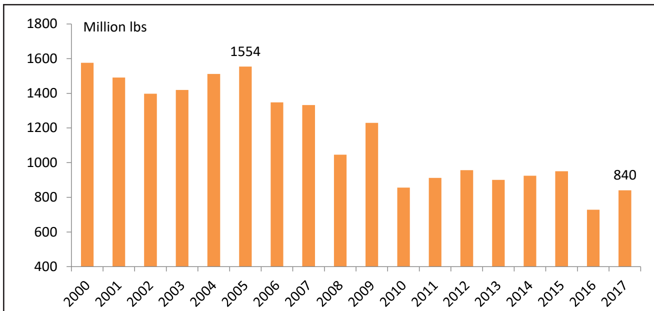

Figure 2. Florida Fresh Tomato Production.
Source: USDA, NASS.

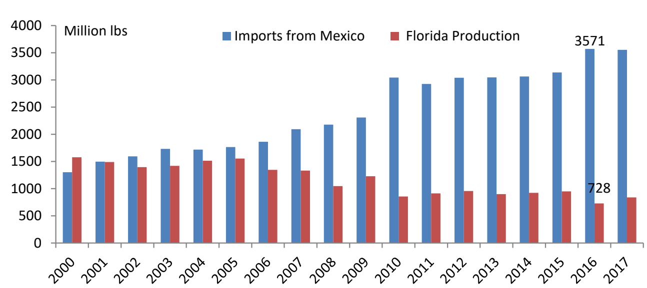

Figure 4. Florida Tomato Production and Mexican Tomato Imports.
Source: US Department of Commerce.

U.S. tomato industry is dependent upon the floor prices. Wu et al. (2018) found that the agreements before 2013 increased the price of Mexican tomatoes but did not increase U.S. tomato prices. Only the latest 2013 agreement with substantially higher reference prices has boosted U.S. tomato prices and lowered the pressure of competition. The 2013 agreement was due to renew in March 2018, and negotiations for a new five-year tomato suspension agreement between Mexico and the United States are currently underway. Mexico's fresh tomato exports to the United States for the 2018-19 season are projected at 1.7 million metric tons, which is similar in volume to that of the 2017-18 and 2016-17 seasons (USDA, 2018).

Amid continued influxes in the volume of imported Mexican tomatoes, the tomato suspension agreement will continue to play an important role in regulating U.S.-Mexico tomato trade. However, the Florida tomato industry has identified loopholes in the enforcement of the agreement, which has led to an increased supply of Mexican tomatoes that would otherwise not have been imported under strict enforcement. For example, the industry complained that Mexican exporters could sell tomatoes above reference prices in the first sale; however, the first buyer could then sell the tomatoes to second buyers for lower prices. The enforcement of reference prices is difficult in such cases. In other cases, Mexican exporters and domestic buyers could use a special price arrangement among different commodities or over time to get around the floor price requirement. The former involves raising tomato prices while lowering other commodities' prices in another deal so that tomatoes could cross the border. The latter involves raising tomato prices to comply with floor prices when market prices are low while lowering them when prices are high. In these "innovative pricing" cases, it is more difficult to enforce or even to detect the violation. All these different exporter strategies call for different agreement designs that involve lower enforcement costs.

USE OF GUEST WORKERS AND MECHANICAL HARVEST TECHNOLOGY

Labor is the most expensive tomato production input, and the industry relies heavily on migrant workers for field work. Growers believe that the majority of agricultural workers are not legally authorized to work in the United States. The U.S. Department of Labor's National Agricultural Workers Survey (NAWS) of 2009-2010 showed that 52% of crop workers surveyed were not legally authorized to work in the United States, and 90% of these unauthorized workers were working in the specialty crop industry (NAWS, 2010). Over the last decade, specialty crop growers have faced greater labor shortages compared to other crop producers. Therefore, the adoption of the H-2A guest worker program has increased significantly in recent years, most notably in Florida (US Department of Labor, 2010-2016). The number of certified H-2A positions in the United States increased from 76,814 in 2007 to 165,741 in 2016 (US Department of Labor 2016). In 2016, Florida became the state with the largest number of H-2A workers. The increasing adoption of the H-2A guest worker program is also driven by the legal risks of employing undocumented workers, as well as uncertainties associated with the current political environment. However, growers have complained that the program is expensive, cumbersome, and inflexible and is therefore unable to meet their labor needs. Reform of the guest worker program is currently being considered in Congress with the aim of relaxing regulations and improving the program's ease of use. In the short term, however, we will still see an increase in the adoption of the program as a last-resort solution to labor shortages.

However, in the long run, even a fundamentally overhauled guest worker program that incurs the same cost as does the use of domestic migrant workers would not make the industry sustainable. This is due to the large gap between domestic and Mexican labor costs. In this sense, mechanization seems to be the ultimate solution for making the U.S. tomato industry more competitive and sustainable.

Mechanization of fruit and vegetable harvest has several potential advantages: reduced harvest costs, the elimination of problems associated with finding high-quality harvest labor, longer harvesting days, and reduced exposure of crops to human bacteria (Huffman, 2010). Huffman (2010) concluded that future mechanization will largely be driven by cost-benefit considerations, including the likely future competitiveness of the U.S. industry in the international market. Thompson and Blank (2000) found that harvest mechanization reduced labor use by 97% in processing tomatoes while also reducing labor costs by 67%. They concluded that mechanization has contributed to the steady increase in production of processing tomatoes in California. Further advances in tomato harvest technology will continue to reduce labor needs. Significant investment in research and development (R&D) programs will potentially lead to the development of mechanical harvesting technologies for fresh tomatoes, thus decreasing labor costs and increasing the competitiveness of the U.S. industry.

An additional advantage of mechanization is that the Florida tomato industry could potentially eliminate the challenges of labor compliance and the legal risk associated with the use of hand labor. This is especially relevant in a climate where worker centers of the industry, such as the Coalition of Immokalee Workers (CIW), are gaining increasing power.

TOMATO MARKETING

Fresh tomatoes can be grown in open fields, adapted environments, and greenhouses. The United States is the largest North American market for greenhouse tomatoes, with large imports from Canada and Mexico. As a matter of fact, the import volume exceeds domestic production. Over the last decade, the United States and Mexico have significantly increased their production of greenhouse fresh tomatoes. Greenhouse tomatoes have altered the composition of U.S. retail tomato sales, accounting for 70% of total fresh tomato sales (Rabobank, 2013). Fresh tomatoes can be further categorized into vine ripe tomatoes and mature green tomatoes. California is the primary producer of vine ripe tomatoes in the United States, while Florida is the primary producer of mature green tomatoes. The mature green tomato is still the primary U.S. fresh field tomato product. In recent years, however, vine ripe tomatoes have been putting market pressure on the mature green tomato industry. Mature green tomatoes require less labor in harvesting and handling and have a longer shelf life, which is preferred by many large-scale commercial producers. Conversely, vine ripe tomatoes require more labor and have a shorter shelf life, which makes their production and marketing more costly and risky.

Labor shortages and high labor costs make production of vine ripe tomatoes in the U.S. less competitive. Additionally, the marketing of a large volume of vine ripe tomatoes in a shorter marketing window is more demanding and risky. The combination of labor availability, cost, and marketing issues makes vine ripe tomatoes less attractive to large operations in the U.S. In Florida, which has been the primary source of mature green tomatoes, the industry has invested a large amount of capital in packing and repacking facilities for mature green tomatoes. This large sunk investment in fixed assets has made it even more difficult to switch to vine ripe tomatoes. Currently, the U.S. retail sector is increasingly dominated by vine ripe tomatoes from Mexico. In the past, mature green tomatoes were marketed to both retail and food service sectors. Since consumers in retail stores are increasingly drawn to vine ripe tomatoes, mature green tomatoes have lost much of their market share in the retail sector and have retreated to the restaurant and food service sectors.

However, there is evidence that the food service sector might also move toward vine ripe tomatoes. Recently, the restaurant chain Wendy's announced that soon they will be sourcing only vine ripe greenhouse tomatoes for its U.S. and Canada locations (Nickle, 2018). If more clients in the food service sector follow suit, this could pose a serious challenge for Florida producers who are growing and marketing mostly mature green tomatoes. Despite the potential damage this could have on the Florida industry, it could also provide an opportunity. This change in direction could become a critical force driving Florida growers to finally embrace consumer preferences and the fresh tomato market's trend, thus becoming a turning point for the Florida tomato industry which has been declining for decades.

DIFFERENTIATION: BREEDING, BRANDING, AND LICENSING

Most produce commodities are considered generic commodities. In the fresh tomato market, tomatoes are differentiated in several ways. For example, vine ripe and mature green tomatoes discussed above are one of the major differentiations made in the market. In addition, tomatoes are also differentiated by shape (e.g., round versus roma tomatoes) and size (e.g., cherry tomatoes). However, within each type of tomato, products are often considered generic, and competition is mainly dependent upon the market price. Nevertheless, studies show that taste and flavor are critical attributes that influence consumer choices. For example, the Tasti-Lee tomatoes developed by University of Florida researchers received a high rating in taste and flavor, and consumers were willing to pay more for them. This suggests that breeding is critical in the development of differentiated products that could compete effectively in the market.

Branding and labeling will further help convey the message of superior quality or unique attributes of products, thus differentiating them from competitors' products. Breeding, branding, and labeling will not necessarily guarantee a competitive edge unless competitors are unable to access the superior varieties developed. This requires that appropriate licensing strategies be in place. For example, the Florida strawberry industry has used a limited licensing strategy for a variety (Florida Radiance) widely grown in Florida. This strategy only allows a small number of selected growers/companies in Mexico to grow Florida Radiance. This practice motivates the selected licensees to monitor/police the market to avoid unauthorized use of the new variety, while also ensuring that the level of competition from licensed production will not damage the Florida strawberry industry.

R&D AND THE FARM BILL

The mechanical harvest technology and breeding discussed above may require a large amount of investment in R&D, which is usually beyond the capacity of individual growers, whether in the amount of investment or in R&D capability. As a result, the industry relies heavily on public research for technology development. Public research funding, especially federal funding, is mainly governed by the Farm Bill, which allocates agricultural research funding every five years. For the specialty crop industry, the Specialty Crop Research Initiative (SCRI) and the Specialty Crop Block Grant Program (SCBGP) are instrumental in research and extension of new technologies. The industry should work closely with legislators on the 2018 Farm Bill to secure funding support for public (or public-private partnership) R&D activities. Given the labor-intensive nature of the specialty crop industry and importance of labor costs in the total production budget, a special SCRI program dedicated to the development of mechanical harvest technology or, more generally, labor saving technologies (or production systems) would be of paramount importance to the sustainability of the tomato industry. The current Farm Bill set aside $125 million under the SCRI for the Citrus Disease Research and Extension (CDRE) program, mainly aimed at identifying solutions to citrus greening which is decimating much of the U.S. citrus industry. Unlike the CDRE program, a mechanical harvest or a similar program would help create a level playing field for domestic fresh tomatoes by lowering the cost of production. Such a program would cover all specialty crops, giving it more legitimacy than a program targeting an individual crop and thus appealing to all major fresh produce commodity groups.

CONCLUSION

Competition from Mexico has been a major challenge for the Florida tomato industry. Elimination of tariff and non-tariff barriers to trade under NAFTA, Mexican government support, lower production costs, and favorable exchange rates have made Mexican tomatoes more competitive than Florida's. The current U.S. administration is renegotiating NAFTA. Whether this NAFTA renegotiation ends up with favorable terms for the Florida specialty crop industry or not, the industry should be prepared to make major efforts in several areas to improve the viability of the industry. These areas include new suspension agreements with lower enforcement costs, adoption of the H-2A or a reformed guest worker program, mechanization, broadening the product mix to include vine ripe tomatoes targeting both food service and retail sectors, product differentiation through breeding, branding and licensing, and securing more R&D funding support through the Farm Bill.

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Competitive Potential of B and Q Biotypes of *Bemisia tabaci* on Florida 91 Tomato

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The silverleaf whitefly is presently considered one member of a group of morphologically indistinguishable whitefly species. Its scientific name is *Bemisia tabaci* MEAM1, and it is commonly referred to as the B biotype of *Bemisia tabaci*. In the late 1980s the silverleaf whitefly became established in Florida, where it quickly displaced the A biotype, which had rarely caused significant problems in vegetables. The silverleaf whitefly transmits >150 viruses, including *Tomato yellow leaf curl virus*, and causes irregular ripening, a plant disorder associated with feeding by whitefly nymphs. Management of silverleaf whitefly requires planting virus free tomato transplants, using repellant metalized mulches, deploying TYLCV-tolerant varieties when appropriate, and intensive insecticide use. Prompt destruction of harvested tomato fields is important to reduce viral inoculum. Insecticides with many distinct modes of action are available for management of silverleaf whitefly, including systemic insecticides in the neonicotinoid, butenolide and diamide groups. Insecticides that reduce the viability of whitefly eggs and kill nymphs include growth regulators (buprofezin, pyriproxyfen) and lipid biosynthesis inhibitors (spirotetramat). Pymetrozine, flonicamid and the soon-to-be-registered pyrifluquinazon interfere with feeding by whiteflies. Broad spectrum insecticides in the pyrethroid and organophosphate groups may also play a useful role in whitefly insecticide rotations. When planning insecticide rotations to manage whiteflies, it is important to use the "treatment window" approach. The objective of this approach is to avoid applying the same modes of action to successive generations of whiteflies. About three weeks are required for whitefly eggs to reach the adult stage under typical Florida field conditions, and adult life span is estimated at two weeks. Many factors, including host plant and weather, can influence whitefly development time and survival. As a rule of thumb, five weeks can be used to define a whitefly generation. Therefore modes of action applied during the first five weeks after planting should not be applied during weeks six through ten.

Bemisia tabaci MED, also known as the Q biotype, is similar to the silverleaf whitefly, although it does not cause irregular ripening of tomato. Both biotypes are characterized by the tendency to develop high levels of resistance to insecticides. Resistance levels among populations of the Q biotype have been recorded that are orders of magnitude greater than resistance levels in some silverleaf whitefly populations. Some populations of the Q biotype have demonstrated the ability to retain resistance even after many generations without exposure to the insecticide. In other countries, notably China and Israel, the Q biotype displaced the silverleaf whitefly as the dominant whitefly in certain field crops when insecticide resistance management guidelines were not followed.

The Q biotype has been detected in Florida on potted plants in the nursery section of large box stores since surveys started in 2005. In the spring of 2016, the Q biotype was found infesting landscape plants in residential areas in Florida. Because of the experience of the Q biotype displacing the silverleaf whitefly in other countries, the concern has arisen that the Q biotype might displace the silverleaf whitefly in Florida, just as the silverleaf whitefly displaced the less harmful A biotype whitefly. The likelihood that the Q biotype will displace the silverleaf whitefly is determined in part by the inherent competitive potential of each whitefly type on a given crop. There is evidence that the silverleaf whitefly can out compete the Q biotype on certain host plants, and that the Q biotype can out compete the silverleaf whitefly on other host species.

METHODS

To evaluate the competitive potential of the silverleaf whitefly versus the Q biotype on tomato, competition studies were carried out in growth rooms at the UF/IFAS Gulf Coast Research and Education Center, Balm, Florida. Thirty-six Florida-91 tomatoes were grown in an insect-free growth room and transferred to one-gallon pots when they had five to seven true leaves. Plants were placed individually in organdi cages in one of two growth rooms that were used for the study. At the initiation of the study, twelve plants were inoculated with six male and six female silverleaf whitefly, twelve plants were inoculated with six males and six females of the Q biotype, and twelve plants were inoculated with six males and six females of each whitefly type. Plants were watered and fertilized during the course of the study, and tomato plants were clipped to a bamboo stake for support as they grew. Temperature in the growth rooms was maintained at 80 degrees F with a few degrees fluctuation around that average over a 24-hour period. At 30, 45, and 70 days post inoculation, four cages from each treatment were placed in a 39-degree F walk-in cooler at GCREC to immobilize the adult whiteflies. All the whitefly adults from each cage were collected using an electronic aspirator. Adults were stored at -20 degrees F until they could be counted, sexed and biotyped using the methods described by Shatters et al. (2009). The three sampling dates correspond roughly to the first, second and third generations of whiteflies developing from the initial introduction of six males and six females.

RESULTS

Figure 1 represents the results from the cages receiving both B and Q adults. There was a 200-fold increase in the number of B biotype (silverleaf) whiteflies over 70 days and a 15-fold increase in the number of Q biotype whiteflies over 70 days when plants were initially inoculated with six males and six females of each biotype. It is noteworthy that there was a 60-fold increase in the number of male B biotype whiteflies over 70 days, while the number of male Q biotype whiteflies increased by only three-fold over 70 days. Studies have demonstrated that male B biotype whiteflies are better able than Q to find females of their own biotype in mixed populations, resulting in higher reproductive success for B over Q. The Q biotype population increased over time, but its relative proportion of the overall whitefly population decreased from 50% at inoculation (six males and six females of each biotype) to seven percent of the population after 70 days. These results suggest that over time the silverleaf whitefly will predominate over the Q biotype on tomato (at least this variety of tomato). The Q biotype has become a problem in field crops in other countries when overuse of certain modes of action resulted in highly resistant populations that were then able to outcompete less resistant B biotype whitefly populations. The natural predominance of the silverleaf whitefly over the Q biotype on Florida tomato may be maintained if growers continue to practice good insecticide resistance management, confining modes of action to treatment windows and relying as much as is practical on biopesticides that do not contribute to the development of resistance. These include insecticidal soaps and microbial insecticides such as *Beauvaria bassiana* products. Since higher temperatures are believed to favor the Q biotype whitefly, the study is being repeated under extremes of temperature representative of field production of tomato in Florida.

