FLORIDA TOMATO INSTITUTE PROCEEDINGS

SEPTEMBER 3, 2008

COMPILED BY:

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CITRUS+ VEGETABLE

UNIVERSITY OF FLORIDA IFAS EXTENSION

THE GROWER

2008 FLORIDA TOMATO INSTITUTE

The Ritz-Carlton, Naples, Florida

September 3, 2008 | PRO 525

MODERATOR: CRYSTAL SNODGRASS, MANATEE COUNTY EXTENSION SERVICE, PALMETTO

9:00 **Welcome –** *Daniel Cantliffe, Distinguished Professor and Chair, UF/IFAS, Horticultural Sciences Dept., Gainesville*

9:15 **State of the Industry –** *Reggie Brown, Florida Tomato Committee, Maitland*

9:30 **CUE and Fumigant Assessment Update –** *Mike Aerts, FFVA, Maitland*

9:50 **Fumigant Update –** *Steve Olson, UF/IFAS, NFREC, Quincy*

10:10 **Update on Late Blight on Tomato: Recent Late Blight Isolates in Florida and Updated Management Options –** *Pam Roberts, UF/IFAS, SWFREC, Immokalee:* ***page 6***

10:30 **Introducing Grafting Technology to the Florida Tomato Industry: Potential Benefits and Challenges –** *Xin Zhao, UF/IFAS, Horticultural Sciences Dept., Gainesville:* ***page 9***

10:50 **Evaluation of TYLC Virus-resistant Varieties Under Commercial Conditions in Southwest Florida –** *Monica Ozores-Hampton, UF/IFAS, SWFREC, Immokalee:* ***page 12***

11:10 **Food Safety Update –** Martha Roberts, UF/IFAS, Tallahassee

11:30 **Lunch** *(on your own)*

MODERATOR: DAVID SUI, PALM BEACH COUNTY EXTENSION SERVICE, WEST PALM BEACH

TOMATO PURPLE LEAF DISORDER WORKSHOP

1:00 **Introduction –** *Gary Vallad, UF/IFAS, GCREC, Wimauma*

1:10 **Tomato Purple Leaf: A New Disorder or Disease of Tomato? –** *Gary Vallad, UF/IFAS, GCREC, Wimauma:* ***page 16***

1:30 **Sudden Decay of Tomato Fruit –** *Jerry Bartz, UF/IFAS Plant Pathology Dept.,Gainesville:* ***page 20***

1:50 **Studies to Determine the Cause of Tomato Purple Leaf Disorder –** *Jane Polston, UF/IFAS Plant Pathodlogy Dept., Gainesville:* ***page 22***

2:10 **Questions and answers**

2:30 **Industry New Product Update –** *Alicia Whidden , Hillsborough County Extension Service, Seffner*

3:30 **Adjourn**

PRODUCTION GUIDES

UPDATE ON LATE BLIGHT ON TOMATO:

RECENT LATE BLIGHT ISOLATES IN FLORIDA AND UPDATED MANAGEMENT OPTIONS

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Late blight, caused by the fungal-like plant pathogen *Phytophthora infestans*, is a chronic disease problem on tomato and potato in Florida and has occurred in south Florida on these hosts in nine out of the previous ten production seasons (Table 1). Environmental conditions in south Florida are generally favorable for late blight development with moderate temperatures and adequate nighttime durations of leaf wetness during the production season. Fungicide spray programs are typically sufficient to manage the disease in commercial fields except during ideal environmental conditions when a more intensive fungicide spray program may be required.

TABLE 1. Occurrence of *Phytophthora infestans* for the previous 10 growing seasons in South Florida.

FLORIDA GROWING SEASON (AUGUST-MAY)	DATE OF FIRST RECORDED DETECTION[Z]	FIRST HOST REPORTED
1998-99	DEC 22, 1998	
1999-00	JAN 29, 2000	POTATO
2000-01	FEB 9, 2001	POTATO
2001-02	FEB 15, 2002	TOMATO
2002-03	NONE	
2003-04	JAN 23, 2004	POTATO
2004-05	JAN 7, 2005	POTATO
2005-06	JAN 10, 2006	TOMATO
2006-07	NOV 17, 2006	TOMATO
2006-07	NOV 20, 2006	POTATO
2007-08	FEB 7, 2008	TOMATO

[Z] SOURCE: FLORIDA EXTENSION PLANT DISEASE DIAGNOSTIC CLINIC, IMMOKALEE, FL AND SOUTH FLORIDA VEGETABLE PEST AND DISEASE HOTLINE.

BACKGROUND

Historically, the worldwide population of *P. infestans* was relatively stable until the late 1980's and consisted of a single clonal lineage, named US-1 which was of the A1 mating type. The exception was *P. infestans* in Mexico where both A1 and A2 mating types occurred and the population was more diverse. In *P. infestans*, sexual recombination leading to new genetic combinations is possible when mating types A1 and A2 are present together. The population of P. infestans is monitored by characterization of isolates using several techniques. Isolates are described by the mating type (A1 or A2), sensitivity to fungicide, pathogenicity, and determination of genotypes through the use of molecular techniques. Genotyping typically includes cellulose acetate electrophoresis (CAE) for the glucose-6-phosphate isomerase (GPI) and peptidase (PEP) allozymes loci, mitochondrial DNA haplotype (mtDNA), and DNA fingerprinting. A clonal lineage of *P. infestans* represents a population reproduced asexually from a single isolate or genotype.