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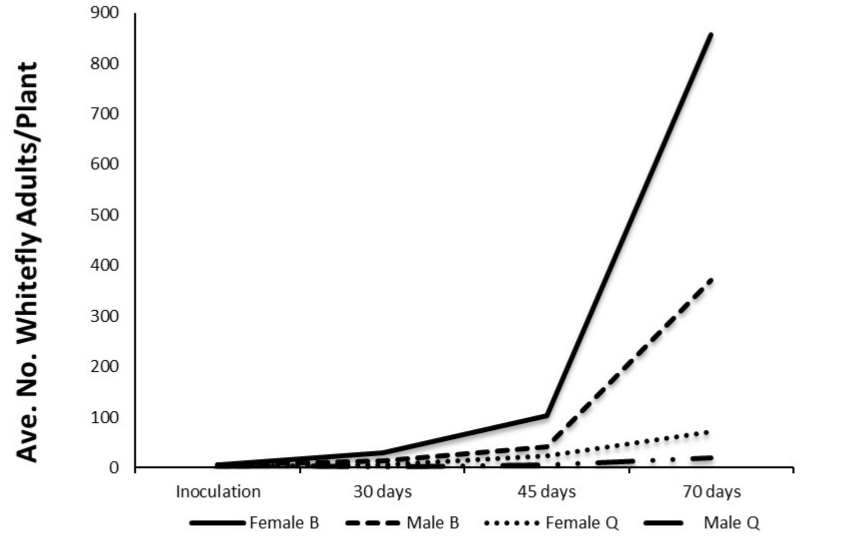

Figure 1. The average number of male and female B (silverleaf) and Q biotype Bemisia tabaci per plant collected from plants 30, 45, and 70 days after inoculation with six male and six female B and Q biotype whiteflies. This study was carried out using caged plants in growth rooms at the UF/IFAS Gulf Coast Research and Education Center, Balm, Florida, at an average temperature of 80 degrees F.

Prediction and Possible Remedy in Managing Thrips (Thysanoptera: Thripidae) and MEAM1 Whitefly (Hemiptera: Aleyrodidae) in Tomato

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INTRODUCTION

Florida leads in the production of fresh market tomatoes in the United States, valued at $437 million in 2014, harvested from 33,000 acres (Vegetable annual summery). Tomato is a high value crop with average production cost of $4.5 – $6.0 thousand per acre depending on the grower and production area where the cost of insecticide for controlling insect pests runs from $500-$700 (per acre). This amount may double up in the instance of virus infection when growers apply effective insecticides as a rescue operation. Tomato crop faces arthropod pest problems across the season starting from planting to harvest. Among the pests, whitefly, thrips, beet armyworm, fruit worm, leafminer, aphids, mites, cucumber beetle, and cutworm are common concern varying in time and growth stages of tomato plants (Webb et al. 2001).

MEAM1 whitefly is a polyphagous, feeds on almost 600 species of plants (Brown et al. 1995, De Barro et al. 2011) and transmits over 100 plant viruses (Hogenhout et al. 2008 and Navas-Castillo et al. 2011). With the increase of biotypes, already 20 known, host species number may exceed far above 900. Serious yield losses frequently occur because of adult and nymphal feeding, and disease agents transmitted by the whiteflies frequently lead to major crop losses throughout the world (Duffus 1987). MEAM1 whitefly is the only known vector of Tomato yellow leaf curl virus (TYLCV) limiting the production of tomatoes in Florida. TYLCV is a member of the genus Begomovirus in the family Geminiviridae, transmitting in a persistent circulative manner (Brown et al. 1995). Whitefly can acquire the virus both in adult and nymphal stages and can transmit the virus throughout its life (Cohen and Nitzhany 1966, Jones 2003). Whitefly transmitted TYLCV has been identified in Florida in 1997 after the establishment of the species in late 1980s (Polston et al. 1999).

Thrips as a group is another important concern to Florida agriculture. Thrips (Thysanoptera) are small, slender and fringed wing insects with characteristic one complete left mandible. Most of the thrips species are invasive, opportunistic and phytophagous on wide array of hosts (Marullo and De Grazia 2013). Globally, the thrips are important agricultural pest because of their larval and adult feeding, oviposition and transmitting plant pathogens (Riley et al. 2011). Among 20 common thrips species in Florida, eight species have been identified as tospovirus vectors (Rotenberg et al 2015). Western flower thrips (*Frankliniella occidentalis*) and common blossom thrips (*F. schulzei*) are two known vectors of tospoviruses like *Tomato chlorotic spot virus* (TCSV) and *Groundnut ring spot virus* (GRSV) in south Florida (Funderburk et al. 2011). These viruses were identified in tomato in 2012 (London et al. 2012, Zhang et al. 2015). Tospoviruses are the members of the family Bunyaviridae, transmitted in a persistent propagative manner (Ullman et al. 1997 and Ullman et al. 2002). Only early larval instar can acquire the virus from infected plants and the developed adults can transmit it throughout lifetime (Moritz et al 2004, Whitefield et al. 2005, Persley et al. 2006). Melon thrips (*Thrips palmi*), common blossom thrips and western flower thrips are most common in tomato and other vegetable fields in Florida.

Epidemiology of emerging viruses in any agroecosystem comprises the diversity of wild plants hosts, cultivated crops and insect complex (Duffus 1971). The wild plants and cultivated crops can be the reservoir of the virus or virus vectors. TYLCV has been detected in cultivated crops like beans and pepper (Cohen and Antignus 1994, Polston et al. 2006) as well as in weeds like *Amaranthus retroflexus* in Florida (Smith et al. 2015), *Cynanchum acutum* L. and *Malva parviflora* L. (Cohen et al. 1988) in Israel. TCSV was identified in tomato in south Florida (Londono et al. 2012); in tomato, pepper, jimsonweed (*Datura stramonium*) and lettuce (*Lactuca sativa*) in Puerto Rico (de Jensen et al. 2014); in celery, lettuce, potato, sweet potato, tomato, *Amaranthus* sp., *Datura ferox*, *Coronopus didymus* and purselane (*Portulaca oleracea*) in Argentina (Gracia et al. 1999).

Routine use of various classes of chemical insecticides are the principal tool to manage the above mentioned pests and their transmitted pathogens in commercial tomato fields. Whitefly has been documented to show resistance to imidacloprid, thiamethoxam and other neonicotinoid insecticides in southeastern USA and Florida (Prabhaker et al. 2005, Schuster et al. 2010, Caballero et al. 2013). Thrips resistance to routinely used insecticides are also common (Jensen 2000, Seal et al. 2012).

In the present study, efforts were made to determine various hosts of two important tomato pests, thrips and MEAM1 whitefly. Once presence of pests is detected on alternative host(s), growers can plant tomato in a manner to avoid abundance of pest population. Most importantly, growers can use appropriate cultural practices and effective insecticides at low population levels to manage pest problems and incidence of viral diseases. Therefore, the objectives of this study are to: i. find various vegetable hosts of thrips and MEAM1 whitefly, and seasonal population pattern of thrips and whitefly on those hosts; ii. Determine weed and ornamental hosts of thrips near tomato fields; and iii. Determine effectiveness of various insecticides.

MATERIALS A ND METHODS

Vegetable hosts. Commonly grown vegetable crops in south Florida include tomato, pepper, squash, eggplant and beans. For determining thrips and whitefly population abundance on these crops, four vegetable growing locations in Miami-Dade County were selected. From each location, one field of each crop was chosen within a one mile diameter of a selected tomato field. However, the nearest field to the tomato field was preferred. From each field ten full grown leaves of each crop were randomly selected and checked visually for whitefly adults. A similar number of leaves was collected and placed in a quart cup with tight-fit lead to record various thrips and their abundance. The leaf samples were washed with 70% alcohol to separate thrips. Number and species of thrips in each sample were recorded by using a binocular microscope at 10X magnification. Thrips were separated into species using various morphological characters. This study was conducted during the growing season from October to June each year for three years.

Weed hosts. In each of four locations, one tomato field was selected for this study. The field with the highest abundance of weed species at least on one side was selected for this study. The side of the field with high abundance of weeds was then divided into four equal sections. From each section, 2 ounces of each species of weed were collected and placed in a quart plastic cup marked with date and location. From the top of each weed plant, a 5-10 cm long section containing flowers and leaves was incised and placed in the cup. Samples were then processed for thrips following above mentioned method. Samples were collected once a week from each location. For the present study, thrips data from all fields were combined together by weed species. The average number of thrips on each weed species was rounded for presenting in the table.

Ornamental hosts. Flower samples were collected from a 100 acre commercial ornamental nursery located at Homestead, FL. Ornamental plants are grown in small blocks of 20 x 30 feet. Crops are maintained using standard commercial practices. Insect pests are managed by using biological control program. Insecticides are used one/two times a month. Ornamental species to sample for the present study were selected based on the scout records. We sampled 23 species of ornamental plants by collecting randomly selected 10 flowers from each species, four times at weekly intervals. Sampled flowers were placed in a quart plastic cup and marked with date and species. Samples were transported to the laboratory where separation and identification of thrips were performed using the above mentioned procedures.

Evaluation of insecticides. Two studies were conducted to evaluate the efficacy of insecticides in controlling g thrips and silverleaf whitefly. Treatments evaluated in the first study included: i. Verimark at 13.5 oz at planting; ii. Verimark at 13.5 oz as tray drench 7 day before planting; iii. Imidacloprid at 10.5 oz at plant as a soil drench; and iv. A nontreated check. `BHN 585' tomato seedlings were planted on 10 March 2014. Seedlings were placed 18 inches apart within rows and 36 inches apart in between rows. Plants were drip irrigated and fertigated with 4-0-8. Each treatment plot consisted of a 40 ft long two beds and was arranged in a randomized complete block design with four replications. A 5 ft wide nonplanted area separated blocks from each other. Treatments were applied on specific dates after planting as described in the treatment list. Methods of applying insecticide treatments were soil drench at planting or tray drench 7 d before planting.

Treatments were evaluated weekly by counting all infected tomato plants in a treatment plot with Groundnut Ring Spot Virus and Tomato Yellow Leaf Curl virus like symptoms. Each week's count represents a cumulative number of all infected plants. Efficacy of treatments for controlling flower thrips was evaluated by randomly collected 10 leaves, one leaf/plant, from each treatment plot. Leaf samples were processed for thrips using above mentioned methods. Efficacy of treatments in controlling silverleaf whitefly was studied by counting adults on randomly selected 10 leaves, one leaf/plant, in each treatment plot.

In the second study, treatments evaluated are shown in Table 7. Foliar application of insecticides was made on two dates- 18 Oct.

and 15 Nov. 2017 using a backpack sprayer with two nozzles at 30 psi delivering 50-70 gallons per acre depending on the plant growth stage. No symptoms of phytotoxicity were observed on tomato foliage due to the application of any of the treatments. Evaluation of treatments for the efficacy in controlling SLW adults was conducted 7, 14, 21 and 28 days after each application. In the case of eggs and nymphs, evaluation was made 7, 14 and 21 and 28 days after the first application, and 7 and 14 days after the second application. On each sampling date, SLW adults were recorded by gently turning randomly selected five mature leaves, one leaf/plant, in each treatment plot. For evaluating effect of treatments on SLW eggs and nymphs, five randomly selected leaves, one leaf/plant, per treatment plot were collected and placed in a plastic bag which was marked with plot, block and treatment. All samples were transported to the Vegetable IPM laboratory, TREC and checked thoroughly using a binocular microscope at 10X magnification for recording eggs and nymphs.

RESULTS AND DISCUSSION

Vegetable crops. Melon thrips, common blossom thrips (CBT) and western flower thrips (WFT) were recorded on all vegetable crops during the growing season starting from October to April (Fig. 1). Melon thrips population abundance was higher on every crop on each month of data collection than CBT and WFT. CBT and WFT population abundance was low, although recorded each month. CBT and WFT population abundance was higher in bean, tomato and pepper than squash and eggplant. CBT and WFT were almost absent on okra. Bean and pepper have been recorded as a host of tomato chlorotic spot virus (McGrath 2016).

MEAM1 whitefly was present on all crops during this study (Fig. 2). Bean, squash and eggplant had the higher number of whitefly than pepper, tomato and okra. Okra is grown all the year round. Although the number of MEAM1 is few in okra in different months of this study, okra serves as a source of an off-season breeding host for MEAM1.

Weed hosts. We collected 21 species of weeds (Table 2). WFT was recorded on nine species of weeds with the highest number in Brazilian jasmine (20) followed by purslane (20). Melon thrips number was higher than WFT and CBT when all weed species are considered. Highest numbers of melon thrips was recorded on Spanish needles (289) followed by tropical amaranth (66) and spiny amaranth. Highest number of larvae was recorded on Spanish needle (182) followed by spiny amaranth (43), cheesytoes (38), tropical amaranth (28), milkweed (28), and purslane (26). Both adults and larvae were found in some weeds in this study can be considered as the reproductive host of thrips.

Ornamental plants. Commonly occurring 23 ornamental plants were sampled for thrips (Table 1). WFT population abundance was higher than melon thrips and CBT. Highest number of WFT was observed on China rose (90) followed by Treasure flower (70), Arizona Sandstone (49), and Purslane (42). Highest number of melon thrips was recoded on China rose followed by Treasure flower. CBT was absent in most ornamental plants. Larvae (immature stages of thrips) were recorded on almost all plants except in Egyptian starcluster and Begonia. Highest number of thrips larvae was recorded in Arizona Sandstone (351) followed by China rose (117) where WFT adults were in high number. This indicates high reproductive activity of WFT in these two ornamental plants. Purselane had the third highest number of larvae (44) where we recorded fourth highest number of adults. Purselane is also recorded as a host of tomato chlorotic spot virus.

EVALUATION OF INSECTICIDES

First study. Both treatments of Verimark consistently reduced TCSV incidence on the first seven weekly sampling dates for 49 days (Table 3). After 49 days the performance of Verimark treatments became inconsistent. Admire did not reduce GRSV incidence in tomato plants in the present study.

Both Verimark treatments and Admire significantly suppressed TYLCV incidence in tomatoes for eight weeks with a few exceptions on first and sixth sampling dates (Table 4). Verimark tray treatment provided better suppression of TYLCV than the at-plant drench treatment although the difference was not statistically significant.

Flower thrips adult abundance was very low in the leaf samples (Table 5). Mean numbers of flower thrips adults in the insecticide treated leaf-samples did not differ from the nontreated control.

Silverleaf whitefly population abundance was medium to high during this study (Table 6). Insecticide treatments inconsistently reduced silverleaf whitefly population.

In the second study, insecticide treatments did not reduce MEAM1 whitefly adults, with a few exceptions, in this study when compared with the nontreated control (Table 8). Mean numbers of SLW eggs across all sampling dates were significantly fewer on all treated leaves than the nontreated control (Table 9). As in the instance of MEAM1 eggs, mean numbers of nymphs across the sampling dates were significantly fewer on all treated leaves than the nontreated control (Table 10). Movento and Assail consistently provided significant reduction of nymphs as compared to nontreated control.

Melon thrips, common blossom thrips, western flower thrips and MEAM1 whitefly are the most damaging pests of tomato in South Florida. All of them cause damage by feeding and transmitting viral diseases. They maintain their populations on multiple alternate hosts when tomato season is over. Their abundance and virus transmission on tomato crop can be predicted from the presence of these hosts in or near the tomato growing area. Weeds, ornamental plants and vegetable crops shown in the tables are the preferable hosts of thrips and whiteflies. Tomato growers should pay attention to these hosts while planting tomato in a location. Effective cultural practices can be used to reduce thrips and whiteflies migrating from these hosts to tomato crops. In the instance when population of thrips and MEAM1 white fly increase above threshold level, above mentioned chemical can be used to manage these pests.

Specifically, prediction will be based on:

a. Vegetable crop hosts near tomato growing area may enhance infestation in tomato fields. Be aware of the population abundance of thrips and MEAM1 whitefly. If thrips and whitefly populations exist there, the nearby tomato plants will be infested.

b. Ornamental nursery contains host plants of thrips and MEAM1 whitefly. Tomato should be planted creating barrier, distance and non-host plants, to restrict thrips and whitefly migration to tomato fields.

c. Weeds are the important source of viruses (TCSV and TYLCV) and vectors (thrips and whitefly), and grow in or around tomato fields. Cultural practices like sanitation (e.g. cleaning weeds) before planting and growing tomatoes can be helpful for sustainable management of pests and their transmitted pathogens.

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Table 1. Number of various thrips species on different ornamental plants grown inside commercial greenhouses

Name of ornamental plants	Common name of ornamental plants	No. of thrips found			
		WFT	CBT	MT	Larva
Torenia sp.	Wishbone flowers	15	0	9	10
Hibiscus sp.	China rose	90	0	33	117
Fuchsia sp.	Fuchsia	14	0	9	4
Ericameria arborescens	Golden Fleece	0	2	0	5
Petinia sp.	Petunia	8	0	5	3
Cosmos sp.	Cosmos	23	0	6	6
Tagetes sp.	Marigold	11	0	0	13
Pentas lanceolata	Egyptian starcluster	0	0	3	0
Gerbera sp.	Gerbera Daisy	5	0	4	17
Portulaca oleracea	Purslane	42	2	2	44
Gazania linearis	Treasure flower	70	2	23	10
Lantana camara	Lantana	3	0	3	10
Impatiens walleriana	busy Lizzie	5	2	0	13
Begonia semperflorens	Begonia	5	0	3	0
Kalanchoe blossfeldiana	Kalanchoe	8	0	0	3
Lilium matrix	Lilium	39	0	5	5
Helianthus annuus	Sunflower	18	0	0	12
Catharanthus roseus	Rose periwinkle	0	0	0	2
Canna spp.	Cannatropical	13	0	0	14
Celosia argentea	Plumed cockscomb	22	0	5	8
Plumbago auriculata	Blue plumbago,	28	7	2	13
Agastache sp.	Arizona Sandstone	49	2	0	351
Mandevilla sp.	Rocktrumpet	15	5	0	30

Table 2. Number of various thrips species on different weed host near a tomato field.

Name of the weed species	Common name of weed	No. of thrips found			
		WFT	CBT	MT	Larva
Chenopodium album	Pigweed	0	2	23	7
Euphorbia heterophylla	Wild poinsettia	0	0	2	3
Ipomea hederopholia	Scarlet morning glory	0	0	0	0
Parthenium hysterophorus	Santa-Maria	0	3	0	5
Bidens alba	Spanish needles	0	2	289	182
Phylla nodiflora	Frog fruit/sawtooth fogfruit	0	0	0	0
Euphorbia hirta	Milkweed	0	2	10	28
Chamaesyce hyssopifolia	Hyssopleaf sandmat	0	0	12	17
Amaranthus polygonoides	Tropical amaranth	0	1	66	28
Amaranthus spinosus	Spiny amaranth	0	0	35	43
Acalypha alepecurodea	Foxtail copperleaf	0	0	0	0
Lantana camara	Wild-sage/red-sage	0	0	5	5
Macroptilium lathyroides	Phasey bean/wild bushbean	0	1	0	0
Portulaca oleracea	Purslane	0	11	4	26
Sida ulmifolia	Common wireweed	0	0	0	0
Sida spinosa	Prickly fanpetals	0	0	0	0
Jasminum fluminense	Brazilian jasmine	0	20	3	5
Phyllanthus amarus	Bahupatra (Sanskrit)	0	0	0	8
Stylosanthes hamata	Cheesytoes	0	1	12	38
Spermacoce verticillata	Shrubby false buttonweed	0	2	0	4
Morinda royoc	Cheese shrub	0	0	0	0

Table 3. Cumulative mean numbers of TCSV symptom like infected tomato plants treated with Verimark and Admire

			Cumulative means of TCSV infected plants at different days after planting											
Treatments	**Rate [oz]/A**	**Timing**	**7**	**14**	**21**	**28**	**35**	**42**	**49**	**56**	**63**	**70**	**77**	**84**
Verimark	13.5	At plant	0.50	0b	0.50b	0b	2.00b	1.25b	3.25b	7.25a	10.75b	14.25a	21.25b	24.00bc
Verimark	13.5	Tray treatment	0.50	0b	0b	0.50b	0.75b	0.75b	2.25b	6.00a	10.75b	13.75a	16.25b	20.25c
Admire	10.5	At plant	0.50	1.25a	3.75a	7.00a	9.75a	17.76a	18.50a	25.25a	29.50a	29.50a	29.50a	29.50a
Control	-		0.65	0b	4.75a	7.00a	9.75a	14.50a	18.75a	26.75a	28.00a	13.75a	28.00a	28.00ab
			ns											

Means within a column followed by a same letter do not differ significantly (P > 0.05; DMRT)

Table 4. Cumulative mean numbers of TYLCV infected tomato plants treated with Verimark and Admire.

			Cumulative means of TYLCV plants at different days after planting											
Treatments	**Rate [oz]/A**	**Timing**	**7**	**14**	**21**	**28**	**35**	**42**	**49**	**56**	**63**	**70**	**77**	**84**
Verimark	13.5	At plant	0	0.50b	2.00ab	3.75b	5.00b	9.75	17.00ab	19.00b	22.25ab	22.75ab	24.25ab	24.25ab
Verimark	13.5	Tray treatment	0	0.25b	0.75bc	2.75bc	4.75b	13.00	14.50b	17.25b	21.00b	21.75b	22.25b	22.25b
Admire	10.5	At plant	0	0b	0.50c	2.50c	4.75b	10.00	17.50b	20.75b	22.50ab	23.75ab	24.00ab	24.00ab
Control	-		0.25	1.50a	3.00a	5.25a	7.50a	13.25	20.00a	25.75a	26.50a	26.50a	27.00a	27.00a
			ns					ns						

Means within a column followed by a same letter do not differ significantly (P > 0.05; DMRT)

Table 5. Mean numbers of flower thrips/10-leaf sample of tomato treated with Verimark and Admire.

			Mean numbers of flower thrips adults/10-leaf sample of tomato on different days after planting											
Treatments	**Rate [oz]/A**	**Timing**	**7**	**14**	**21**	**28**	**35**	**42**	**49**	**56**	**63**	**70**	**77**	**84**
Verimark	13.5	At plant	0	0	0.25	0.25	0.25	0.25	0	0	0	0.25	0	0
Verimark	13.5	Tray treatment	0	0	0.25	0	0.25	0	0	0.25	0	0	0.25	0
Admire	10.5	At plant	0	0.25	0.50	0.25	0.25	0.50	0.25	0.25	0.25	0	0.25	0
Control	-		0	0.50	0.50	0.50	0.25	0.50	0.25	0.25	0.25	0.25	0.50	0.25
			ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns

Means within a column followed by a same letter do not differ significantly (P > 0.05; DMRT)

Table 6. Mean numbers of SLW/tomato leaf on different DAP. Plants were treated with Verimark and Admire.

			Mean numbers of SLW adults/tomato leaf on different days after planting											
Treatments	**Rate [oz]/A**	**Timing**	**7**	**14**	**21**	**28**	**35**	**42**	**49**	**56**	**63**	**70**	**77**	**84**
Verimark	13.5	At plant	0b	0.25	0.25	0.50	0.50b	1.00b	1.0	2.00	2.00b	3.00	1.50	0.75
Verimark	13.5	Tray treatment	0b	0.25	0.50	0.50	0.25b	1.00b	1.0	2.00	2.00b	2.75	1.25	0.75
Admire	10.5	At plant	0b	0.25	0.50	0.75	1.00ab	2.25ab	2.00	2.00	2.75ab	3.00	2.33	0.50
Control	-		0.50a	1.0	1.25	1.75	2.00a	3.00a	2.50	3.00	4.25a	4.25	2.75	1.00
				ns	ns	ns			ns	ns		ns	ns	ns

Means within a column followed by a same letter do not differ significantly (P > 0.05; DMRT)

Table 7. Insecticide treatments and rate/acre of various insecticides applied in Study 2.

Treatment	Rate [oz]/acre
ADA67509 Pymetrozine + Acetamiprid	2.75 1.50
ADA67509 Pymetrozine + Acetamiprid	2.75 2.50
ADA67509 Pymetrozine + Acetamiprid	2.75 4.00
Fulfill Pymetrozine	2.75
Assail Acetamiprid	2.5
Movento Spirotetramat	5.0
Control	

Table 8. Mean number of SLW adults on tomatoes treated with ADA67509, fall 2017. Treatments were applied on two dates- 18 Oct. and 15 Nov. 2017.

		Mean number of SLW adults							
Treatment	Rate/acre	25 Oct	01 Nov	08 Nov	15 Nov	22 Nov	29 Nov	5 Dec	15 Dec
Fulfill ADA67509 Assail	2.75 oz 1.50 gm	0.00a	1.00a	4.25ab	8.00a	7.50a	1.75a	4.75ab	2.50a
Fulfill ADA67509 Assail	2.75 oz 2.50 gm	0.00a	0.75ab	3.25b	10.75a	5.00a	1.50a	2.75ab	0.75a
Fulfill ADA67509 Assail	2.75 oz 4.00 gm	0.00a	0.25ab	5.50ab	11.00a	4.75a	2.00a	2.50b	1.00a
Fulfill	2.75 oz	0.00a	0.25ab	5.25ab	7.00a	5.00a	0.75a	2.25b	1.50a
Assail	2.5 oz	0.00a	0.00b	5.50ab	9.75a	7.00a	1.75a	3.25ab	1.75a
Movento	5.0 oz	0.00	0.75ab	4.50ab	9.25a	4.75a	3.00a	3.75ab	1.75a
Control		0.25a	1.00a	9.75a	15.75a	5.00a	2.75a	6.00a	1.50a

Means within a column followed by a same letter or no letter do not differ statistically (P>0.05; DMRT)

Table 9. Mean number of SLW eggs on tomatoes treated with ADA67509, fall 2017. Treatments were applied on two dates- 18 Oct. and 15 Nov. 2017.

		Mean no of SLW eggs						
Treatment	Rate/acre	25 Oct	01 Nov	08 Nov	15 Nov	22 Nov	29 Nov	Average
Fulfill ADA67509 Assail	2.75 oz 1.50 gm	4.25bc	2.75ac	7.75a	11.75a	8.25a	3.75ab	6.42bc
Fulfill ADA67509 Assail	2.75 oz 2.50 gm	2.50bc	0.25c	2.25ab	4.75ab	4.00ab	5.50ab	3.21c
Fulfill ADA67509 Assail	2.75 oz 4.00 gm	3.50bc	1.50bc	2.25ab	3.00ab	4.00ab	2.75ab	2.83c
Fulfill	2.75 oz	10.00b	14.00a	8.50a	10.50a	6.00ab	4.50ab	8.92ab
Assail	2.5 oz	1.25c	5.25ac	3.50ab	8.25ab	5.75ab	5.75ab	4.96c
Movento	5.0 oz	1.50c	0.25c	0.00b	0.75b	0.75b	1.75b	0.83d
Control		24.25a	10.50ab	6.50a	6.75ab	5.50ab	8.75a	10.38a

Means within a column followed by a same letter or no letter do not differ statistically (P>0.05; DMRT)

Table 10. Mean number of SLW nymphs on tomatoes treated with ADA 67509, fall 2017. Treatments were applied on two dates- 18 Oct. and 15 Nov. 2017.

		Mean number of SLW nymphs						
Treatment	Rate/acre	25 Oct	01 Nov	08 Nov	15 Nov	22 Nov	29 Nov	Average
Fulfill ADA67509 Assail	2.75 oz 1.50 gm	1.25a	1.00ab	2.00a	3.50ab	2.00ab	3.25a	2.17bd
Fulfill ADA67509 Assail	2.75 oz 2.50 gm	0.50a	0.00b	0.00a	0.75b	6.25a	6.50a	2.33bd
Fulfill ADA67509 Assail	2.75 oz 4.00 gm	0.50a	0.75ab	3.00a	0.75b	0.75a	1.50a	0.92cd
Fulfill	2.75 oz	2.75a	0.50ab	0.75a	6.50a	1.75ab	10.50a	3.79ab
Assail	2.5 oz	1.00a	3.50a	0.00a	6.25a	3.75ab	3.25a	2.96bc
Movento	5.0 oz	1.75a	0.50ab	0.00a	0.00b	0.00c	0.50a	0.46d
Control		3.25a	3.75a	7.25a	10.50a	6.50a	7.50a	6.46a

Means within a column followed by a same letter or no letter do not differ statistically (P>0.05; DMRT)

Figure 1. Seasonal distribution pattern of three species of thrips in five common vegetable crops (Average of 2015, 2016 and 2017 data). Melon= Melon thrips; cbt = common blossom thrips; wf = western flower thrips.

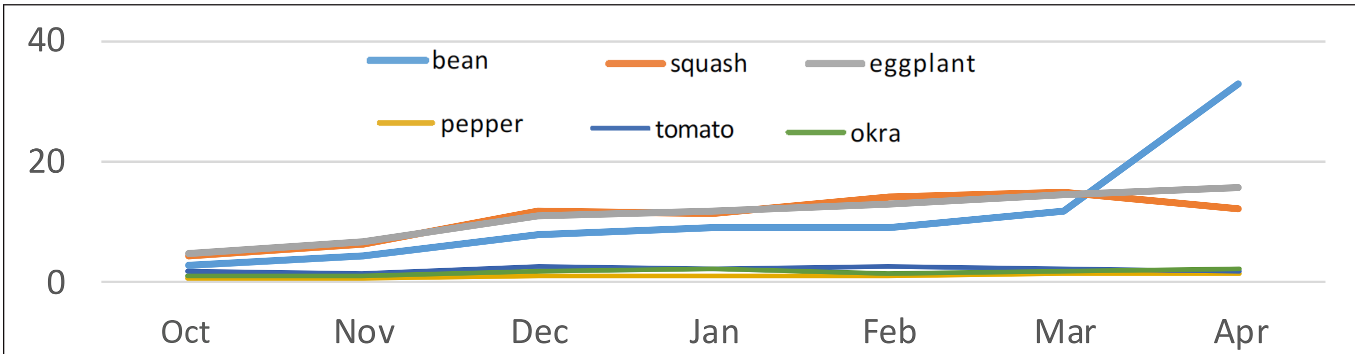

Figure 2. Seasonal distribution pattern of MEAM1 whitefly in six common vegetable crops (Average of 2015, 2016 and 2017 data).

Managing Bacterial Spot of Tomato by Application of Biofilm Formation-Inhibiting Compounds

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INTRODUCTION

Fresh market tomato is the most important vegetable crop in Florida with a total value of $453.1 million on 32,200 acres harvested in 2015,accounting for 38% of the fresh market tomato in the USA ($1.29 billion)(Paret, 2013). Bacterial spot of tomato, incited by four *Xanthomonas* species in which *X. perforans* is the current major species in Florida, is one of major diseases in tomato production in Florida. Because of insufficient disease management strategies, managing this disease primarily relies on application of copper bactericides.

Infection of tomato seedlings with *X. perforans* can be destructive and can result in total crop loss. Infection of enlarging fruit reduces fruit quality and may make them unmarketable (Kucharek, 2000). When favorable weather conditions persist and pathogens are present, repeated chemical application is necessary to protect the plants, but very costly to the growers. In Miami-Dade County of south Florida, due to the conducive weather in the growing season, control by copper bactericides is often marginal due to widespread resistance to copper in the pathogen populations (Pernezny et al., 2008). Strategies for growers to control this disease are very limited (Paret, 2013). Although Agri-Mycin, containing streptomycin sulfate, was highly effective against bacterial spot and bacterial speck in our field trial in the 2016-2017 season (Zhang et al., 2017), the potential in the pathogen to develop resistance is high (Paret, 2013). One alternative approach is using systemic acquired resistance (SAR) to the pathogens through application of the SAR inducers, such as acibenzolar-S-methyl (Actigard). Actigard has showed significant effects on reducing the bacterial disease in our field trials, however, it can adversely affect the plant growth, and even fruit yield, if not applied properly (Kunmar et al., 2017; Zhang et al., 2017). Continuing efforts are necessary for providing more approaches for effectively managing the important bacterial disease for the tomato industry.

N-acetyl-L-cysteine (NAC) is the derivative of the amino acid L-cysteine, and a precursor of the antioxidant glutathione in the animal and human body (Samuni et al., 2013). NAC has bactericidal properties and breaks down bacterial biofilms of many clinically important pathogens (Dinicola et al, 2014; Pérez-Giraldo et al., 1997; Zhao and Liu, 2010). In medical studies, it has been reported that NAC is a safe and effective medicine for the treatment of many diseases that are mediated by free radical damage, and is used therapeutically in disorders related to oxidative stress (Cotgreave, 1996). Besides NAC, many other compounds have been found effective inhibiting biofilm formation of various medical bacteria (Chen et al., 2013; Rabin et al., 2015) and a few against the plant pathogenic bacteria (Li and Wang, 2014).

In our preliminary study, NAC was found effective against *X. perforans* and it significantly reduced bacterial spot disease on tomato in the greenhouse. *In vitro* studies indicated that NAC inhibited formation of biofilm by *X. perforans* (Zhang, unpublished data). We are not aware of any previous studies on using NAC for control of plant diseases including those caused by pathogenic plant pathogens. In this study, we have evaluated the effect of several biofilm formation-inhibiting compounds for control of bacterial leaf spot in tomato under greenhouse conditions.

MATERIALS AND MET HODS

Compounds and solution preparation. Seven biofilm formation-inhibiting compounds, including carvacrol, diphenyl disulfide, D-leucine, 3-Indoleacetonitrile (IAN), N-acetyl-L-cysteine (NAC), norspermidine, and tannic acid, were selected based on previous studies (Li and Wang, 2014; Rabin et al., 2015). All compounds were purchased from Sigma-Aldrich (St. Louis, MO). Stocks of carvacrol (0.05 M), diphenyl disulfide (0.1 M), and IAN (100 mg/ml) were prepared by dissolving with 95% ethanol, 95% ethanol, and DMSO, respectively. Stocks of other four compounds were prepared with sterile distilled water. The pH was adjusted to 7.0 for the stock solutions of NAC and tannic acid (Dusane et al., 2015.). All stock solutions were stored at 4 °C prior to use.

Pathogen preparation, plant inoculation, and disease evaluation. A *X. perforans* strain QL1, sensitive to copper that was isolated from symptomatic tomato plants collected at Homestead, FL, and a copper tolerant strain TB15 of *X. perforans* provided by Jeffrey Jones were used in this study. Original cultures were maintained at -80°C. For each strain, a concentrated bacterial suspension prepared with cells grown on nutrient agar (NA) plate for 24 h at 28°C was maintained at -20°C and was used for inoculum preparation.

To prepare bacterial inoculum, 200 µl of concentrated suspension was spread on each NA plate. After 24 h incubation at 28°C, bacterial cells were washed off into sterile distilled water. The concentration was adjusted to optical density of 0.2 at 600 nm (about 1×10^8 CFU/ml) prior to inoculation.

The susceptible tomato cv. Florida 47 was used throughout the experiments. Tomato plants with three fully expanded compound leaflets (about two weeks after transplanting) were sprayed with the bacterial suspension (with or without selected compound) until runoff. Plants inoculated with bacterial alone were used as the untreated control. Except specified, the copper-sensitive strain QL1 was used to inoculate the plants. Five plants were inoculated as five replicates for each treatment. Inoculated plants were incubated in a moist chamber overnight inside a greenhouse with temperatures of 22-28 °C.

After incubation, plants of various treatments were placed randomly on the bench and maintained for disease development in the same greenhouse. When typical lesions of bacterial spot were fully developed on the untreated control plants, the three inoculated compound leaflets of each plant were selected for disease evaluation. Disease severity was rated as the percentage of leaf area with bacterial lesions for each compound leaflet of each plant. Analysis of variance (ANOVA) was conducted to separate means of different treatments using SAS PROC ANOVA (SAS version 9.4, Cary, NC).

Preliminary evaluations on the compounds. Concentrations of selected compounds were first determined based on previous studies (Li and Wang, 2014; Rabin et al., 2015), then modified after results were obtained from our preliminary tests for certain compounds. Test solution for each compound was either made from its stock or made with the compound right before test. Bacterial cells grown on NA plates overnight were collected and the concentration was determined with a spectrophotometer (United Products & Instruments Inc., NJ). Immediately before inoculating the tomato plants, bacterial cells were mixed with each test solution, in which the bacterial concentration was adjusted to OD_{600}=0.2 and the test solution was adjusted to its designated concentration. Plants were then sprayed with the mixture of bacteria and compounds as the way described above. Each compound was tested twice.

Timing of IAN application on bacterial leaf spot. A preliminary test on the timing of compound application in reducing disease severity of tomato bacterial leaf spot was conducted with carvacrol, IAN, NAC, and tannic acid. The compounds at minimum effective concentrations were foliar sprayed onto tomato plants until runoff at 3 days before and after inoculation. Only IAN at 1.0 mg/ml had significant effects on reducing disease severity when it was applied at both times. A formal test was then conducted by applying IAN at 1.0 mg/ml at 1 and 3 days before and 1 and 3 days after inoculation. Plants were inoculated as the way described previously with the bacteria only, except with one treatment that the plants were inoculated with a mixture of IAN and the bacteria. This experiment was conducted twice.