However, in the early 1980's the A2 mating type was found in Europe and by the early 1990's, it was also found in the U.S. (Deahl et al. 1991). Dramatic population shifts of *P. infestans* including increased aggressiveness occurred worldwide and within Florida in the early 1990's (Goodwin et al., 1992; Goodwin et al., 1998; Weingartner and Tombololato, 2002). Additionally, isolates became resistant to phenylamide (metalaxyl) and it became increasingly more difficult to control the disease (Deahl et al. 2002; Fry and Smart, 1999). In Florida, a new genotype, US-6, was detected for the first time from tomato in Lee County in 1991 (Weingartner and Tombolato, 2002). However, it was not until 1993 that epidemics associated with the new genotype occurred in the state. From 1993 through 2002, the population of *P. infestans* on tomato became much more diverse as genotypes characterized as US-1, US-6, US-7, US-8, US-10, US-11 and US 17 were detected in Florida (Table 2).

CURRENT SITUATION

Currently, it appears that another shift in pathogen population is occurring within Florida, the US, and Europe. Isolates with unique genotypes and epidemiological parameters including increased aggressive were detected in Florida and throughout the northeastern region of the United States and Europe (Cooke et al., 2007a; Deahl, author, unpublished, 2008; Schultz et al., 2006). The more aggressive, fungicide-resistant and host-specialized isolates have appeared on potato and tomato crops and changes to the late blight population are documented throughout Europe (www.eucablight.org).

In Florida, during the 2004-05 production season, a different late blight was recognized by growers who reported that the disease on tomato was very aggressive and that fungicides were not nearly as effective to control the disease as compared to previous seasons. Growers along the northeast growing region of the US reported the same phenomenon later in the same season. Characterization of *P. infestans* isolates from tomato documented a new, unique genotype of *P. infestans* with apparently increased aggressiveness that confirmed field reports (Fig. 1; Shultz et al. 2006; Deahl, unpublished data). Isolates of P. infestans from Florida tomato in the 2004-05 and the two following seasons were characterized and compared by mating type, GPI and PEP allozymes loci, mitochondrial genomic haplotype, RG57 DNA fingerprint, pathogenicity and sensitivity to metalaxyl (Goodwin et al., 1992; Goodwin et al., 1995; Griffith and Shaw, 1998; Shattock, 1998). Isolates from the 2004-05

TABLE 2. Genotypes of *Phytophthora infestans* and years detected during the period 1993 to 2007 in Florida (Modified from Weingartner and Tombolato, 2002).

YEAR	GENOTYPES	YEAR	GENOTYPES
1993	US-1, US-6, US-7	2000	US-8, US-10, US17
1994	US-8	2001	US-8
1995	US-1, US-8	2002	US-11, US17
1996	US-7, US-8	2004-05	N/D[Z]
1997	US-1, US-8, US17	2005-06	US-8, N/D[Z,Y]
1998	US-8, US-11, US17	2006-07	N/D[Z,Y]
1999	US-8, US-10, US17		

[Z] N/D = NOT DETERMINED, DOES NOT CONFORM TO ANY PUBLISHED US GENOTYPE; ON TOMATO
[Y] DIFFERENT GENOTYPE FROM 2004-05 ISOLATES (SEE TABLE 3)

epidemic shared identical profiles by these techniques and were sensitive to metalaxyl, except one which exhibited intermediate resistance. In the following growing seasons, the genotype profile of the isolates which occurred in 2004-05 has not been detected; however, characterization of isolates from these seasons showed that they are also unique compared to previously documented US genotypes in Florida and within the US (Table 3; Deahl, unpublished data). The isolates collected in 2006 and 2007 exhibited a greater range in response to metalaxyl from sensitive to resistant. In contrast, the population of *P. infestans* on potato appears to be more stable and is genotyped in Florida as US-8 which is also the predominant population in the US (Wangsomboondee et al., 2002). However, the presence of this genotype, adds to the increased the risk of variability within the population since it could possibly recombine with the isolates on tomato (Weingartner and Tombololato, 2002). Continued studies are needed to determine the range of genomic diversity of the pathogen and if the population is continuing to change. Therefore, it is important to monitor the population shift of *P. infestans* continuously to determine the risk of increased aggressiveness, including the risk of fungicide insensitivity by the new genotypes.

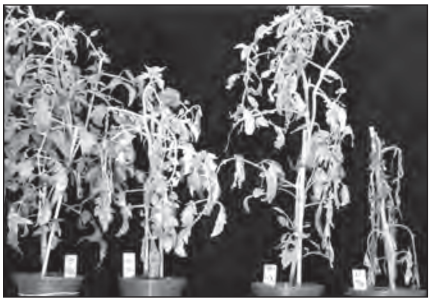

FIGURE 1. Pathogenicity test on 'Florida 47' tomato plants inoculated with 10^3 sporangial suspension. Two representative isolates from 2004-05 (left) and two from 2006 (right) are presented after 14 days in greenhouse.

MANAGEMENT CONSIDERATIONS

The initial source of inoculum for late blight may be from infected cull piles, volunteers, and alternative hosts. Sporangia of *P. infestans* are readily airborne and dispersed by wind and rain. Under tropical/subtropical conditions, the sporangia are always abundant and were concluded to have more important role in late blight outbreaks than inoculum from crop debris or alternative hosts in Brazil (Lima et al., 2008). There are no reports of oospores in Florida although both mating types have occurred (Weingartner and Tombolto, 2002; Tombolato, 2002). Oospores survive in the soil for long periods of time in the absence of host tissue. Whether oospores exist and may initiate late blight is not understood in Florida. The importance of oospores as an additional source of inoculum means a genetically more diverse pathogen population and its presence early in the growing season gives the pathogen a greater ability to respond to control strategies such as fungicide treatments (Andersson et al. 2008). Additionally, it has been reported that in rare cases, a few isolates are self-fertile and able to form oospores alone which would mean greater ability to survive long term, particularly in soil (Smart, 1998).