Effects of IAN on reducing copper usage in control of bacterial leaf spot. Solutions of IAN alone or mixtures of IAN and copper hydroxide (Kocide 3000, Certis USA, Columbia, MD) were used to treat tomato plants immediately before inoculation was made with the bacteria. Two bacterial strains, one copper-sensitive (QL1) and one copper-tolerant (TB15), were used in this experiment. IAN concentrations were tested at 0.5 and 1.0 mg/ml. Kocide concentrations were 0.5 and 1.0 mg/ml for the copper-sensitive strain, and 1.0 and 2.1 mg/ml (full label rate) for strain TB15. Prepared solutions of each treatment were foliar sprayed onto the plants until runoff. Immediately after the leaves were air-dried, plants were inoculated with the bacterial suspension at a concentration of 1×10^8 CFU/ml following the procedure described above. Plants inoculated but not treated with any chemicals were used as the untreated control. Each experiment was conducted twice.

RESULTS

Effectiveness of selected compounds on tomato bacterial leaf spot. In the preliminary study, five (carvacrol, D-leucine, IAN, NAC, and tannic acid) of the seven selected biofilm formation-inhibiting compounds consistently reduced the disease severity of bacterial leaf spot on tomato in two independent tests when they were applied together with the bacteria at specified concentrations compared with the untreated control (Table 1). Subsequently, these five compounds were further tested for their effectiveness in improving control of tomato bacterial leaf spot.

Timing of IAN application on bacterial leaf spot. Compared to the untreated control, IAN at 1.0 mg/ml significantly ($P<0.05$) reduced the disease severity in both tests when it was applied 1 day before inoculation, same day when it was mixed with the bacteria, 1 and 3 days after inoculation (Table 2). However, IAN significantly reduced the disease severity in one of the two tests when it was

Table 1. Summary of greenhouse trials testing selected compounds for control of bacterial spot on tomato

Compounds and concentration	Test 1[z]		Test 2[z]	
	control	treatment	control	treatment
Carvacrol @ 1.0 mM	37.9 a	0.6 b	44.7 a	2.6 b
Diphenyl disulfide @1.0 mM	28.0 a	8.4 b	44.7 a	41.8 a
D-Leucine @ 10 mM	60.8 a	42.5 b	55.3 a	35.0 b
IAN @ 1.0 mg/ml	44.7 a	23.6 b	60.5 a	36.0 b
NAC @ 10 mg/ml [y]	37.9 a	16.2 b	44.7 a	20.5 b
Norspermidine @ 0.3 mM	8.6 a	4.7 a	44.7 a	40.5 a
Tannic acid @ 1.0 mM [y]	60.5 a	34.6 b	78.0 a	42.0 b

[z] Means followed by the same letter for each test of the same compound were not significantly different at *P* = 0.05.
[y] pH values of test solutions were adjusted to 7.0 before used for test.

Table 2. Disease severity of bacterial spot on tomato plants when treated with 3-Indoleacetonitrile (IAN, 1.0 mg/ml) at different times from inoculation

Timing of treatment	Test 1[z]	Test 2[z]
Untreated Control	59.3 a	75.3 a
3 days before inoculation	63.3 a	58.0 b
1 day before inoculation	39.3 b	24.7 d
Same time as inoculation	5.1 c	12.7 e
1 day after inoculation	6.1 c	46.7 c
3 days after inoculation	36.7 b	63.3 b

[z] Means followed by the same letter in each column were not significantly different at P = 0.05.

Table 3. Effect of IAN and copper bactericide (Kocide 3000) on disease severity of bacterial spot on tomato plants when inoculated with a copper-sensitive strain QL1

Treatment	Test 1[z]	Test 2[z]
Untreated control	59.3 a	72.7 a
IAN-1 (@ 0.5 mg/ml)	48.0 bc	44.0 b
IAN-2 (@ 1.0 mg/ml)	33.3 de	40.7 bc
Kocide-1 (@ 0.5 mg/ml)	48.7 b	40.7 bc
Kocide-2 (@ 1.0 mg/ml)	38.3 cd	40.0 bc
IAN-1+Kocide-1	28.0 ef	36.7 bcd
IAN-1+Kocide-2	24.7 ef	38.0 bcd
IAN-2+Kocide-1	14.0 g	28.7 d
IAN-2+Kocide-2	19.0 fg	32.0 cd

[z] Means followed by the same letter in each column were not significantly different at P = 0.05.

Table 4. Effect of IAN and copper bactericide (Kocide 3000) on disease severity of bacterial spot on tomato plants when inoculated with a copper-tolerant strain TB15

Treatment	Test 1[z]	Test 2[z]
Untreated control	72.7 a	81.7 a
IAN-1 (@ 0.5 mg/ml)	72.0 a	58.3 b
IAN-2 (@ 1.0 mg/ml)	52.0 b	49.2 bc
Kocide-1 (@ 1.0 mg/ml)	46.0 b	52.5 bc
Kocide-2 (@ 2.1 mg/ml)	46.0 b	43.3 cd
IAN-1+Kocide-1	34.7 c	56.7 b
IAN-1+Kocide-2	17.0 d	39.2 d
IAN-2+Kocide-1	48.7 b	34.2 de
IAN-2+Kocide-2	32.0 c	27.5 e

[z] Means followed by the same letter in each column were not significantly different at P = 0.05.

applied 3 days before inoculation. Average disease reduction of the two tests was 50.5%, 87.5%, 63.9%, and 27.0% when IAN was applied at 1 day before inoculation, mixed with the bacteria for inoculation, 1 day and 3 days after inoculation, respectively.

Effects of IAN on reducing copper bactericide in control of bacterial leaf spot. For the copper-sensitive strain QL1, both IAN and Kocide 3000 significantly reduced the disease severity when they were applied alone at both concentrations in two tests compared to the untreated control (Table 3). The average disease reduction in the two tests was 29.3% and 43.9% for IAN at 0.5 and 1.0 mg/ml, respectively, and 31.0% and 40.2% for Kocide 3000 at 0.5 mg/ml and 1.0 mg/ml, respectively. All the mixtures of IAN and Kocide 3000 in test 1 significantly further reduced the disease severity than any one of them alone, whereas a similar trend was observed in test 2, but not significant. In test 1, increase of Kocide 3000 concentration did not significantly decrease the disease severity at each concentration of IAN. The average disease reduction was 55.6% and 72.2% when Kocide 3000 mixed with IAN at 0.5 mg/ml and 1.0 mg/ml, respectively.

For the copper-tolerant strain TB15, IAN at 0.5 mg/ml significantly reduced the disease severity by 28.8% in one of the two tests, compared to the untreated control (Table 4). IAN significantly reduced the disease severity in both tests at 1.0 mg/ml, and the average disease reduction was 34.2%. Kocide 3000 at both concentrations significantly reduced the disease severity in both tests. However, increase of Kocide 3000 concentration did not significantly decrease the disease severity in both tests. The average disease reduction was 36.2% and 41.9% for Kocide 3000 at 1.0 and 2.1 mg/ml, respectively. The mixtures of IAN and Kocide 3000 significantly further reduced the disease severity than any one of them alone in one of the tests. In test 1, disease reduction was 52.3% and 76.6% when Kocide 3000 was applied at 1.0 mg/ml and 2.1 mg/ml, respectively, with IAN concentration at 0.5 mg/ml. In test 2, disease reduction was 61.2% for the mixture of IAN at 1.0 mg/ml and Kocide 3000 at 2.1 mg/ml.

CONCLUSIONS

The compounds (carvacrol, D-leucine, IAN, NAC and tannic acid) at the tested concentrations in this study significantly ($P<0.05$) reduced the disease severity of bacterial leaf spot under greenhouse conditions, compared to the untreated control when the compounds were foliar applied the same time as the pathogen inoculation. In addition, disease severity was significantly decreased on IAN-treated plants when IAN (1.0 mg/ml) was applied 1 and 3 days before and after the pathogen inoculation. Importantly, application of IAN significantly improved the efficacy of Kocide 3000 in control of bacterial spot in tomato caused by both copper-sensitive and copper-tolerant strains of *X. perforans*, while reducing use of the copper bactericide Kocide 3000.

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Field Performance of Nano Magnesium Oxide, a New Antibacterial Compound Against Bacterial Spot of Tomato

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INTRODUCTION

Copper is the most widely and heavily used bactericide/fungicide worldwide on many agricultural crops due to its low cost and broad-spectrum activity on many pathogens. For example, in case of tomatoes in Florida, copper has been historically used for many decades for management of bacterial and fungal diseases. One of the documented direct implications of this unrestricted copper use on tomato is the development of copper-resistant bacterial strains of *Xanthomonas perforans*, the causal agent of bacterial spot disease of tomato. Currently all strains of this bacterium in Florida are resistant to copper, and thus copper bactericides are ineffective in managing the disease. In the recent years, many nanomaterials/copper composites have been identified as an alternative for copper and reducing the rates of copper that can be effectively used for disease management. This includes copper composites including copper-core shell silica, multi-valent copper, and copper-fixed quat which are effective bactericides of copper-tolerant strains at 1/5th of the current use rate of commercial copper and promising for potential commercialization (Strayer et al., 2018); development of a DNA-GO based silver nanoparticle, a highly effective bactericide which can be an alternative for copper for small scale use (Ocsoy et al., 2013; Strayer et al., 2016), and use of photocatalytic nanomaterials that are titanium dioxide doped on to zinc or silver, that can be an alternative for copper (Paret et al., 2013). Another material of possibility is as nano magnesium oxide. In previous studies, MgO was shown to have antibacterial activity against several mammalian pathogens (Aruoja et al. 2009; Huang et al. 2005; Sawai 2003). In case of plant pathogens, MgO caused high inhibition rates in spore germination of *Alternaria alternata*, *Fusarium oxysporum*, *Rhizopus stolonifer*, and *Mucor plumbeus* (Wani and Shah 2012). The objectives of this study were to understand the bactericide properties of MgO in comparison to copper bactericide under field conditions, and to evaluate the potential of phytotoxicity on tomatoes.

MATERIALS AND METHODS

MgO powder (99+%, 20 nm); was purchased from US Research Nanomaterials, Inc. (Houston, TX, USA). The particle was suspended and sonicated in autoclaved deionized water and adjusted to 10,000 µg/ml and used as a stock suspension. Two trials; one at NFREC, Quincy and one at GCREC, Wimauma were conducted in 2016. Each treatment had four replications consisting of 15 BHN 602 tomato plants in Quincy and HM1823 in Wimauma. The plots were arranged in a completely randomized block design. In Quincy, bed dimensions were 20.3 cm tall and 76.2 cm wide. Beds were spaced 1.8 m apart and plants were spaced 50.8 cm within the row (McAvoy et al. 2012). In Wimauma, beds were spaced 1.5 m apart and plants were spaced 60.96 cm within the row. Fertilizers were applied based on soil type and cooperative extension recommendations (Olson et al. 2012). Field transplanted tomatoes were sprayed starting one week prior to bacterial inoculation. The treatments consisted of weekly applications of MgO at 200 and 1000 µg/ml, Kocide 3000 (2.1 g/liter), the grower standard Kocide 3000 (2.1 g/liter) + Penncozeb 75DF (1.2 g/liter) and an untreated control until harvesting. A suspension of Cu-tolerant *X. perforans* strain GEV485, adjusted to 5x10^8 CFU/ml in deionized water was used for inoculation. The plants were assessed for disease severity and phytotoxicity using the Horsfall-Barratt disease severity scale (Barratt and Horsfall 1945) every week after inoculation until harvest. The area under disease progress curve (AUDPC) was then calculated (Campbell and Madden 1990). Statistical significance in treatments were analyzed using ANOVA followed by Student Newman-Keuls (SNK; $P=0.05$) method in IBM® SPSS® Statistics Version 22.

RESULTS AND DISCUSSION

Plants treated with MgO nanomaterials at 200 ppm in both trials showed a significant reduction in AUDPC in both trials compared to the untreated control (Table 1). At 1000 ppm, the Quincy trial showed the same trend in reduction in AUDPC compared to the untreated. However, in Wimauma, no statistical differences were noted for this set of treatments. Kocide 3000 or Kocide 3000 + Penncozeb 75 DF did not cause any significant reduction in AUDPC in both trials. No phytotoxicity was observed in both trials (data not shown).

The trials indicated to the potential of this MgO nanomaterial in management of bacterial spot of tomato. A formulation is currently being prepared by Swadeshmukul Santra at the University of Central Florida through funding from the Florida Tomato Committee. This ongoing study includes comparative performance assessments of non-formulated MgO used in this study shown above compared to formulated Mg-based nanomaterials and composites.

Table 1: AUDPC of bacterial spot on tomato treated with MgO and compared to grower standard and untreated control in spring season of 2016.

Treatment	Rate (µg/ml)	Location: Quincy	Location: Wimauma
MgO	1000	913.5 a	866.4 ab
	200	853.6 a	580.1 a
Kocide 3000	2,100	1,135.4 ab	972.1 ab
Kocide 3000 + Penncozeb 75 DF	2100 + 1,200	1,188.0 ab	773.4 ab
Water (Untreated)		1,402.1 b	1,136.8 b

Herbicide Injury in Tomato: Prevention and Rescue

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INTRODUCTION

Herbicides are a necessary tool in the weed management toolbox for vegetable crops. Although herbicidal products are designed to control undesirable plants, by being safe to the desirable plants, the imprudent use of these products will result in crop injury incidences. The primary route of herbicide exposure to vegetable crop includes drift or volatilization, misapplication or tank contamination, and in some instances through runoff. The source of phytotoxicity sometimes originates from the farm or may be the result of herbicides used on adjoining crop production or pasture lands. Glyphosate and 2,4-D are the most widely used herbicides in citrus groves and pasture respectively, and tomatoes in the neighboring farms can be very sensitive to both these chemicals. The consequential damage can not only result in visual injury symptoms, but also in reducing plant vigor and yield. Also, very often, the herbicide injury symptoms are confused with pest damage or plant diseases.

HERBICIDE INJURY SYMPTOMS IN TOMATO

Looking for symptom patterns in the field will help in identification of herbicide injury. It is imperative to determine when the signs of damage first appeared, and what herbicides were recently applied in the farm or surrounding crop and pasture areas. It is also worthwhile to note the appearance of plants in the neighboring blocks or location in the farms. Observing the changes in symptom severity within the affected block of plants may indicate the direction of drift or movement of the herbicide. The potential for herbicide drift injury varies with application methods, exposure intensity (applied rate) and the stage of plant growth (Carlin et al., 1971; Fagliari et al., 2005).

Exposure to glyphosate

The most identifiable symptoms of glyphosate injury in tomatoes is the whitening or bleaching at the base of leaflets and growing tips (Figure 1). The symptoms of glyphosate injury in leaves are often confused with tomato physiological leaf roll which is primarily caused by hot weather. Tomato plants exposed to higher doses of glyphosate is also characterized by upward curling and browning of leaf edges.

Exposure to 2,4-D

Tomato plants are extremely susceptible to auxin group of herbicides including 2,4-D. Injury symptoms can occur even with exposure to minuscule concentrations of the herbicide. The most identifiable symptoms of 2,4-D exposure are the occurrence of deformed petioles and downward cupped leaflets. Elongation and twisting of stems (Figure 2) and yellowing of veins may be observed. Plants exposed to high dose intensity will develop brown coloration on the stem. In many cases, the 2,4-D injury resembles viral disease symptoms.

Effect on fruit quality and yield:

Exposure of herbicides during early growth stages of tomato may result in fruit deformity in tomatoes. 'Catfacing' is the generic term used to describe a tomato fruit that has a deformity and is usually not marketable (Olson and Freeman, 2004). The deformity is caused by physiological stress that hinders the normal formation of fruit. The fruit will have large scars and cavities in the blossom end (Figure 3). The fruits may be kidney-shaped or distorted into other shapes. There is insufficient published information as to the exact cause, but exposure to herbicides such as 2,4-D and glyphosate has been considered as one of the primary reasons for such catfacing in tomato fruits (Leiwis Ivey and Sidhu, 2016; Olson and Freeman, 2004).

Figure 2: 2,4-D injury symptoms in tomato

Figure 1: Glyphosate injury symptoms in tomato

Figure 3: Catfacing in tomato fruits

HERBICIDE INJURY PREVENTION

Spray drift

The best way to avoid herbicide injury is to prevent the 'drift' or 'off-target' movement to an unintentional crop area from the application site. The potential for the spray drift is dependent on the spray droplet size and weather conditions. The common rule of thumb is that as the spray particle size decreases the potential for drift will be increased. Hence, selecting a spray nozzle that produces relatively larger spray droplets will reduce the drift hazard. Also, herbicide application during hot temperature and high wind will increase the herbicide volatilization and movement to the non-target sites. It is imperative to read the herbicide label as the off-label rates of application may result in herbicide drift situations.

Tank contamination

Tomato injury from sprayer contamination can occur up to several days even months after using an inadequately cleaned spray tank. The best practice is to dedicate a sprayer for herbicides and avoid using the cross spraying in different crops. If this is not feasible, the spray tanks should be cleaned after each use according to the herbicide label recommendation. Also the following general procedure can be followed in case the herbicide label does not specify a tank cleaning process.

1. Agitate and rinse the spray tanks and flush the lines, booms and nozzles using fresh water for 5 to 10 min. The rinsate should be sprayed onto an area away from crops but with good drainage.
2. Use a cleaning solution to fill the tank (e.g., household ammonia @ 1 quart / gal or trisodium phosphate @ 2 lbs. / gal). If 2, 4-D was used in the spray tank, allow the cleaning solution to sit in the tank overnight.
3. Agitate and rinse the tank and flush the lines, booms and nozzles with cleaning solution and let the cleaning solution sit in the system for a few hours. Finally, spray the cleaning solution in an area appropriate for the cleaning solution.

Herbicide persistence

Persistence and carryover of herbicides applied during the previous season can be another reason for herbicide injury in tomatoes. Damage to the plants due to elevated concentration of herbicides in plant root zone is a possible outcome of herbicide carryover. Moreover, storms and floods can facilitate the movement of herbicide residues in farms. Soil analysis and herbicide bioassays are useful to detect if the affected soils have herbicide residues well below injury threshold to tomato plants. Herbicide bioassay is a technique that utilizes indicator plants to test if the herbicide is present in soils at concentrations high enough to inhibit the plant germination and alter plant growth.

HERBICIDE INJURY RESCUE

Herbicide injury in tomato resulting from a combination of circumstances related to drift, weather and application errors cannot be predicted and may not be reversed. In most cases growers believe there is not much they can do about this type of crop injuries. If the symptoms are not severe, most probably plant may regain the growth in due course of time. Plants may have the ability to recover from the spray injury metabolically, and that solely depends on the intensity of exposure and stage of growth (Carlin and Hill, 1971; Fagliari et al., 2005). Furthermore, depending on the duration of the metabolic stress, this could adversely affect the productivity of the crops (Creech et al., 2004). Tomato plants exposed to herbicide injury will not only result in a growth setback but also yield loss. When glyphosate rates increased, foliar damage, and number of fruits per tomato plant changed with the stage of development at the time of exposure and the time of evaluation after treatment. Plants treated with high rates of glyphosate in pre-bloom had developed moderate to severe foliar injury by two weeks after treatment. But phytotoxicity to plants treated post-bloom was only mild to moderate (Gilreath and Chase, 2001).

There is a growing awareness that herbicide injury can be minimized if crop nutrition is adequate. For instance, herbicide-induced injury and stress in wheat, corn and soybean were reversed by foliar application of nutrients like nitrogen, potassium, phosphorus, manganese, zinc and boron (Haley, 2017). Similarly, the potential of copper and zinc to speed up the crop recovery from stress due to paraquat injury has been reported in peas (Iturbe-Ormaetxe et al., 1998). Evaluating the utility of foliar nutrient application for their potential rescue effects in tomato from injury and stress due to herbicide drift or spray contamination may be an important next step towards improving commercial tomato production and performance.

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The Electronic Logging Devices (ELDs) Mandate and Hours of Service (HOS) for Produce Haulers

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Electronic logging devices, or ELDs, became mandatory for commercial motor carriers (CMV) on December 18, 2017 (FMSCA, 2017a). The compliance timeline for the produce industry was delayed with two 90-day waivers. On June 18, 2018, however, ELDs became mandatory for produce haulers as well. The primary purpose behind requiring ELDs was to ensure greater compliance with existing hours of service (HOS) requirements by motor carriers and their drivers (Omnitracs, 2018a). The objectives of this paper are to: 1) review HOS rules; 2) clarify agricultural exceptions to the HOS rules; and 3) offer a preliminary discussion as to how ELDs could affect South Florida produce growers.

HOURS OF SERVICE (HOS) RULES

During the 1930s the U.S. trucking industry was rapidly expanding and began to move a significant amount of freight across the continental United States (Park, 2018). At the same time, safety experts were making a causal link between driver fatigue and highway accidents. Hence, the first rules were established to limit hours of service for commercial motor vehicle (CMV) drivers. Yager (2009) outlined the evolution of HOS rules from the 1930s through 2008. In 1937, a driver could operate a CMV up to 10 hours during a 24-hour period and had to be "off-duty" for at least 8 consecutive hours before starting another 24-hour period. Total "on-duty" time was a maximum of 60-hours over 7 consecutive days. Changes in 1962 granted drivers more flexibility by shortening the "duty period" from 24 to 15 hours and extendable with breaks during the day. A driver still had to be "off-duty" for at least 8 consecutive hours per day and total "on-duty" time was limited to 60 hours over 7 days, or 70 hours over 8 days. Major changes to HOS occurred in 2003 when drivers could increase their driving time from 10 to 11 hours but only within a shorter 14-hour "on-duty" window, and a window not extendable with break times. Consecutive "off-duty" time increased from 8 to 10 hours. The weekly limits, 60 hours over 7 days, or 70 hours over 8 days, remained the same, but now drivers could "restart" their "on-duty" record by taking a 34-hour continuous break. Other than requiring a 30-minute rest break after 8 hours of driving, the HOS rules have remained unchanged through September 2018 (FMCSA, 2017b).

AGRICULTURAL EXEMPTIONS

Agriculture enjoys exemptions to the HOS rules so long as CMV drivers haul agricultural products within 150 air-miles of the "agricultural source" (FMCSA, 2018). Products include not only crop and livestock commodities, but also equipment, seed, fertilizer, and other materials needed for farm production. The agricultural source is defined as the originating location from where agricultural products are hauled. For a tomato grower-shipper, the agricultural source changes depending on what is being shipped and when the shipment occurs. Moving plants from a transplant house to the field makes the nursery an "agricultural source" during planting time. The "agricultural source" shifts to the field when a grower hauls harvested fruit to the packinghouse. When packed tomato cartons are shipped to a re-pack facility, another warehouse, or to a wholesale/retail distribution point, the packinghouse becomes an "agricultural source." With respect to the last scenario of moving commodities between packinghouses and other destinations within the supply chain, HOS agricultural exemption requires that the commodity NOT be altered through processing. While a fresh market tomato is graded and ripened at a packinghouse, its condition is fundamentally the same as when it was picked in the field. Therefore, the 150 air mile radius exemption can be used at the tomato packinghouse. Juice oranges, on the other hand, are altered when they are crushed at the processing plant. The juice processing plant would not be considered an "agricultural source" and transport of orange juice would NOT qualify for the HOS exemption.

The important implication of the agricultural exemption is that a CMV driver's on-duty and driving times while moving agricultural products within 150 air miles of its source, are NOT counted toward his or her daily and weekly HOS limits. As an example, consider the shipment of round tomatoes from Immokalee, FL, to Hunts Point, NY. The driver starts his day at 7:00 am and spends the first hour fueling and conducting a safety check of his truck. At 8:00 am he begins loading his trailer. By noon, his trailer is fully loaded and he begins his trip to New York. At 3:00 pm he reaches the northern outskirts of Orlando, FL, which marks the 150 air-mile arc (172 ground-mile) from Immokalee. Because of agricultural exemption, the HOS calculations for this particular trip starts does not start until 3:00 pm. The driver could drive until 1:00 am the following morning before reaching the 11-hour HOS daily limit. Whether driving a CMV for 13 consecutive hours as part of a 17 hour-day is prudent and safe is matter for a separate discussion. Nevertheless, such a day would be allowed under the agricultural exemption.

While the agricultural exemption permits drivers hauling agricultural products to waive HOS calculations within a 150 air-mile radius, drivers and motor carriers still must maintain records of duty status (RODS) for seven consecutive days plus the current day (FMSCA, 2018). Under the agricultural exemption, a driver could mark his paper logbook or annotate his ELD with "agricultural exemption" for the time he was driving and working within the 150 air-mile radius.

ELECTRONIC LOGGING DEVICES (ELDS)

Motor carriers had been experimenting with automatic recording devices since the 1980s. Early devices were expensive. In 1995 a single device could cost as much as $2,500 (Omnitracs, 2018b). By 2016, advances in GPS technology and software pushed costs down to less than $200 (Cruz, 2017). The 2012 congressional act, Moving Ahead for Progress in the 21st Century (MAP-21), required that all CMV hauling freight be equipped with ELDs. The final ELD rule was published in December 2015 and called for a four-year, three-part compliance phase-in. Phase 1, December 2015 through December 2017, was a transition period. During this period, ELD use was voluntary and operators had the option of continuing with paper logbooks or using previously installed logging devices. Phase 2, December 18, 2017 through December 16, 2019, requires all trucks to have installed ELDs unless they had previously installed an alternative logging device prior to December 2017. Phase 3, which begins after December 16, 2019, requires all drivers and carriers to use self-certified ELDs that are registered with FMSCA (FMSCA, 2017a). A certified ELD must:

1. connect directly to the truck's engine and provides a continuous record while the CMV is operating,
2. allow a driver to select one of three options – "on-duty, driving," "on-duty, not driving," and "off-duty,"
3. quickly provide law enforcement with a graphical display of the driver's record of duty service, and
4. transfer data via a wireless system or with USB drives.

ELDs can accommodate the agricultural exemption for HOS rules. Within a 150 air-mile radius of an "agricultural source," a CMV driver can note within his ELD that he or she is operating under an "agricultural exemption." There are a few other exemptions to the ELD mandate:

1. All CMVs that are older than model year 2000 are exempt from using ELDs, and
2. Drivers, agricultural or otherwise, who do not operate outside the HOS limits for more than 8 out of 30 days, are also exempt from having to purchase and maintain ELDs.

ELDs do not, in any way, change HOS rules. The primary purpose to mandate ELDs is to ensure compliance of motor carriers and their drivers with HOS rules as they currently exist (Omnitracs, 2018a). Paper logs are not viewed as a reliable record of what drivers actually accrue as on-duty and consecutive driving hours. Proponents of ELDs argue that ELDs will increase accuracy of HOS reporting, reduce paperwork for needed HOS compliance, and increase scheduling efficiencies for dispatchers by improving communications between drivers and dispatchers (Omintracs, 2018b). ELDs also have the capacity to record incidences of speeding, hard braking, and other engine functions. Accurately logging of CMV operations may also protect drivers from unrealistic or unsafe employer expectations that may encourage speeding or violating HOS rules.

IMPLICATIONS OF ELDS ON SOUTH FLORIDA PRODUCE HAULERS

FMSCA estimated that reduced paperwork costs and higher fuel efficiencies resulting from mandatory adoption of ELDs would reduce freight costs across the U.S. by $1.6 billion annually (Omnitracs, 2018a). Many motor carriers argue that the cost of installing new ELD technology and stricter compliance with HOS rules will offset any savings (Cruz, 2017). Trucking rates have increased significantly. April 2018 data showed trucking rates were more than 20% higher than in March 2017 (Karst, 2018a). As recently as June 2018, rates increased between 16 and 35% from the previous month (Karst, 2018b). The extent to which ELDs by themselves are responsible for these rate increases is unclear. Strong economic growth within the U.S., low unemployment, and a shortage of qualified CDL drivers are other important reasons for the recent rate increases. The cost of installing ELDs could force smaller, independent owner-operators out of the freight industry. If this is the case, then the shortage of CMVs and drivers will be exacerbated and likely push freight rates even higher.

ELDs could affect freight rates by improving compliance with HOS rules and increasing the total time to move products from one point to another. To illustrate this point, consider an extreme case of compliance versus noncompliance of HOS rules when shipping two (2) trailer loads of tomatoes from Immokalee, FL, to Hunts Point, NY. Each refrigerated trailer holds 1,700 25-pound cartons (CH Robinson, 2017). Now imagine two drivers both earning the same annual income, $80,000 per year, and work/drive 250 days a year, earning $320 per day. The first driver operates within the HOS rules (complaint) and second driver does not (noncompliant). HOS rules restrict the first driver to 11 hours of driving per day and if he averages 60 miles per hour, he travels 660 miles per day. The second driver averages the same speed (i.e. 60 miles per hour), but drives 15 hours, four hours outside HOS rules. The trip from FL to NY is 1,253 miles (http://www.distance-cities.com). The second driver travels 900 miles per day and completes his trip in 1.4 days (1,253 mile divided by 900 miles per day). Abiding by HOS rules, the first driver takes 1.9 days to complete the same trip (1,253 miles divided by 660 miles per day), or 36% more time than the second noncompliant driver. Assuming both drivers continue to earn the same daily income ($320), the difference in cost of the first driver (compliant, $608) and the second driver (noncompliant, $448) was $160. Given 1,700 cartons per load, abiding by HOS rules increased costs from added driver time by $.09 per carton ($160/1,700 cartons).

While costs to ship tomatoes and other produce out of South Florida will likely increase with ELDs, a more important question is how ELDs will affect freight costs from other areas of the country. Mexican produce comes through McAllen, TX, and Nogales, AZ. Much of that produce is shipped to east coast markets in direct competition with South Florida's growers. We examine how ELDs could benefit South Florida growers using the following parameters:

- Destination: Hunts Point, NY;
- Trailer capacity: 1,700 25-pound cartons of round, mature-green tomatoes;
- Driver income: $80,000/year; 250 driving days per year; or $320 per day;
- Driving speed: 60 miles per hour;
- HOS with ELD: 11 hours per day; 660 miles per day;
- HOS without ELD: 15 hours per day; 900 miles per day.

Table 1 summarizes the number of days and average cost required to complete trips from each starting point to Hunts Point, NY, given the specified parameters. Freight costs

Table 1. Additional cost of shipping tomatoes to Hunts Point, NY, for HOS complaint drivers.

Starting Point	Mileage miles	Day to complete trip		ELD extra time days	Added cost in driver income $/trip	Added cost per carton $/ctn
		ELD Noncomplaint	ELD Complaint			
Immokalee, FL	1,253	1.4	1.9	0.5	$160	$0.09
McAllen, TX	2,003	2.2	3.0	0.8	$256	$0.15
Nogales, AZ	2,497	2.8	3.8	1.0	$320	$0.19

for HOS complaint drivers from McAllen, TX, and Nogales, AZ, would be 6-cents and 10-cents more per carton, respectively, then those from South Florida. While growers do not pay freight costs to move produce from their packinghouses to terminal sale points, stricter adherence to HOS rules provides South Florida growers with a competitive advantage from relatively lower freight costs.

CONCLUDING COMMENTS

ELDs are mandated across a large portion of the freight industry, including trucks hauling fresh produce. The primary purpose of ELDs are to ensure that motor carriers and their drivers follow HOS rules. The agricultural exemption provides agricultural producers and haulers a radius of 150 air-miles in which HOS and ELDs are not required. Ultimately, South Florida produce growers will be impacted by ELDs as most of their output is exported out of state to east coast and northern U.S. markets, well beyond the 150 air-mile radius. There is still some debate over whether the net effect from ELDs will increase or decrease overall costs. In time, as motor carriers and drivers adapt to the new technology, we will see whether the cost reduction in paper work and/or fuel and logistic efficiencies will offset the cost of the ELD equipment and the "flexibility" drivers enjoyed when HOS were not being recorded by ELDs. For South Florida growers, specifically, greater compliance with HOS rules may provide a competitive advantage as their produce markets along the east coast of the U.S. are geographically closer then Mexican produce entering the U.S. through McAllen or Nogales.

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Insecticides Labeled for Management of Arthropod Pests on Tomato

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Insecticides labeled for management of arthropod pests on tomato.

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

Insect	MOA Code	Trade name (Active Ingredient) *Restricted	Rate (Product/acre)	Rate per Season	Days to Harvest	REI (hours)	Remarks
Aphids (including aphid transmitted viruses, green peach aphid, potato aphid)	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	
	1A	***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.
	1B	**Malathion 8 F**	1.5 pt				
	3A	***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	
	3A	***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	
	3A	***Danitol 2.4 EC** (fenpropathrin)	7-10.67 fl oz	Do not exceed 42.67 fl. oz. total application /A per season.	3	24	
	3A	**Karate with Zeon*** (lambdacyhalothrin)	0.96-1.92 fl. oz.	Do not apply more than 23.04 fl. oz. /A per season.	5	24	
	3A	***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.
	3A	**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 & 4A	**Leverage*** 360 (beta-cyfluthrin & imidacloprid)	3.8-4.1		0	12	
	3A & 6	**Gladiator*** (avermectin B1 & zeta-cypermethrin)	19 fl. oz.	Do not apply more than 57 fl. oz./A per 12 month cropping year.	7	12	
	3A & 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** (lambda-cyhalothrin)	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 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.

Insecticides labeled for management of arthropod pests on tomato. (continued)

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

Insect	MOA Code	Trade name (Active Ingredient) *Restricted	Rate (Product/acre)	Rate per Season	Days to Harvest	REI (hours)	Remarks
	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** (thiamethoxam)	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 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.
	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. Toxic to bees.
	4C	**Closer SC** (sulfoxaflor)	1.5 - 2.0 fl oz	Do not exceed 17 fl oz Closer per acre per year.	1	12	DO NOT APPLY UNTIL AFTER PETAL FALL.
	4D	**Sivanto Prime** (flupyradifurone)	**soil:** 21.0 - 28.0 fl oz **foliar:** 7.0 -14.0 fl oz	Do not apply more than 28.0 fl oz per acre per year.	soil application: 45 days; foliar: 1 day	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).
	23	**Movento** (spirotetramat)	4.0-5.0 fl oz	Maximum of 10 fl oz/acre per season.	1	24	
	28	**Exirel** (cyantraniliprole)	13.5-20.5 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.

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Insect	MOA Code	Trade name (Active Ingredient) *Restricted	Rate (Product/acre)	Rate per Season	Days to Harvest	REI (hours)	Remarks
	28	**Verimark** (cyantraniliprole)	6.75-13.5 fl. oz. tray drench/ transplant water. 6.75-10 dripfl. oz..	Do not apply more than 0.4 lb ai/A per crop.	1	4	
	29	**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.
	-	**Aza-Direct** (azadirachtin)	1-2 pts, up to 3.5 pts, if needed		0	4	Antifeedant, repellant, insect growth regulator. OMRI-listed.
	-	**Azatin XL** (azadirachtin)	5-21 fl oz		0	4	Antifeedant, repellant, insect growth regulator.
	-	**BotaniGard ES** (*Beauvaria bassiana* strain GHA)	0.25 - 1 quart per acre. Apply in sufficient water to cover foliage, typically 5 - 100 gallons per acre.		0	4	
	-	**Grandevo** (*Chromobacterium subtsugae*)	1.0-3.0 lb		0	4	Thorough coverage is necessary for effective control.
	-	**Molt-X** (azadirachtin)	10 fl oz		0	4	Antifeedant, repellant, insect growth regulator. OMRI-listed.
	-	**Mycotrol ESO** (*Beauveria bassiana* strain GHA)	0.25 - 1 quart per acre. Apply in sufficient water to cover foliage, typically 5 - 100 gallons per acre.		0	4	OMRI Listed
	-	**Neemix 4.5** (azadirachtin)	4.0-16.0 fl oz		0	12	IGR, feeding repellant. OMRI-listed.
	-	**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.
	-	**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.
	-	**SuffOil-X** (mineral 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**	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				Organic Stylet-Oil and Saf-T-Side are OMRI-listed.
Beetles (including beetle larvae, blister beetles, Colorado potato beetle, cucumber beetles, flea 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	
	3A	***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.**
	3A	***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	
	3A	***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	
	3A	***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.
	3A	**Karate with Zeon*** (lambdacyhalothrin)	0.96-1.92 fl. oz.	Do not apply more than 23.04 fl. oz. /A per season.	5	24	

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Insect	MOA Code	Trade name (Active Ingredient) *Restricted	Rate (Product/acre)	Rate per Season	Days to Harvest	REI (hours)	Remarks
	3A	***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.
	3A	***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.
	3A	**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** (lambda-cyhalothrin)	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.
	3A & 4A	**Leverage*** 360 (beta-cyfluthrin & imidacloprid)	3.8-4.1		0	12	
	3A & 6	**Gladiator*** (avermectin B1 & zeta-cypermethrin)	19 fl. oz.	Do not apply more than 57 fl. oz./A per 12 month cropping year.	7	12	
	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** (thiamethoxam)	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.			
	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.
		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.