Quick profiling of *P. infestans* isolates from the field during at the beginning of an outbreak can aid in grower management decisions. However, complete characterization including the genotype is time-consuming since the pathogen must be isolated and purified prior to testing. For a quick (less than 24 hour) preliminary identification, the GPI profile can be used. Since the 2004-05 *P. infestans* isolates and some of other US genotypes are distinct by the GPI profile, in particular when compared to the isolates which occurred in the previous three seasons, the GPI profile can be used to quickly differentiate between some of these populations. Therefore, we have used this as quick tool in the diagnostic clinic in Immokalee to determine tentative isolate profile pending completion of the other assays.

Late blight management recommendations are similar for tomato and potato. However, one important difference is that late blight tolerant potato cultivars are available but no commercial resistance is available in tomato. Although not seed-borne on tomato, transplants may be infected while in the transplant house, therefore transplants must be free from symptoms. Since potato is vegetatively propagated and tubers may be infested, therefore certified, disease-free seed pieces should be planted. Other practices that help manage the disease are cultural practices to remove sources of inoculum such as destroying cull piles and destroying volunteer potato or tomato plants. Other sources of inoculum may be weeds or other solanaceous plants (Deahl and Fravel, 2003; Deahl et al. 2005; Deahl et al. 2006; Tombolato 2002). Tombolato (2002) determined through pathogenicity tests conducted in greenhouse studies that *P. infestans* can also infect pepper, petunia, American Black nightshade and Jimson weed. These hosts occur widely throughout south Florida home gardens and farms. Surveys have not been conducted to identify natural sources of inoculum on weeds or pepper or petunia of P. infestans in Florida. Early detection through scouting for plant symptoms of late blight is critical to initiate a fungicide spray program. The first report of late blight within a county was recorded in the 2006-07 growing season (Fig. 2). The first report for the season was from Collier County in November and subsequent findings in other counties were recorded in south and central Florida through April 2007. Additionally, growers are usually recommended to begin fungicide applications when weather conditions (cool temperatures and extended leaf moisture periods) are conducive to

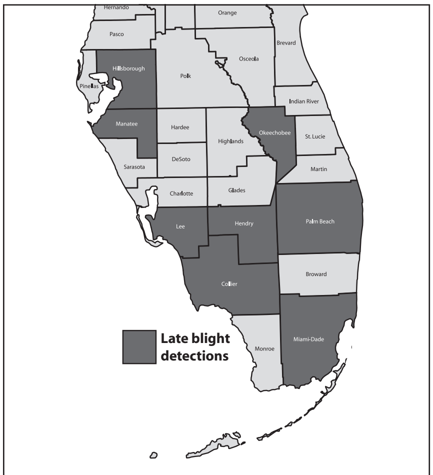

FIGURE 2. Confirmed reports of Late Blight by county in growing season 2006-07 (November-April).

DATE OF FIRST REPORTED DETECTION	COUNTY
11/21/06	COLLIER
01/18/07	HENDRY
01/18/07	PALM BEACH
01/19/07	LEE
01/19/07	HILLSBOROUGH
01/30/07	MIAMI-DADE
02/02/07	OKEECHOBEE
03/27/07	HENDRY
03/30/07	COLLIER (SWFREC)
04/2007	MANATEE

TABLE 3. Mating type, mitochondrial DNA haplotype (mtDNA), metalaxyl sensitivity, allozyme genotype (GPI), and RG57 fingerprint of isolates of *Phytophthora infestans* on tomato from 2004-2007.

GROWING SEASON	SAMPLE SIZE	MATING TYPE	mtDNA	GPI	METALAXYL SENSITIVITY[Z]	RG57 DNA FINGERPRINT	US GENOTYPE
2004-05	N=7	A2	IA	100/100	S (85%)	UNIQUE	N/D[Y]
					I (15%)		
2005-06	N=8	A2	IA	100/122	S (12%)	UNIQUE FROM 2004-5 AND OTHER PUBLISHED PROFILES	N/D
					I (88%)		
2006-07	N=12	A2	IA	100/122	S (25%)		N/D
					I (42%)	SAME AS 2005-06	
					R (8%)		
					U (25%)		

[Z] SENSITIVITY TO METALAXYL OF ISOLATES OF P. *INFESTANS*: R = RESISTANT; S = SENSITIVE; I = INTERMEDIATE (AS DEFINED BY SHATTOCK, 1988). U = UNDETERMINED
[Y] N/D = NOT DETERMINED, DOES NOT CONFORM TO ANY PUBLISHED US GENOTYPE

disease development. Although late blight forecasting models and spray decision aids have been developed since 1979 (i.e. LATEBLIGHT), their use in south Florida has been largely precluded due to the favorable environmental conditions which exist during much of the production season. Several fungicides including those representing new classes of chemistry and novel modes of action are now labeled for late blight on tomato and potato in Florida. ✻

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INTRODUCING GRAFTING TECHNOLOGY TO THE FLORIDA TOMATO INDUSTRY:

POTENTIAL BENEFITS AND CHALLENGES

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Vegetable grafting follows the same principles applied to fruit tree grafting. A new "graft hybrid" with combined desirable traits consists of the producing shoots that are removed from a plant called the scion and the roots that are provided by a plant called the rootstock. Production of grafted vegetables began in the 1920s when watermelon was grafted onto gourd rootstocks to battle Fusarium wilt in Japan and Korea. Although research efforts have continued thereon, vegetable grafting did not become popular until grafted eggplant transplants were used for commercial production in the 1960s (Lee, 1994; Oda, 1999). To date, this innovative technology has been successfully practiced on solanaceous and cucurbitaceous vegetables including eggplant, tomato, pepper, watermelon, cucumber, and melon, particularly in asian (e.g., Japan, Korea, China, and Israel) and mediterranean countries (e.g., Spain, Italy, Turkey, and Morocco; Lee, 2003; Lee, 2007; Leonardi and Romano, 2004; Oda, 2007). In addition to disease resistance, grafted plants have shown improved tolerance to various environmental stresses as well as enhanced uptake of water and nutrients, resulting in vigorous growth, extended growing period, and possible yield increase. Interest in vegetable grafting is expanding while the multifaceted benefits of grafted vegetables continue to be elucidated.

HOW CAN THE FLORIDA TOMATO INDUSTRY BENEFIT FROM USING GRAFTED TOMATO?

Alternative to methyl bromide. In commercial tomato production, the availability of broad spectrum fumigants together with reduced rotation and land availability have created a dependence on methyl bromide/chloropicrin mixes for the control of soil-borne pathogens, weeds, and nematodes. With the phased-out ban on methyl bromide in the U.S. as described in the Montreal Protocol, intense efforts have been made in the U.S. and Florida to find alternative chemical strategies. Little importance has been given to grafting in that quest. However, interest in this technique as an effective means to control disease is emerging today. USDA Horticultural Research Laboratory and several land-grant universities, such as University of Florida, North Carolina State University, The Ohio State University, and University of Arizona, have recently launched research programs on tomato grafting.

TABLE 1. List of selected suppliers for tomato rootstock seeds in the United States.

COMPANY	WEBSITE
AMERICAN TAKII SEED	http://www.takii.com/
BRUINSMA SEEDS	http://www.bruinsma.com/engels/
DE RUITER SEEDS	http://www.deruiterusa.com/
D. PALMER SEED	http://www.dpalmerseed.com/
JOHNNY'S SELECTED SEEDS	http://www.johnnyseeds.com/
RIJK ZWAAN USA	http://www.rijkzwaanusa.com/

At UF, we have initiated a project to investigate the feasibility of grafted tomato production using disease-resistant rootstocks in the absence of soil fumigants. Tomato rootstocks are bred primarily for their resistance to Fusarium wilt, Verticillium wilt, bacterial wilt, crown and root rot, root-knot nematodes, and/or tobacco mosaic virus (Lee, 2003; Oda, 2007). A few seed companies can currently provide tomato rootstocks in the U.S. (Table 1). We are currently testing 'Maxifort' (De Ruiter Seeds) which is one of the most popular rootstocks for greenhouse tomato production in the US because of its prominent disease resistance, high grafting compatibility, and strong vigor. Another newly released rootstock by De Ruiter is also included in our on-going study, which is claimed by the company to be especially suitable for growing grafted tomato in the open field (personal communication).

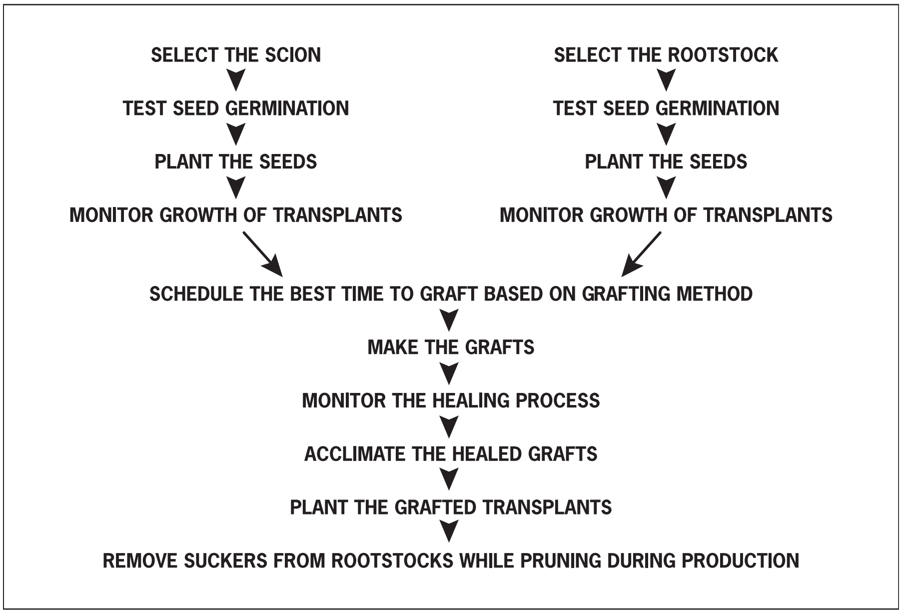
Complementary to tomato breeding programs. Grafting can create a new tomato plant by joining through a physical contact (the graft) a rootstock plant and a scion plant. It appears that grafting is a technique that could be more rapid than breeding in combining the advantages of disease resistance of the rootstock with the horticultural characteristics of the scion. One of the greatest challenges in plant breeding is the difficulty of combining multiple desirable traits into a single variety. In tomato breeding, the use of hybrids is driven principally by the convenience of combining varieties with dominant disease resistance genes. Likewise, the use of grafted tomatoes has the potential to accelerate the breeding process and take full advantage of the tomato germplasm. It is known that some of the commercially available rootstocks are interspecific hybrids derived from *Lycospericon esculentum* and *L. hirsutum* (Oda, 2007). Scion varieties with desirable above-ground traits (such as fruit quality and resistance to foliar diseases and insects) may be grafted onto rootstock varieties with desirable below-ground qualities (resistance to soil-borne diseases). Furthermore, new genetic sources of resistance to emerging pest problems may be more rapidly deployed as rootstocks without the need to integrate them into existing elite high quality lines. In short, grafting allows simultaneous breeding for above and below ground traits, thereby requiring the breeding of four parents.