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Insect	MOA Code	Trade name (Active Ingredient) *Restricted	Rate (Product/acre)	Rate per Season	Days to Harvest	REI (hours)	Remarks
	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 Prime** (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 1^{st} & 2^{nd} 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)	6.75-13.5 fl. oz. tray drench/transplant water. 6.75-10 drip fl. oz.	Do not apply more than 0.4 lb ai/A per crop.	1	4	
	-	**Aza-Direct** (azadirachtin)	1-2 pts, up to 3.5 pts, if needed		0	4	Antifeedant, repellant, insect growth regulator. OMRI-listed.
	-	**Azatin XL** (azadirachtin)	5-21 fl oz		0	4	Antifeedant, repellant, insect growth regulator.
	-	**Neemix 4.5** (azadirachtin)	4.0-16.0 fl oz		0	12	IGR, feeding repellant. OMRI-listed.
	-	**SuffOil-X** (mineral oil)	1-2 gallons per 100 gallons of water.			4	OMRI listed.
	-	**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		0	4	
Caterpillars: including cabbage looper, corn earworm, garden webworm, hornworms, imported cabbageworm, loopers, saltmarsh caterpillar, tobacco budworm, tomato fruitworm; armyworms (beet armyworm, fall armyworm, southern armyworm, true armyworm, yellowstriped armyworm); cutworms (black cutworm, granulate cutworm).	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.
	3A	***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.**
	3A	***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	
	3A	***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	
	3A	***Danitol 2.4 EC** (fenpropathrin)	7-10.67 fl oz	Do not exceed 42.67 fl. oz. total application /A per season.	3	24	
	3A	***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.

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Insect	MOA Code	Trade name (Active Ingredient) *Restricted	Rate (Product/acre)	Rate per Season	Days to Harvest	REI (hours)	Remarks
	3A	***Karate with Zeon** (lambdacyhalothrin)	0.96-1.92 fl. oz.	Do not apply more than 23.04 fl. oz. /A per season.	5	24	
	3A	***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.
	3A	***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.
	3A	**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** (lambda-cyhalothrin)	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.
	3A & 4A	**Leverage*** 360 (beta-cyfluthrin & imidacloprid)	3.8-4.1		0	12	
	3A & 6	**Gladiator*** (avermectin B1 & zeta-cypermethrin)	19 fl. oz.	Do not apply more than 57 fl. oz./A per 12 month cropping year.	7	12	
	3A & 28	***Besiege** (lambda-cyhalothrin & chlorantraniliprole)	5.0-9.0 fl oz	Do not exceed a total of 31 fl oz of Besiege per acre per year.	5	24	
	4A	**Platinum** (thiamethoxam)	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.			
	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. 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	
	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.
	6 & 28	***Minecto Pro** (abamectin & cyantraniliprole)	5.5-10 fl oz	Do not apply more than 20 fl oz per acre per year.	7	24	This label contains pollinator warnings.
	11A	**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.
	11A	**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.
	11A	**Crymax WDG** (*Bacillus thuringiensis* subspecies *kurstaki*)	0.5-2.0 lb		0	4	Use high rate for armyworms. Treat when larvae are young.
	11A	**Deliver** (*Bacillus thuringiensis* subspecies *kurstaki*)	0.25-1.5 lb		0	4	Use higher rates for armyworms. OMRI-listed.
	11A	**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.

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Insect	MOA Code	Trade name (Active Ingredient) *Restricted	Rate (Product/acre)	Rate per Season	Days to Harvest	REI (hours)	Remarks
	11A	**Javelin WG** (*Bacillus thuringiensis* subspecies *kurstaki*)	0.12-1.5 lb		0	4	Treat when larvae are young. Thorough coverage is essential. OMRI-listed.
	11A	**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 slow-acting 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	**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	
	-	**Aza-Direct** (azadirachtin)	1-2 pts, up to 3.5 pts, if needed		0	4	Antifeedant, repellant, insect growth regulator. OMRI-listed.
	-	**Azatin XL** (azadirachtin)	5-21 fl oz		0	4	Antifeedant, repellant, insect growth regulator.
	-	**CheckMate TPW-F** (pheromone)	1.2-6.0 fl oz		0	0	For mating disruption of tomato pinworm-See label for details.
	-	**Grandevo** (*Chromobacterium subtsugae*)	1.0-3.0 lb		0	4	Thorough coverage is necessary for effective control.
	-	**Molt-X** (azadirachtin)	10 fl oz		0	4	Antifeedant, repellant, insect growth regulator. OMRI-listed.
	-	**MBI-203 EP** (*Chromobacterium subtsugae*)	4.0-12.0 quarts		0	4	OMRI listed. Can be used in the greenhouse.
	-	**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	Slow-acting 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.
	3A	***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	
	3A	***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.
	3A	**Karate with Zeon*** (lambdacyhalothrin)	0.96-1.92 fl. oz.	Do not apply more than 23.04 fl. oz. /A per season.	5	24	
	3A	***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.
	3A	**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	

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Insect	MOA Code	Trade name (Active Ingredient) *Restricted	Rate (Product/acre)	Rate per Season	Days to Harvest	REI (hours)	Remarks
	3A	***Warrior II** (lambda-cyhalothrin)	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.
	3A & 28	***Besiege** (lambda-cyhalothrin & chlorantraniliprole)	5.0-9.0 fl oz	Do not exceed a total of 31 fl oz of Besiege per acre per year.	5	24	
	-	**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.
	3A	***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.
	3A	**Karate with Zeon*** (lambdacyhalothrin)	0.96-1.92 fl. oz.	Do not apply more than 23.04 fl. oz. /A per season.	5	24	
	3A	***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.
	3A	**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 & 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	
	3A & 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** (lambda-cyhalothrin)	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)	**foliar:** 1.6-2.1 oz	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)	**soil:** 4.8-6.4 oz	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** (thiamethoxam)	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.			
	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.

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Insect	MOA Code	Trade name (Active Ingredient) *Restricted	Rate (Product/acre)	Rate per Season	Days to Harvest	REI (hours)	Remarks
	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 per acre 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 Prime** (flupyradifurone)	**soil:** 21.0 - 28.0 fl oz; **foliar:** 7.0-10.5 fl oz	Do not apply more than 28.0 fl oz per acre per year.	soil application: 45 days; foliar: 1 day	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	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.
	-	**Aza-Direct** (azadirachtin)	1-2 pts, up to 3.5 pts, if needed		0	4	Antifeedant, repellant, insect growth regulator. OMRI-listed.
	-	**Azatin XL** (azadirachtin)	5-21 fl oz		0	4	Antifeedant, repellant, insect growth regulator.
	-	**Molt-X** (azadirachtin)	10 fl oz		0	4	Antifeedant, repellant, insect growth regulator. OMRI-listed.
	-	**M-Pede 49% EC** (Soap, insecticidal)	1-2% V/V		0	12	OMRI-listed
	-	**SuffOil-X** (mineral oil)	1-2 gallons per 100 gallons of water.		0	4	OMRI listed.
	-	**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		0	4	
***Liriomyza* leafminers**	1A	***Vydate L** (oxamyl)	**foliar:** 2.0-4.0 pt	Do not apply more than 32 pts/A per season.	3	48	
	3A & 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.
	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.
	5	**Entrust** (spinosad)	0.5-2.5 oz	Do not apply more than 9 oz per acre per crop.	1	4	OMRI-listed.
	5	**Radiant SC** (spinetoram)	5-10 fl oz.	Do not apply more than 34 fl. oz./A per calendar year.	1	4	
	6	***Agri-Mek 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.

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	6	***Agri-Mek 0.15 EC** (abamectin)	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.
	6 & 28	***Minecto Pro** (abamectin & cyantraniliprole)	5.5-10 fl oz	Do not apply more than 20 fl oz per acre per year.	7	24	This label contains pollinator warnings.
	28	**Coragen** (chlorantraniliprole/rynaxypyr)	5-7.5 fl. oz. (soil, drip or foliar)		1	4	For control of larvae.
	28	**Exirel** (cyantraniliprole)	13.5-20.5 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)	6.75-13.5 fl. oz. tray drench/ transplant water. 6.75-10 dripfl. oz.	Do not apply more than 0.4 lb ai/A per crop.	1	4	
	-	**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 (including broad mites, twospotted spider mites, tomato russett mites, carmine spider mites)	1B	**Malathion 5** (malathion)	1.0-2.5 pt	10 pints	1	12	8F can be used in greenhouse.
	1B	**Malathion 8 F**	1.5 pt				
	3A	***Danitol 2.4 EC** (fenpropathrin)	7-10.67 fl oz	Do not exceed 42.67 fl. oz. total application /A per season.	3	24	
	3A	***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.
	3A	***Karate with Zeon** (lambdacyhalothrin)	0.96-1.92 fl. oz.	Do not apply more than 23.04 fl. oz. /A per season.	5	24	
	3A	**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 & 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	***Agri-Mek 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.
	6	***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.
	6 & 28	***Minecto Pro** (abamectin & cyantraniliprole)	5.5-10 fl oz	Do not apply more than 20 fl oz per acre per year.	7	24	This label contains pollinator warnings.
	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.
	-	**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.
	-	**Aza-Direct** (azadirachtin)	1-2 pts, up to 3.5 pts, if needed		0	4	Antifeedant, repellant, insect growth regulator. OMRI-listed.
	-	**Grandevo** (*Chromobacterium subtsugae*)	1.0-3.0 lb		0	4	Thorough coverage is necessary for effective control.
	-	**M-Pede 49% EC** (Soap, insecticidal)	1-2% V/V		0	12	OMRI-listed

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	-	**MET52 EC** (*Metarhizium anispoliae* strain F52)	**drench:** 40-80 fl. oz.; **foliar:** 0.5 pint - 2qt		0	0	
	-	**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.
	-	**SuffOil-X** (mineral oil)	1-2 gallons per 100 gallons of water.			4	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				
Mole crickets	1B	***Diazinon AG500; *50 W** (diazinon)	**AG500:** 1-4 qt **50W:** 2-8 lb	Do not make more than one soil application per 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.
	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	***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.
	3A	**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	***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** (lambda-cyhalothrin)	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.
	3A & 28	***Besiege** (lambda-cyhalothrin & chlorantraniliprole)	5.0-9.0 fl oz	Do not exceed a total of 31 fl oz of Besiege per acre per year.	5	24	
	4A	**Belay 50 WDG** (clothianidin)	**foliar:** 1.6-2.1 oz	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)	**soil:** 4.8-6.4 oz	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.
	4C	**Closer SC** (sulfoxaflor)	2.75-4.5 fl oz	Do not apply more than 17 fl oz per acre per year.	1	12	DO NOT APPLY THIS PRODUCT UNTIL AFTER PETAL FALL.
	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.
	29	**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.
	--	**M-Pede 49% EC** (Soap, insecticidal)	1-2% V/V		0	12	OMRI-listed
Planthoppers	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	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 Prime** (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	
	-	**Neemix 4.5** (azadirachtin)	4.0-16.0 fl oz		0	12	IGR, feeding repellant. OMRI-listed.

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Insect	MOA Code	Trade name (Active Ingredient) *Restricted	Rate (Product/acre)	Rate per Season	Days to Harvest	REI (hours)	Remarks
Soil insects (including centipedes, crickets, earwigs, millipedes, sow bugs, springtails)	1A	**10% Sevin Granules** (carbaryl)	20 lb		3	12	Maximum of 4 applications, not more often than once every 7 days.
Stink bugs (including brown stink bug and green stink bug)	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.
	3A	***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	
	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	***Danitol 2.4 EC** (fenpropathrin)	7-10.67 fl oz	Do not exceed 42.67 fl. oz. total application /A per season.	3	24	
	3A	***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.
	3A	**Karate with Zeon*** (lambdacyhalothrin)	0.96-1.92 fl. oz.	Do not apply more than 23.04 fl. oz. /A per season.	5	24	
	3A	***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.
	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** (lambda-cyhalothrin)	0.96-1.92 fl oz	Do not apply more than 23.04 fl. oz/A per season.	5	24	
	3A & 4A	***Leverage** 360 (beta-cyfluthrin & imidacloprid)	3.8-4.1		0	12	
	3A & 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	
	3A & 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 & 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. 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.
	-	**Aza-Direct** (azadirachtin)	1-2 pts, up to 3.5 pts, if needed		0	4	Antifeedant, repellant, insect growth regulator. OMRI-listed.

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Insect	MOA Code	Trade name (Active Ingredient) *Restricted	Rate (Product/acre)	Rate per Season	Days to Harvest	REI (hours)	Remarks
Thrips: check label for species controlled (includes melon thrips, western flower thrips, Florida flower thrips, eastern flower thrips, foliar feeding thrips, chilli thrips)	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.
	3A	***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	
	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	***Hero** (bifenthrin & zeta-cypermethrin)	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.
	3A	**Karate with Zeon*** (lambdacyhalothrin)	0.96-1.92 fl. oz.	Do not apply more than 23.04 fl. oz. /A per season.	5	24	
	3A	***Mustang** (zeta-cypermethrin)	3.4-4.3 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.
	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** (lambda-cyhalothrin)	0.96-1.92 fl oz	Do not apply more than 23.04 fl. oz/A per season.	5	24	
	3A	**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 & 4A	***Leverage** 360 (beta-cyfluthrin & imidacloprid)	3.8-4.1		0	12	
	3A & 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	
	3A & 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	
	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** (thiamethoxam)	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.			
	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.
	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.

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	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	***Agri-Mek SC** (abam-ectin)	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.
	6	***Agri-Mek 0.15 EC** (abamectin)	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.
	6 & 28	***Minecto Pro** (abamectin & cyantraniliprole)	5.5-10 fl oz	Do not apply more than 20 fl oz per acre per year.	7	24	This label contains pollinator warnings.
	15	**Rimon 0.83EC** (noval-uron)	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)	13.5-20.5 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)	10.0-13.5 fl. oz.	Do not apply more than 0.4 lb ai/A per crop.	1	4	
	29	**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.
	-	**Aza-Direct** (azadirachtin)	1-2 pts, up to 3.5 pts, if needed		0	4	Antifeedant, repellant, insect growth regulator. OMRI-listed.
	-	**Azatin XL** (azadirachtin)	5-21 fl oz		0	4	Antifeedant, repellant, insect growth regulator.
	-	**BotaniGard ES** (*Beauveria bassiana* strain GHA)	0.25 - 1 quart per acre. Apply in sufficient water to cover foliage, typically 5 - 100 gallons per acre.		0	4	Thorough coverage is necessary for effective control.
	-	**Grandevo** (*Chromobacterium subtsugae*)	1.0-3.0 lb		0	4	
	-	**MET52 EC** (*Metarhizium anispoliae* strain F52)	drench: 40-80 fl. oz.; foliar: 0.5 pint - 2qt		0	0	OMRI Listed
	-	**Molt-X** (azadirachtin)	10 fl oz		0	4	Antifeedant, repellant, insect growth regulator. OMRI-listed.
	--	**M-Pede 49% EC** (Soap, insecticidal)	1-2% V/V		0	12	Do not exceed four applications per season.
	-	**Mycotrol ESO** (*Beauveria bassiana* strain GHA)	0.25 quart -1 quart/100 gallons		0	4	Repeat applications at 3-10 days asneeded to maintain control. Can be used in greenhouse for food crop transplants raised to be planted into the field. OMRI listed.
	-	**PFR-97** (*Isaria fumosorosea* Apopka strain 97)	1.0-2.0 lbs		0	4	Begin applications before pests reach damaging levels.
	-	**Requiem 25EC** (extract of *Chenopodium ambrosioides*)	2-4 qt	Limited to 10 applications per crop cycle.	0	4	OMRI listed.
	-	**Suffoil-X** (mineral oil)	1-2% v/v		0	4	OMRI listed.
	-	**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	
	-	**JMS Stylet-Oil** (oil, insecticidal)	3.0-6.0 qt/100 gal water		0	4	

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Weevils (vegetable weevil)	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** (lambda-cyhalothrin)	0.96-1.92 fl oz	Do not apply more than 23.04 fl. oz/A per season.	5	24	See label for limits on each active ingredient.
	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	Antifeedant, repellant, insect growth regulator. OMRI-listed.
	-	**Aza-Direct** (azadirachtin)	1-2 pts, up to 3.5 pts, if needed		0	4	Antifeedant, repellant, insect growth regulator.
	-	**Azatin XL** (azadirachtin)	5-21 fl oz		0	4	
Whiteflies	1A	***Vydate L** (oxamyl)	**foliar:** 2.0-4.0 pt	Do not apply more than 32 pts/A per season.	3	48	
	3A	***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	
	3A	***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	
	3A	***Danitol 2.4 EC** (fenpropathrin)	7-10.67 fl oz	Do not exceed 42.67 fl. oz. total application /A per season.	3	24	Do not make more than 4 applications per season. Do not make applications less than 10 days apart.
	3A	***Hero** (bifenthrin & zeta-cypermethrin)	10.3 oz	Do not apply more than 43.26 fl. oz./A per season.	1	12	
	3A	**Karate with Zeon*** (lambdacyhalothrin)	0.96-1.92 fl. oz.	Do not apply more than 23.04 fl. oz. /A per season.	5	24	
	3A	***Mustang** (zeta-cypermethrin)	3.4-4.3 oz	Do not apply more than 25.8 fl. oz./A per season.	1	12	Pyrethrins degrade rapidly in sunlight. Thorough coverage is important. OMRI-listed. Do not apply more than 10 times per season.
	3A	**Pyganic Crop Protection EC 5.0 II** (pyrethrins)	4.5-18.0 fl oz	11.25 pints.	0	12	
	3A	***Brigade 2EC** (bifenthrin)	2.1-5.2 fl oz	Make no more than 4 applications per season.	1	12	
	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** (lambda-cyhalothrin)	0.96-1.92 fl oz	Do not apply more than 23.04 fl. oz/A per season.	5	24	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.
	3A & 28	***Besiege** (lambda-cyhalothrin & chlorantraniliprole)	5.0-9.0 fl oz	Do not apply more than 31.0 fl oz /A per season.	5	24	Do not make applications less than 10 days apart.
	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.
	4A	**Admire Pro** (imidacloprid)	7-10.5 fl oz	Maximum allowed on tomato is 10.5 fl. oz/A.	21	12	Greenhouse use: 1 application to mature plants, see label for cautions.
	4A	**Admire Pro** (imidacloprid)	0.6 fl oz per 1000 plants		0 (soil)	12	Planthouse: 1 application. See label.
	4A	**Admire Pro** (imidacloprid)	0.44 fl oz per 10,000 plants		21	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	**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 use an adjuvant. Toxic to bees. Do not release irrigation water from the treated area.
	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	See label for application instructions. Do not release irrigation water from the treated area.

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	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 plant-ing	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** (thiamethoxam)	5-11 fl oz	Do not exceed a total of 11 fl. oz. Platinum/A per growing season.	30	12	
	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	Do not apply to crop that has been already treated with imidacloprid or thiamethoxam at planting.
	4A	**Provado 1.6F** (imidacloprid)	3.8-6.2 fl oz	Maximum per crop per season 19.2 fl oz/A.	0	12	For transplant production only. Can be ap-plied as foliar spray or soil drench.
	4A	**Safari 20 SG** (dinotefuran)	7.0-14.0 oz		1	12	Application restrictions exist for this product because of risk to bees and other insect pol-linators. 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	**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 appli-cation. Do not apply more than 10.5 fl. oz/A per season foliarly.	1	12	Use only one application method (soil or fo-liar). Limited to three applications per season. Toxic to honeybees.
	4A	**Venom 20 SG (**dinotefuran)	**foli-ar:**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). Must have supplemental label for rates over 6.0 oz/acre.
	4A	**Venom 20 SG (**dinotefuran)	**soil:** 1.13-1.34 lb	Do not apply more than 2.68 lb/A per season.	21	12	Several methods of soil application – see label.
	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	Do not use in greenhouses or on transplants. Do not use if seed has been treated with thia-methoxam or if other Group 4A insecticides will be used. Highly toxic to bees.
	4C	**Closer SC** (sulfoxaflor)	4.25 - 4.5 fl oz	Do not apply more than 17 fl oz per acre per year.	1	12	DO NOT APPLY THIS PRODUCT UNTIL AFTER PETAL FALL.
	4D	**Sivanto Prime** (flupyradifurone)	**soil:** 21.0 - 28.0; **foliar:** 10.5 - 14.0	Do not apply more 28.0 fl oz per acre per year.	soil applica-tion: 45 days; foliar: 1 day		
	4A & 28	**Voliam Flexi** (thiamethoxam & chlorantraniliprole)	4.0-7.0 oz	Do not exceed 14 oz/A per season.	1	12	
	7C	**Knack IGR** (pyriproxyfen)	8-10 fl oz	Do not exceed 20 fl. oz./A per season.	14	12	(FL-040006) 24(c) label for growing trans-plants also (FL-03004).
	9B	**Fulfill (**pymetrozine)	2.75 oz	Do not apply more than 5.5 oz/acre per crop.	0	12	
	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	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.
	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	Do not make more than two applications per growing season. Allow 14 days between applications.
	21A	**Portal (**fenpyroximate)	2.0 pt	Do not apply more than 4.0 pints/A per crop cycle.	1	12	
	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	
	28	**Exirel** (cyantraniliprole)	13.5-20.5 fl. oz.	Do not apply a total of more than 0.4 lb ai/A per crop.	1	12	
	28	**Verimark** (cyantraniliprole)	6.75-13.5 fl. oz. tray drench/ transplant water; 6.75-10.0 fl. oz. drip.	Do not apply more than 0.4 lb ai/A per crop.	1	4	

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	29	**Beleaf 50 SG** (flonicamid)	4.2 oz.	Do not apply more than 8.4 oz per acre per season.	0		
	-	**Aza-Direct** (azadirachtin)	1-2 pts, up to 3.5 pts, if needed		0	4	Antifeedant, repellant, insect growth regulator.
	-	**Azatin XL** (azadirachtin)	5-21 fl oz		0	4	
	-	**BotaniGard ES** (*Beauveria bassiana* strain GHA)	0.25 - 1.0 quart per acre. Apply in sufficient water to cover foliage, typically 5 - 100 gallons per acre.		0	4	
	-	**Grandevo** (*Chromobacterium subtsugae*)	1.0-3.0 lb		0	4	
	-	**MET52 EC** (*Metarhizium anispoliae* strain F52)	**drench:** 40-80 fl. oz.; **foliar:** 0.5 pint - 2qt		0	0	OMRI Listed
	-	**Molt-X** (azadirachtin)	10 fl oz		0	4	Antifeedant, repellant, insect growth regulator. OMRI-listed.
	-	**Mycotrol ESO** (*Beauveria bassiana* strain GHA)	0.25 - 1 quart per acre. Apply in sufficient water to cover foliage, typically 5 - 100 gallons per acre.		0	4	OMRI Listed
	-	**Neemix 4.5** (azadirachtin)	4.0-16.0 fl oz		0	12	
	-	**PFR-97** (*Isaria fumosorosea* Apopka strain 97)	1.0-2.0 lbs		0	4	Begin applications before pests reach damaging levels.
	-	**Requiem 25EC** **(**extract of Chenopodium ambrosioides)	2-4 qt	Limited to 10 applications per crop cycle.	0	4	OMRI listed.
	-	**SuffOil-X** **(**mineral oil)	1-2 gallons per 100 gallons of water.			4	OMRI-listed
	-	**M-Pede 49% EC** **(**Soap, insecticidal)	1-2% V/V		0	12	Do not exceed four applications per season.
	-	Ultra Fine Oil, Saf-T-Side, others	1.0-2.0 gal/100 gal		0	4	Organic Stylet-Oil and Saf-T-Side are OMRI-listed.
	-	**JMS Stylet-Oil** **(**oil, insecticidal)	3.0-6.0 qt/100 gal water				Incorporate into soil - see label.
Wireworms	1B	***Diazinon AG500; *50 W** (diazinon)	**AG500:** 1-4 qt **50W:** 2-8 lb	Do not make more than one soil application per year regrardless of target pest.	preplant	48	

Mode of Action (MOA) codes for plant pest insecticides from the Insecticide Resistance Action Committee (IRAC) Mode of Action Classification v. 8.2 March 2017. Number codes (1 through 29) are used to distinguish the main insecticide mode of action groups, with additional letters for certain sub-groups within each main group. All insecticides within the same group (with same number) indicate same active ingredient or similar mode of action. This information must be considered for the insecticide resistance management decisions. - = unknown, or a mode of action that has not been classified yet.

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. OMRI listed: Listed by the Organic Materials Review Institute for use in organic production.

*** Restricted use insecticide.**

Herbicides Labeled for Weed Management in Tomato

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Herbicides Labeled for Weed Management in Tomato

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

Active ingredient lb. a.i./A	Trade name product/A	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.
Napropamide 1.0 - 2.0	(Devrinol DF-XT) 50 DF 2.0 - 4.0 lb. (Devrinol 2-XT) 2-4 quarts	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.

Active ingredient lb. a.i./A	Trade name product/A	MOA Code	Weeds controlled / remarks
	Labels change frequently. Be sure to read a current product label before applying any chemical.		
Pendimethalin **0.48 - 0.72**	(Prowl $H_2$0) 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 **rosettes** less than 3 in. diameter. Apply as a preplant burndown treatment. Nonionic surfactant or crop oil concentrate recommended.
Rimsulfuron **0.03 - 0.06**	(Pruvin, **Solida**) 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
Sulfentrazone **0.070 - 0.19**	Spartan FL 4F 2.25 - 6.0 oz		Pre-emergent control of broadleaves and grasses. Applications must be made prior to transplant. Do not apply more than 12.0 oz per acre per application or per 12 month period.
Trifluralin **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 **Desiccant**) 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_2$0) 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.
Rimsulfuron **0.02 - 0.03**	(Pruvin, **Solida**) 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. Do not exceed 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.

Active ingredient lb. a.i./A	Trade name product/A	MOA Code	Weeds controlled / remarks
			Labels change frequently. Be sure to read a current product label before applying any chemical.
			***** POSTHARVEST *****
Diquat **0.5**	(Reglone **Desiccant**) 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.

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 guidelinesand 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 guidelineand 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 – For Vydate L, 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 (Fluensulfone) - 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.						
Velum Prime (Fluopyram) – For suppression of nematodes, make soil application of 6.5 to 6.84 fl oz/acre. Chemigationally apply the specified dosage into root-zone through low-pressure drip, trickle, micro-sprinkler or equivalent equipment. Allow a minimum 7-day interval between soil applications. These products are 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 30-40%. 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 Florida ☹.** 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 20, 2018** 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.

Tomato Fungicides

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Tomato Fungicides

Conventional fungicides are 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 2018).

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

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

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:** Americop 40 DF, 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, Chloro-nil 720, Echo 720, Echo 90 DF, Echo Zn, Equus 500 Zn, Equus 720 SST, Equus DF, Initiate 720	**SEE INDIVIDUAL LABELS**		0	0.5	Use higher rates at fruit set and lower rates before fruit set.
	3	Rhyme (flutriafol)	7 fl oz	28 fl oz	0	0.5	Limit is 4 applications per season.
(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 an-other effective fungicide from a different FRAC group. See label for additional instructions pertaining to greenhouse usage.
	7 & 3	Aprovia Top (benzovindiflupyr + difenoconazole)	13.5 fl oz	53.6 fl oz	0	0.5	No more than 2 sequential applications on a 7-day interval before rotating to a non-FRAC group 7 fungicide; subsequent applications on no shorter than a 14-day interval. Limit of 4 apps per a year. See label for surfactant precau-tions. Not labeled for greenhouse use.
(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.
	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 restric-tion with off label crops.
	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.

Conventional fungicides are 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 2018).

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

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

Pertinent Diseases or Pathogens	Fungicide Group[1]	Chemical (active ingredients)	Max. Rate/Acre		Min. Days to		Remarks[2]
			Applic.	Season	Harvest	Reentry	
	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 & 3	Topguard EQ (azoxystrobin + flutriafol)	8 fl oz	32 fl oz	0	0.5	Limit is 4 applications per season. Do not use adjuvants or EC formulated tank mix partners. The addition of silicone or oil based additives may cause injury at high temperatures. Do not exceed 0.125% (v/v) adjuvant levels.
	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:** Americop 40 DF, 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:** Americop 40 DF, 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.
	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 FireWall 17 WP or 50 WP (streptomycin sulfate)	200 ppm	-	-	0.5	See label for details. For transplant production only. Many isolates are resistant to streptomycin.

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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	
	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	Rhyme (flutriafol)	7 fl oz	28 fl oz	0	0.5	Limit is 4 applications per season.
	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 usage.
	7 & 3	Aprovia Top (benzovindiflupyr + difenoconazole)	13.5 fl oz	53.6 fl oz	0	0.5	No more than 2 sequential applications on a 7-day interval before rotating to a non-FRAC group 7 fungicide; subsequent applications on no shorter than a 14-day interval. Limit of 4 apps per a year. See label for surfactant precautions. Not labeled for greenhouse use.
	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 usage.
	7 & 11	Luna Sensation (fluopyram + trifloxystrobin)	7.6 fl oz	27.1 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 & 3	Topguard EQ (azoxystrobin + flutriafol)	8 fl oz	32 fl oz	0	0.5	Limit is 4 applications per season. Do not use adjuvants or EC formulated tank mix partners. The addition of silicone or oil based additives may cause injury at high temperatures. Do not exceed 0.125% (v/v) adjuvant levels.
	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.
	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.

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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]
	U15 + M5	Orondis Opti (oxathiapiprolin + chlorothalonil)	2.5 pt	10 pt	0	4 hr	Do use Orondis Opti following a soil app. of another oxathiapiprolin product. No more than 2 sequential apps. before rotating to another mode of action; 7 day minimum app. interval. Applications of Orondis Opti should not exceed more than 33% of the total foliar fungicide apps., or 4 apps. per crop, whichever is fewer. Limit on multiple crops is 6 apps. per acre per year. Not labeled for greenhouse use.
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	**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 usage.
(suppression)	7	Endura (boscalid)	12.5 oz	25 oz	0	0.5	Alternate with non-FRAC code 7 fungicides.
	7	Luna Privelege	6.84 fl oz	13.7 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 usage.
	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 usage.
	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.
(suppression)	7 & 11	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.
	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.
	12	Emblem (fludioxonil)	7 fl oz	28 fl oz	0	0.5	Transplant and Greenhouse use only. Limit to 4 applications per year. No more than 2 sequential applications before rotating to a different mode of action for 2 applications.
	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.
	17	Decree 50 WDG (fenhexamid)	1.5 lb	6 lb	0	0.5	Transplant and Greenhouse use only. Do not make more than 2 consecutive applications.
	19	Ph-D WDG	6.2 oz	31.0 oz	0	4 hr	Alternate with a non-FRAC code 19 fungicide.
		Oso 5% SC (polyoxin D zinc salt)	13 fl oz	78 fl oz	0	4 hr	

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	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.
	U15 + M5	Orondis Opti (oxathiapiprolin + chlorothalonil)	2.5 pt	10 pt	0	4 hr	Do use Orondis Opti following a soil app. of another oxathiapiprolin product. No more than 2 sequential apps. before rotating to another mode of action; 7 day minimum app. interval. Applications of Orondis Opti should not exceed more than 33% of the total foliar fungicide apps., or 4 apps. per crop, whichever is fewer. Limit on multiple crops is 6 apps. per acre per year. Not labeled for greenhouse use.
Buckeye rot **Phytophthora fruit rot**	M1 + 4	Ridomil Gold Copper (copper hydroxide + mefenoxam)	2 lb	6 lb	14	2	Limited to 3 apps per season. Tankmix with mancozeb.
(*Phytophthora* spp.)	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, 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 + M5	Orondis Opti (oxathiapiprolin + chlorothalonil)	2.5 pt	10 pt	0	4 hr	Do use Orondis Opti following a soil app. of another oxathiapiprolin product. No more than 2 sequential apps. before rotating to another mode of action; 7 day minimum app. interval. Applications of Orondis Opti should not exceed more than 33% of the total foliar fungicide apps., or 4 apps. per crop, whichever is fewer. Limit on multiple crops is 6 apps. per acre per year. Not labeled for greenhouse use.
	U15 + 40	Orondis Ultra (oxathiapiprolin + mandipropamid)	8.0 fl oz	32 fl oz	1	4 hr	Do use Orondis Ultra following a soil app. of another oxathiapiprolin product. No more than 2 sequential apps. before rotating to another mode of action; 7 day minimum app. interval. Applications of Orondis Ultra should not exceed more than 33% of the total foliar fungicide apps., or 4 apps. per crop, whichever is fewer. Limit on multiple crops is 6 apps. per acre per year. See label for greenhouse instructions.
Early blight	M1	(copper compounds) **Many brands available:** Americop 40 DF, 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	

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	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	**SEE INDIVIDUAL LABELS**		0	0.5	Use higher rates at fruit set and lower rates before fruit set.
	3	Rhyme (flutriafol)	7 fl oz	28 fl oz	0	0.5	Limit is 4 applications per season.
	3	Tebuzol 3.6F Toledo 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 usage.
	7	Luna Privelege	6.84 fl oz	13.7 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 usage.
	7 & 3	Aprovia Top (benzovindiflupyr + difenoconazole)	13.5 fl oz	53.6 fl oz	0	0.5	No more than 2 sequential applications on a 7-day interval before rotating to a non-FRAC group 7 fungicide; subsequent applications on no shorter than a 14-day interval. Limit of 4 apps per a year. See label for surfactant precautions. Not labeled for greenhouse use.
	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 usage.
	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 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	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.

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	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 & 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 & 3	Topguard EQ (azoxystrobin + flutriafol)	8 fl oz	32 fl oz	0	0.5	Limit is 4 applications per season. Do not use adjuvants or EC formulated tank mix partners. The addition of silicone or oil based additives may cause injury at high temperatures. Do not exceed 0.125% (v/v) adjuvant levels.
	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.
	12	Emblem (fludioxonil)	7 fl oz	28 fl oz	0	0.5	Transplant and Greenhouse use only. Limit to 4 applications per year. No more than 2 sequential applications before rotating to a different mode of action for 2 applications.
	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 (zoaximide + mancozeb)	2.0 lb	16 lb	5	2	
	22 & M5	Zing! (zoaximide + chlorothalonil)	36 fl oz	288 fl oz	5	0.5	Limit is 8 apps per season. No more than 2 sequential applications before alternating to a different mode of action.
	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.
	U15 + M5	Orondis Opti (oxathiapiprolin + chlorothalonil)	2.5 pt	10 pt	0	4 hr	Do use Orondis Opti following a soil app. of another oxathiapiprolin product. No more than 2 sequential apps. before rotating to another mode of action; 7 day minimum app. interval. Applications of Orondis Opti should not exceed more than 33% of the total foliar fungicide apps., or 4 apps. per crop, whichever is fewer. Limit on multiple crops is 6 apps. per acre per year. Not labeled for greenhouse use.
Late blight	M1	(copper compounds) **Many brands available:** Americop 40 DF, 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.	