Innovative component of best management practices. Increased efficiency of nutrient and water absorption has been observed on grafted vegetables, possibly caused by the vigorous root system of the rootstock (Lee, 1994). Reduced fertilizer inputs have been reported on grafted cucurbits (Lee, 2003). However, performance of grafted vegetables varies substantially among grafting combinations with different rootstocks. In a recent study, out of three rootstocks tested, only 'Beaufort' (De Ruiter Seeds) exhibited significantly higher uptake of nitrogen, phosphorus, potassium, calcium, magnesium, and sulfur on the basis of production area accompanied by a significant yield increase, as compared to the self-grafted control plants (Leonardi and Giuffrida, 2006). Given the availability of appropriate rootstocks for targeted tomato scion varieties, a distinctive nutrient management program for grafted tomato production may be established to achieve improved fertilizer use efficiency in Florida where nutrient leaching and runoff may be of environmental concern. Double-stem pruning and lower plant density can be used for cultivation of grafted tomatoes (Leonardi and Romano, 2004). In-depth studies are underway to evaluate the rootstock effect on water and nutrient uptake characteristics in grafted tomato plants.

Potential for increase of crop productivity even under little disease pressure. Despite the initial objective of vegetable grafting to improve crop resistance to soil-borne diseases, yield increase of grafted vegetables has been directly linked to improvement of tolerance to abiotic stresses (including low and high temperatures, salinity, and flooding), enhancement of nutrient and water uptake, and delayed senescence due to the grafting vigor. Modification of endogenous plant hormone status by rootstock has also been indicated as playing a role in promoting growth of grafted vegetables (Edelstein, 2004; Lee, 1994, 2003). With improved yield performance, fruit quality attributes of grafted tomatoes (measured as firmness, pH, soluble solids, titratable acidity, and concentrations of lycopene, and minerals) were not affected by rootstocks (Khah et al., 2006). In our greenhouse study of grafted tomato, 'Florida 47' grafted onto 'Maxifort' showed an overall increase in fruit number and fruit size compared to the self-rooted 'Florida 47'.

Unique role in organic and sustainable tomato production. Pest control and nutrient management represent critical challenges in organic vegetable production. A team at The Ohio State University is investigating the benefits of grafting technology for sustainable and organic tomato production systems (The Vegetable Growers News, 2006). Grafting disease susceptible heirloom tomatoes with resistant rootstocks is recommended for organic cultivation by researchers at North Carolina State University (Rivard, 2006; Rivard and Louws, 2006). As an environmentally friendly practice for disease management and enhancement of crop productivity that can be easily incorporated into organic systems, grafting is very likely to be adopted by the rapidly growing organic tomato industry in Florida.

FIGURE 1. Overview of procedures for grafted tomato production



DEALING WITH LIMITATIONS AND CHALLENGES

Vegetable grafting technology is certainly not a panacea. Limitations and challenges associated with growing grafted tomatoes should be considered to optimize management practices and ensure both economic viability and environmental benefits.

Cost. The cost of using grafted plants in commercial production is often perceived as an obstacle for the wide-spread adoption of this technique. However, the cost of grafted transplants should be compared to the potential savings in pest-control products and potential yield increase. A glance at the procedures used for grafted tomato production reveals the additional cost of seeds (2 seeds vs 1), greenhouse space (2 transplants vs 1), supplies, and labor associated with grafting (Fig. 1). Current tomato rootstock varieties are mostly developed abroad, resulting in high price of seeds and limited availability. With development of domestic tomato rootstock breeding programs, low price of rootstock seeds is expected. The main grafting methods for tomatoes include splice grafting (tube grafting), cleft grafting, and tongue approach grafting (Oda, 1999; 2007). A trained person can graft 125-150 seedlings per hour. Grafting machines and robots with high efficiency (300-1,200 grafts per hour) are now available (Lee, 1994; 2003). The grafting technique and systems have been improved over the decades and will continue to evolve towards higher efficiency and quality. A parallel comparison of grafted tomatoes to non-grafted tomatoes at various production conditions will help to determine the profitability. An important objective of our on-going tomato grafting project is to provide an objective, updated economic analysis for grafted tomato production in Florida, in which cost of grafting, cost reduction of soil fumigants, potentially higher yield of grafted tomatoes, and contribution of grafting to protecting environmental quality are all taken into account.

Incompatibility. Graft incompatibility refers to the failure of the scion to unite with the rootstock and the lack of healthy growth of the grafted plant. Incompatibility between scion and rootstock causes physiological disorder, considerable yield decrease, undesirable fruit quality, and even plant collapse (Edelstein, 2004). Although survival rate of grafts following the healing process may be used to assess incompatibility, field evaluation is often necessary for selection of rootstocks with good compatibility. Modern rootstock varieties are selected to avoid incompatibility problem, however, in practice, scion-rootstock combinations still need to be experimented prior to commercial production.