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	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	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, Chloro-nil 720, Echo 720, Echo 90 DF, Echo Zn, Equus 500 Zn, Equus 720 SST, Equus DF, Initiate 720	**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 fungi-cide 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 fungi-cide; use of an adjuvant may cause phytotoxic-ity.
	11 & 3	Topguard EQ (azoxystrobin + flutriafol)	8 fl oz	32 fl oz	0	0.5	Limit is 4 applications per season. Do not use adjuvants or EC formulated tank mix partners. The addition of silicone or oil based additives may cause injury at high temperatures. Do not exceed 0.125% (v/v) adjuvant levels.
(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 (zoaximide + mancozeb)	2.0 lb	16 lb	5	2	
	22 & M5	Zing! (zoaximide + chlorothalonil)	36 fl oz	288 fl oz	5	0.5	Limit is 8 apps per season. No more than 2 sequential applications before alternating to a different mode of action.
	27	Curzate 60DF (cymoxanil)	5 oz	30 oz per year	3	0.5	Must tank mix with another effective product.

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			Applic.	Season	Harvest	Reentry	
	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.
	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	Revus (mandipropamid)	8 fl oz	32 fl oz	1	4 hr	No more than 2 sequential appl. Rotate with another effective fungicide; See label.
	40	Micora (mandipropamid)	8 fl oz/ 5,000 sq ft	16 fl oz/ 5,000 sq ft	n.a.	4 hr	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 + M5	Orondis Opti (oxathiapiprolin + chlorothalonil)	2.5 pt	10 pt	0	4 hr	Do use Orondis Opti following a soil app. of another oxathiapiprolin product. No more than 2 sequential apps. before rotating to another mode of action; 7 day minimum app. interval. Applications of Orondis Opti should not exceed more than 33% of the total foliar fungicide apps., or 4 apps. per crop, whichever is fewer. Limit on multiple crops is 6 apps. per acre per year. Not labeled for greenhouse use.
	U15 + 40	Orondis Ultra (oxathiapiprolin + mandipropamid)	8.0 fl oz	32 fl oz	1	4 hr	Do use Orondis Ultra following a soil app. of another oxathiapiprolin product. No more than 2 sequential apps. before rotating to another mode of action; 7 day minimum app. interval. Applications of Orondis Ultra should not exceed more than 33% of the total foliar fungicide apps., or 4 apps. per crop, whichever is fewer. Limit on multiple crops is 6 apps. per acre per year. See label for greenhouse instructions.
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	**SEE INDIVIDUAL LABELS**		0	0.5	Use higher rates at fruit set and lower rates before fruit set.
	7 & 3	Aprovia Top (benzovindiflupyr + difenoconazole)	13.5 fl oz	53.6 fl oz	0	0.5	No more than 2 sequential applications on a 7-day interval before rotating to a non-FRAC group 7 fungicide; subsequent applications on no shorter than a 14-day interval. Limit of 4 apps per a year. See label for surfactant precautions. Not labeled for greenhouse use.

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			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.
	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.
	U15 + M5	Orondis Opti (oxathiapiprolin + chlorothalonil)	2.5 pt	10 pt	0	4 hr	Do use Orondis Opti following a soil app. of another oxathiapiprolin product. No more than 2 sequential apps. before rotating to another mode of action; 7 day minimum app. interval. Applications of Orondis Opti should not exceed more than 33% of the total foliar fungicide apps., or 4 apps. per crop, whichever is fewer. Limit on multiple crops is 6 apps. per acre per year. Not labeled for greenhouse use.
Grey leaf spot (*Stemphyllium* spp.)	M1	(copper compounds) Many brands available: Americop 40 DF, 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.
	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	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	**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 (mefenoxam + chlorothalonil)	3 lb	12 lb	14	2	Limit is 4 apps./crop.
	7 & 3	Aprovia Top (benzovindiflupyr + difenoconazole)	13.5 fl oz	53.6 fl oz	0	0.5	No more than 2 sequential applications on a 7-day interval before rotating to a non-FRAC group 7 fungicide; subsequent applications on no shorter than a 14-day interval. Limit of 4 apps per a year. See label for surfactant precautions. Not labeled for greenhouse use.
	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 usage.
	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.

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			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.
	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.
	U15 + M5	Orondis Opti (oxathiapiprolin + chlorothalonil)	2.5 pt	10 pt	0	4 hr	Do use Orondis Opti following a soil app. of another oxathiapiprolin product. No more than 2 sequential apps. before rotating to another mode of action; 7 day minimum app. interval. Applications of Orondis Opti should not exceed more than 33% of the total foliar fungicide apps., or 4 apps. per crop, whichever is fewer. Limit on multiple crops is 6 apps. per acre per year. Not labeled for greenhouse use.
Phytophthora crown rot, Phytophthora root rot (*Phytophthora* spp.)	4	Ridomil Gold SL Ultra Flourish (mefenoxam)	1 pt 2 pt	3 pt 6 pt	28 7	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.
	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.

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	U15	Orondis Gold 200 (oxathiapiprolin)	9.6 fl oz	19.2 fl oz	0	4 hr	Soil applications cannot be combined or followed by foliar applications of Orondis Opti or Orondis Ultra. No more than 2 sequential apps. before rotating to another mode of action; 7 day minimum app. interval. Applications of Orondis Gold should not exceed more than 33% of the total fungicide apps., or 4 apps. per crop, whichever is fewer. Limit on multiple crops is 6 apps. per acre per year. Not labeled for greenhouse use.
	U15 + 40	Orondis Ultra (oxathiapiprolin + mandipropamid)	8.0 fl oz	32 fl oz	1	4 hr	Do use Orondis Ultra following a soil app. of another oxathiapiprolin product. No more than 2 sequential apps. before rotating to another mode of action; 7 day minimum app. interval. Applications of Orondis Ultra should not exceed more than 33% of the total foliar fungicide apps., or 4 apps. per crop, whichever is fewer. Limit on multiple crops is 6 apps. per acre per year. See label for greenhouse instructions.
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	Rhyme (flutriafol)	7 fl oz	28 fl oz	0	0.5	Limit is 4 applications per season.
	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.
	3	Trionic 4SC (triflumizole)	4 fl oz/ 100 gal	16 fl oz	1	0.5	Greenhouse use only. Limit is 4 applications per season.
	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 usage.
	7	Luna Privelege Velum Prime (fluopyram)	6.84 fl oz	13.7 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 usage. See Velum Prime label for soil applications.
	7 & 3	Aprovia Top (benzovindiflupyr + difenoconazole)	13.5 fl oz	53.6 fl oz	0	0.5	No more than 2 sequential applications on a 7-day interval before rotating to a non-FRAC group 7 fungicide; subsequent applications on no shorter than a 14-day interval. Limit of 4 apps per a year. See label for surfactant precautions. Not labeled for greenhouse use.
	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 usage.
	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.

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			Applic.	Season	Harvest	Reentry	
	11	Heritage	3.2 oz	1.6 lb	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.
		Quadris FL	6.2 fl oz	37 fl oz	0	4 hr	
		Equation	6.2 fl oz	37 fl oz	0	4 hr	
		Satori	6.2 fl oz	37 fl oz	0	4 hr	
		(azoxystrobin)					
	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	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.
		Gem 500 SC	3.8 floz	16 fl oz	3	0.5	
		(trifloxystrobin)					
	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 & 3	Topguard EQ (azoxystrobin + flutriafol)	8 fl oz	32 fl oz	0	0.5	Limit is 4 applications per season. Do not use adjuvants or EC formulated tank mix partners. The addition of silicone or oil based additives may cause injury at high temperatures. Do not exceed 0.125% (v/v) adjuvant levels.
	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.
	12	Emblem (fludioxonil)	7 fl oz	28 fl oz	0	0.5	Transplant and Greenhouse use only. Limit to 4 applications per year. No more than 2 sequential applications before rotating to a different mode of action for 2 applications.
	19	Ph-D WDG	6.2 oz	31.0 oz	0	4 hr	Alternate with a non-FRAC code 19 fungicide.
		Oso 5% SC	13 fl oz	78 fl oz	0	4 hr	
		(polyoxin D zinc salt)					
	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	Ridomil Gold GR	20 lb	40 lb	28	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.
		Ridomil Gold SL	2 pt	3 pt	7	2*	
		Ultra Flourish	2 pt	6 pt	7	2	
		(mefenoxam)					
	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.

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	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	**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.
	7 & 3	Aprovia Top (benzovindiflupyr + difenoconazole)	13.5 fl oz	53.6 fl oz	0	0.5	No more than 2 sequential applications on a 7-day interval before rotating to a non-FRAC group 7 fungicide; subsequent applications on no shorter than a 14-day interval. Limit of 4 apps per a year. See label for surfactant precautions. Not labeled for greenhouse use.
(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.
	14	Blocker 4F Terraclor 75 WP (PCNB)	**SEE INDIVIDUAL LABELS**		Soil treatment at planting	0.5	See label for application type and restrictions
	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 specific precautions and limitations for mixing with this product.
	U15 + M5	Orondis Opti (oxathiapiprolin + chlorothalonil)	2.5 pt	10 pt	0	4 hr	Do use Orondis Opti following a soil app. of another oxathiapiprolin product. No more than 2 sequential apps. before rotating to another mode of action; 7 day minimum app. interval. Applications of Orondis Opti should not exceed more than 33% of the total foliar fungicide apps., or 4 apps. per crop, whichever is fewer. Limit on multiple crops is 6 apps. per acre per year. Not labeled for greenhouse use.
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:** Americop 40 DF, 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.	
	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		
	M3	Ziram 76DF (ziram)	4 lbs	23.7 lb	7	2	Do not use on cherry tomatoes.

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			Applic.	Season	Harvest	Reentry	
	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	**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 usage.
	7	Luna Privelege	6.84 fl oz	13.7 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 usage.
	7 & 3	Aprovia Top (benzovindiflupyr + difenoconazole)	13.5 fl oz	53.6 fl oz	0	0.5	No more than 2 sequential applications on a 7-day interval before rotating to a non-FRAC group 7 fungicide; subsequent applications on no shorter than a 14-day interval. Limit of 4 apps per a year. See label for surfactant precautions. Not labeled for greenhouse use.
	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 usage.
	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	3.2 oz	1.6 lb	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.
		Quadris FL	6.2 fl oz	37 fl oz	0	4 hr	
		Equation	6.2 fl oz	37 fl oz	0	4 hr	
		Satori	6.2 fl oz	37 fl oz	0	4 hr	
		(azoxystrobin)					
	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	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.
	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 & 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	Topguard EQ (azoxystrobin + flutriafol)	8 fl oz	32 fl oz	0	0.5	Limit is 4 applications per season. Do not use adjuvants or EC formulated tank mix partners. The addition of silicone or oil based additives may cause injury at high temperatures. Do not exceed 0.125% (v/v) adjuvant levels.
	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.

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	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	
	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.
	U15 + M5	Orondis Opti (oxathiapiprolin + chlorothalonil)	2.5 pt	10 pt	0	4 hr	Do use Orondis Opti following a soil app. of another oxathiapiprolin product. No more than 2 sequential apps. before rotating to another mode of action; 7 day minimum app. interval. Applications of Orondis Opti should not exceed more than 33% of the total foliar fungicide apps., or 4 apps. per crop, whichever is fewer. Limit on multiple crops is 6 apps. per acre per year. Not labeled for greenhouse use.
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.
(suppression)	7 & 3	Aprovia Top (benzovindiflupyr + difenoconazole)	13.5 fl oz	53.6 fl oz	0	0.5	No more than 2 sequential applications on a 7-day interval before rotating to a non-FRAC group 7 fungicide; subsequent applications on no shorter than a 14-day interval. Limit of 4 apps per a year. See label for surfactant precautions. Not labeled for greenhouse use.
	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.
	3	Rhyme (flutriafol)	7 fl oz	28 fl oz	0	0.5	Limit is 4 applications per season.
	4 & M5	Ridomil Gold Bravo 76.4 W (chlorothalonil + mefenoxam)	3 lb	12 lb	14	2	Limit is 4 appl./crop.

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			Applic.	Season	Harvest	Reentry	
	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 apps. before switching to another effective fungicide with a different mode of action. See label for additional instructions pertaining to greenhouse usage.
	7 & 3	Aprovia Top (benzovindiflupyr + difenoconazole)	13.5 fl oz	53.6 fl oz	0	0.5	No more than 2 sequential applications on a 7-day interval before rotating to a non-FRAC group 7 fungicide; subsequent applications on no shorter than a 14-day interval. Limit of 4 apps per a year. See label for surfactant precautions. Not labeled for greenhouse use.
	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 usage.
	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	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	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 & 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	Topguard EQ (azoxystrobin + flutriafol)	8 fl oz	32 fl oz	0	0.5	Limit is 4 applications per season. Do not use adjuvants or EC formulated tank mix partners. The addition of silicone or oil based additives may cause injury at high temperatures. Do not exceed 0.125% (v/v) adjuvant levels.
	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.

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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]
	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.
	U15 + M5	Orondis Opti (oxathiapiprolin + chlorothalonil)	2.5 pt	10 pt	0	4 hr	Do use Orondis Opti following a soil app. of another oxathiapiprolin product. No more than 2 sequential apps. before rotating to another mode of action; 7 day minimum app. interval. Applications of Orondis Opti should not exceed more than 33% of the total foliar fungicide apps., or 4 apps. per crop, whichever is fewer. Limit on multiple crops is 6 apps. per acre per year. Not labeled for greenhouse use.
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.
(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 2018; 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

Ordered alphabetically by commercial name. (Updated June 2018).

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]
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.
(potassium bicarbonate), NC *Many brands available:* **Armicarb 100, Armicarb "O", Carb-O-Nator, Eco-mate, Kaligreen, Milstop**	Broad spectrum fungicide	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.
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* strain DSM 14940, 14941)	Anthracnose, Botrytis, Phomopsis, Rhizopus	0	4 hr	Yes	See label for specific rates and application recommendations. Check label for precautions regarding incompatibility with fungicides.
BotryStop (*Ulocladium oudemansii* U3 strain)	Botrytis, Sclerotinia	0	4 hr	No	See label for specific rates, application recommendations, and precautions regarding fungicide compatibility.
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.
Cinnerate (Cinnamon oil), NC	Powdery mildew, Botrytis, Rusts	0	0	Yes	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.
Debug (Fats and glyceridic oils Mongosa, Azadirachtin), NC	Powdery mildew, Rust, *Rhizoctonia*, *Sclerotinia, Sclerotium rolfsii*	0	4 hr	Yes	See label for specific rates and application recommendations.
Double Nickel 55 **Double Nickel LC** **Triathlon BA** (*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.

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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.
GreenClean PRO **PerCarb** (sodium carbonate peroxyhydrate)	Broad spectrum fungicide/bactericide	0		No	See label for specific rates and application recommendations.
(Hydrogen peroxide + peroxyacetic acid), NC *Many brands available:* **Jet-Ag, OxiDate 2.0, Rendition, SaniDate 12.0, SaniDate WTO, SaniDate 5.0, SaniDate FD, SaniDate 15.0, StorOx 2.0, TerraStart, TerraClean 5.0, ZeroTol 2.0**	Broad spectrum fungicide	0	1 hr for enclosed areas; until spray dries in open field areas.	No	See labels for specific rates, application recommendations, and precautions regarding use with other pesticides. Some formulations can be used as a soil drench at transplant and periodically throughout the season. Can also be used as a seed treatment or for post-harvest treatments.
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.
LEAP ES (*Bacillus thuringiensis*, subsp. *kurstaki*, strain ABTS-351 and methyl salicylate)	*Xanthomonas* spp.	0	0.5	No	Apply before disease is observed in the field; should be used as part of a plant pathogen control program. See label for details regarding insecticidal activity.
Lifeguard (*Bacillus mycoides* isolate J)	Broad spectrum fungicide		4 hr	Yes	See label for specific rates and application recommendations.
Nutrol (potassium phosphate)	Powdery mildew	0	0	No	Do not mix with copper fungicides or other products affected by low pH (< 5.5). See label for specific rates and application recommendations.
OxiPhos (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.
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.
(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, Phiticide, 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.
Prev-Am (sodium tetraborohydrate decahydrate)	*Downy mildew, Botrytis, Powdery mildew, Late blight, White rust, White mold,*	0	0.5	No	See label for details, crop specific recommendations, and precautions.
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.
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.
RootShield Granular (Trichoderma harzianum Rifai strain T-22), NC	Cylindrocladium *spp.,* Fusarium spp., *Pythium* spp., *Rhizoctonia* spp., *Thielaviopsis* spp.	0	0	Yes	See label for specific rates, application recommendations, and precautions regarding use and fungicide compatibility.
(Trichoderma harzianum Rifai strain KRL-AG2), NC					

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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]
RootSheild Plus Granular **RootShield Plus WP** (*Trichoderma harzianum* Rifai strain T-22 and *Trichoderma virens* strain G-41), NC	*Cylindrocladium spp., Fusarium spp., Pythium spp., Rhizoctonia spp., Thielaviopsis spp.*	0	4 hr	Yes	See label for specific rates, application recommendations, and precautions regarding use and fungicide compatibility.
Serenade ASO **Serenade Max** **Serenade Opti** **Serenade Optimum** **Serenade Soil** (*Bacillus subtilis* strain QST 713), 44	Bacterial speck, Bacterial spot, Botrytis, Early Blight, Fusarium spp., Late Blight, ,Phytophthora spp., Powdery mildew, Pythium spp., Rhizoctonia spp., Target spot, Verticillium spp.	0	4 hr	Yes	For foliar applications mix with copper compounds or other effective fungicides for improved disease control. See label for details regarding specific foliar and soil applications and target diseases.
Serifel Biofungicide (*Bacillus amyloliquefaciens* strain MBI 600)	Broad spectrum fungicide	0	4 hr	Yes	See label for details, crop specific recommendations, and precautions.
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 (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. See label for precautions regarding use and fungicide compatibility.
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.
SuffOil-X **TriTek** (mineral oil)	Powdery mildew	0	4 hr	Yes	See label for specific rates, application recommendations, precautions, and fungicide compatibility.
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.
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.
Thyme Guard (thyme oil extract)	Broad spectrum bactericide and fungicide	-	-	Yes	See label for specific rates and application recommendations.

Product (active ingredient), Fungicide Group[1]	Pertinent Diseases or Pathogens	Minimum Days to: Harvest	Minimum Days to: Reentry	OMRI Listed	Remarks[2]
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Ultra-Pure Oil (mineral oil)	Powdery mildew	0	4 hr	Yes	See label for specific rates, application recommendations, precautions, and fungicide compatibility.
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 2018; 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.