Incomplete resistance. Although rootstocks can be highly resistant to a variety of soil-borne pathogens, complete resistance to all the root diseases and strains is unachievable. Successful production of grafted tomatoes in a given region will largely depend upon a careful selection of rootstocks that cope with prevalent devastating pathogens on site. Additionally, microclimate conditions may affect expression of resistance. For example, tomato rootstocks resistant to root-knot nematodes may become susceptible at soil temperature above 28 °C. During field establishment, transplant depth must be such that graft unions of tomato plants are above the soil surface to reduce the risk of secondary infection. When infection risk is high, tomato scion varieties with resistance to viruses and foliar pathogens should be used since current rootstocks are not known to confer resistance again these infections. Little is known about competition of grafted tomato plants with weeds commonly found in Florida tomato field production.

Detrimental effects of rootstock on fruit quality. Adverse effects of certain rootstocks on fruit quality of grafted cucurbits have been reported, such as undesirable fruit shape and taste (Edelstein, M. 2004; Lee, 1994). Even though the quality of grafted tomatoes is generally comparable to that of self-rooted plants, analysis of fruit quality is necessary especially when a new rootstock is used.

Delay of early harvest. Grafting may delay first flowering date and first harvest due to the physical stress incurred by grafting (Khah et al., 2006). Market tomato growers ought to be fully aware of such inconvenience and carefully schedule grafting and planting to minimize the effect. On the other hand, rootstocks that promote early production, however, might also be available.

Lack of studies of molecular basis for grafting vigor. Growth vigor of the "graft hybrid" is essentially an outcome of expression or interaction of the rootstock genetic material with that of the scion. Characterizing and sequencing the genes involved in the grafting vigor would allow targeted selection of rootstock-scion combinations. Previous research on graft vigor utilized in commercial production focused on the biochemical-physiological mechanisms. Not until recently did the research start to shed light on the function of long-distance transportation of RNA through phloem in grafted plants (Kudo and Harada, 2007). Elucidating the role of graft-transmissible RNA in altering the characters of scion and achieving desirable grafting vigor also presents tremendous opportunities for innovative use of genetic resources in tomato production.

CONCLUDING REMARKS

The Florida tomato industry which comprises 40,000 acres of tomatoes is faced with the complete phase-out of methyl bromide in the near future. Among all the possible alternatives, the grafting technique deserves full attention thanks to the multifold benefits that it may bring to the large tomato industry in Florida. As for perennial crops, successful grafting of tomato involves not only the selection of a mechanical technique that unites two plants, but also a judicious choice of the rootstock and the scion. Integration of grafting into the present tomato production systems will require a comprehensive analysis of cost and returns. Adaption of rootstocks to specific production environments deserves intensive evaluation. We believe that in the near future, grafting will become an integral part of sustainable commercial tomato production in Florida. ✻

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EVALUATION OF TYLC VIRUS-RESISTANT VARIETIES

UNDER COMMERCIAL CONDITIONS IN SOUTHWEST FLORIDA

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During the spring of 2007, tomato crops in Southwest Florida experienced high whitefly populations and high incidence of tomato yellow leaf curl virus (TYLCV) which resulted in significant yield losses. Considered by some to be the worst tomato virus worldwide, TYLCV is now endemic to Florida. The virus causes stunted growth and flower abortion with early infections resulting in almost no fruit set (Schuster and Stansly, 1996). Tomato growers have focused on whitefly control to reduce losses. Management of whitefly and TYLCV rests primarily on insecticides, particularly the neonicotinoids, and tomato-free planting periods initiated by timely crop destruction after harvest (Schuster and Polston, 1999). However, insufficient control, in part due to insecticide resistance calls for alternative management tools.

The most important of these management tools is to the use of TYLCV-resistant varieties. TYLCV-resistant varieties adapted to Florida have already been developed by several seed companies and the University of Florida, and were evaluated 8 years ago (Gilreath et al. 2000) and more recently by Cushman and Stansly (2006). With the availability of new promising advanced selections, the objectives of this study were to document the TYLCV resistance and horticultural characteristics of these TYLCV-resistant tomato varieties.

TABLE 1. Tomato varieties and advanced breeding lines evaluation during Spring 2007 and 2008.

VARIETY	SOURCE	NUMBER OF SUCKERS PRUNED	VIRUS INCIDENCE[Z] (%)	BACTERIAL SPOT RATING (1-5)	FUSARIUM CROWN ROT (%)
SPRING 2007, ROUND TOMATOES					
BHN 745	BHN SEED	2-3	33.9CD	N/D	N/D
FLA 8576	UF[Y]	2-3	39.3C	N/D	N/D
FLA 8579	UF	2-3	32.1CD	N/D	N/D
FLA 8580	UF	2-3	62.5B	N/D	N/D
HA 3074 ('INBAR')	HAZERA	2-3	21.4CD	N/D	N/D
HA 3075 ('OFRI')	HAZERA	2-3	35.7CD	N/D	N/D
HA 3078	HAZERA	2-3	28.6CD	N/D	N/D
TYGRESS	SEMINIS	2-3	16.1D	N/D	N/D
FLORIDA 47 (CONTROL)	SEMINIS	2-3	94.6A	N/D	N/D
SIGNIFICANCE[X]			*	—	—
SPRING 2007, ROMA TOMATOES					
HA 3071	HAZERA	2-3	23.2B	N/D	N/D
HA 3811	HAZERA	2-3	91.1A	N/D	N/D
SIGNIFICANCE			**	—	—
SPRING 2008, ROUND TOMATOES					
BHN 765	BHN	NO	0B	4.0A	0B
BHN 745	BHN	NO	0B	2.0BC	3.4B
FLA 8579	UF	NO	0B	2.0BC	0B
FLA 8632	UF	NO	0B	1.3C	3.4B
FLA 8633	UF	NO	0B	2.7ABC	0B
HA 3074 ('INBAR')	HAZERA	4-5	0B	3.3AB	18.5A
HA 3075 ('OFRI')	HAZERA	2-3	0B	2.0BC	3.4B
HA 3091	HAZERA	2-3	0B	3.0AB	5B
SAK 5421	SAKATA	NO	0B	2.0BC	5B
SAK 5443	SAKATA	NO	0B	2.7ABC	3.4B
SECURITY 28	HARRIS MORAN	2	0B	3.0AB	3.4B
TYGRESS	SEMINIS	2-3	0B	3.3AB	3.4B
SEBRING (CONTROL)	SYNGENTA	2-3	11.5A	3.0AB	0B
FLORIDA 47 (CONTROL)	SEMINIS	2-3	6.3A	2.7ABC	0B
SIGNIFICANCE			**	*	*
SPRING 2008, ROMA TOMATOES[W]					
SHANTY	HAZERA	NO	0B	3.3	0
SAK 5808	SAKATA	4-5	0B	3.0	5
MARIANA (CONTROL)	SAKATA	NO	10A	2.3	6.5
SIGNIFICANCE			**	NS	NS

[Z] PERCENTAGE OF TYLVC-AFFECTED PLANTS AT END OF TRIAL, AFTER THIRD HARVEST. VALUES ARE MEANS OF FOUR AND THREE REPLICATIONS OF 10 AND 20 PLANTS DURING SPRING 2007 AND 2008, RESPECTIVELY.
[Y] UNIVERSITY OF FLORIDA
[X] MEANS SEPARATION BY DUNCAN'S MULTIPLE RANGE TEST, P ≤ 0.05 LEVEL, MEANS FOLLOWED BY DIFFERENT LETTERS ARE STATISTICALLY DIFFERENT ; ** SIGNIFICANCE AT P ≤ 0.01; * SIGNIFICANCE AT P ≤ 0.05; NS = NOT SIGNIFICANT.

MATERIALS AND METHODS

Two field experiments were conducted in the spring, one at the University of Florida's Southwest Florida Research and Education Center (SWREC) in 2007 on an Immokalee fine sand and the other on a commercial tomato farm in Immokalee, FL in 2008 on an EauGallie fine sand. Eleven (in 2007) and 14 (in 2008) TYLCV-resistant varieties were evaluated and compared to susceptible standard varieties in a completely randomized experimental design with four and three replications, respectively.

Cultural Practices. The fields were rototilled, and the pre-plant fertilizer (bottom and hot mix) was applied following the modified broadcast method to supply 243-64-264 and 300-60-462 lb./acre of N-P2O5-K2O, in 2007 and 2008, respectively. Beds were 32-inch wide and 8-inch tall in 2007, and 36-inch wide and 9-inch tall in 2008, and formed on 6-ft centers on both years (1 acre = 7,260 linear bed feet). Beds were then fumigated with methyl bromide and chloropicrin (67:33, w:w) at a rate of 350 lb./acre in 2007, and (50:50, w:w) at the rate of 200 lb./acre in 2008. All beds were immediately covered with low-density black polyethylene mulch.

On 20 Feb, 2007 and 4 Jan, 2008 (0 days after transplanting, DAT), transplants grown at the Redi Plants Corp. greenhouse were established in the field at a within-row spacing of 18 (in 2007) and 22 (in 2008) inches, which created a stand of approx. 4,840 and 4,035 plants/acre, respectively. Plots were 21-ft long in 2007 (14 plants) and 36-ft long in 2008 (20 plants). On 28 DAT, each tomato variety was pruned following the seed company specification (Table 1). The field was seepage irrigated and tomato plants staked and tied. Tomatoes were then grown following UF/IFAS pesticide recommendations according to the scouting reports (Olson et al., 2006). Ten tomatoes plants were harvested three times on 7, 22, 29 May, 2007 (66, 91 and 98 DAT) and 7, 21 and 30 Apr., 2008 (93, 107 and 116 DAT).

Data collection. Whitefly (*Bemisia argentifolii*) population was monitored by number of adult whitefly per leaf during the season and counts of TYLCV-symptomatic plants at the third harvest (30 Apr., 2008). The number of plants showing symptoms of fusarium crown rot (caused by *Fusarium oxysporum* f.sp. radicis-lycopersici) in each plot was counted at third harvest (30 Apr., 2008). Bacterial spot (caused by *Xanthomonas campestris*) was rated on a 1-to-5 scale (1=low and 5=high) at the third harvest (30 Apr., 2008). Using a 1-to-5 scale (1= very poor; 5=very good), earliness, plant vigor, fruit size, firmness, fruit quality, potential yield and an overall plant rating were determined by 28 participants at first harvest (7 Apr., 2008). To avoid bias, tomato varieties were coded and the

TABLE 2. First harvest and total marketable fruit yield categories for selected tomato varieties grown at the South West Florida Research and Education Center, Immokalee, FL, in Spring 2007.

VARIETIES	YIELD (25-LB BOXES/ACRE)								
	FIRST HARVEST				TOTAL HARVEST				
	XL[Z]	L[Z]	M[Z]	FHT[Z]	XL	L	M	CULL	TOTAL
ROUND TOMATOES									
BHN 745	630CD[Y]	72ABC	41	744	770AB	128D	175	1,433A	1,073BCD
FLA 8576	442CD	39C	48	530	584AB	128D	273	1,095BC	985CD
FLA 8579	694BC	64ABC	39	797	888AB	175BCD	249	1,022BC	1,312BCD
FLA 8580	590CD	105A	36	731	813AB	305A	324	694D	1,442BC
HA 3074 ('INBAR')	991AB	68ABC	33	1,092	1,472A	232ABC	311	833CD	2,015A
HA 3075 ('OFRI')	726BC	96AB	56	878	1,025A	264AB	271	708D	1,561AB
HA 3078	1,118A	70ABC	50	1,238	1,590A	217ABCD	262	1,094BC	2,069A
TYGRESS	722BC	59BC	53	835	1,039A	211BCD	269	1,146B	1,518ABC
FLORIDA 47 (CONTROL)	330D	43C	59	431	430B	69CD	255	596D	854D
SIGNIFICANCE[Y]	**	*	NS	NS	**	**	NS	**	**
ROMA TOMATOES									
HA 3071	N/D	N/D	N/D	600	N/D	N/D	N/D	1,300	951
HA 3811	N/D	N/D	N/D	159	N/D	N/D	N/D	314	622
SIGNIFICANCE				*				*	*

[Z] XL= EXTRA-LARGE (5X6 INDUSTRY GRADE); L=LARGE (6X6); M=MEDIUM (6X7); S=SMALL; FHT = FIRST HARVEST TOTAL.
[Y] MEANS SEPARATION BY DUNCAN'S MULTIPLE RANGE TEST, P ≤ 0.05 LEVEL, MEANS FOLLOWED BY DIFFERENT LETTERS ARE STATISTICALLY DIFFERENT ; ** SIGNIFICANCE AT P ≤ 0.01; * SIGNIFICANCE AT P ≤ 0.05; NS = NOT SIGNIFICANT.

TABLE 3. First harvest and total marketable fruit yield categories for selected tomato varieties grown on a commercial farm in Immokalee, FL, in Spring 2008.

VARIETIES	YIELD (25 LB-BOXES/ACRE)								
	FIRST HARVEST				TOTAL HARVEST				
	XL[X]	L[X]	M[X]	FHT[X]	XL	L	M	CULL	
ROUND TOMATOES									
BHN 745	957AB[Y]	204BC	89BCD	1,250A	1,593AB	787	327CD	1,092AB	2,706
BHN 765	972AB	214BC	81BCD	1,266A	1,580AB	741	432BCD	1,151AB	2,752
FLA 8579	624CD	422A	165BCD	1,211A	889D	905	579BC	657CDE	2,373
FLA 8632	141E	212BC	331A	684C	171E	578	1,436A	557DEF	2,185
FLA 8633	464D	175BC	75BCD	714CB	848D	850	588BC	842BCD	2,286
HA 3074 ('INBAR')	782ABC	171BC	169BCD	1,123ABC	1,091CD	511	600BC	516DEF	2,202
HA 3075 ('OFRI')	782ABC	199BC	143BCD	1,314A	1,365ABC	731	436BCD	681CDE	2,532
HA 3091	1,027AB	109C	43D	1,179AB	1,635A	594	215D	1,332A	2,444
SAK 5421	823ABC	169BC	137BCD	1,129ABC	1,249BC	649	534BC	1,320A	2,432
SAK 5443	884ABC	172BC	59CD	1,115ABC	1,571AB	707	335CD	1,010ABC	2,613
SECURITY 28	1,059A	125C	36D	1,221A	1,667A	491	231D	991ABC	2,389
TYGRESS	1,019AB	307AB	223AB	1,549A	1,262BC	719	598BC	231F	2,580
SEBRING (CONTROL)	721BCD	307AB	203ABC	1,230A	1,279ABC	972	629B	487DEF	2,880
FLORIDA 47 (CONTROL)	922ABC	225BC	78BCD	1,225A	1,627A	768	367BCD	448EF	2,761
SIGNIFICANCE[Y]	**	**	**	**	**	NS	**	**	NS

VARIETIES	YIELD (25 LB-BOXES/ACRE)										
	FIRST HARVEST					TOTAL HARVEST					TOTAL
	XL	L	M	S	FHT	XL	L	M	S	CULL	
ROMA TOMATOES[W]											
SHANTY	504	19B	0	0	523	757AB	620B	262B	43	2,181A	1,682B
SAK 5808	337	304A	0	0	641	655B	1,656A	659A	51	298B	3,021A
MARIANA (CONTROL)	774	73B	0	0	847	1,086A	846B	710A	242	394B	2,884A
SIG W.	NS	*	NS	NS	NS	*	*	*	NS	**	*

[Z] XL= EXTRA-LARGE (5X6 INDUSTRY GRADE); L=LARGE (6X6); M=MEDIUM (6X7); S=SMALL; FHT = FIRST TOTAL HARVEST.
[Y] MEANS SEPARATION BY DUNCAN'S MULTIPLE RANGE TEST, P ≤ 0.05 LEVEL, MEANS FOLLOWED BY THE SAME LETTER ARE NOT STATISTICALLY DIFFERENT. ** SIGNIFICANCE AT P ≤ 0.01; *SIGNIFICANCE AT P ≤ 0.05; NS = NOT SIGNIFICANT.

TABLE 4. Total culls (TC) and cull distribution in the categories of blossom end scar (BES), zipper and catface (Zip+CatF), sunscald and yellow shoulder (SS + YS), radial and concentric cracking (Crk), odd shape (OS) and other defects (Other) for tomato varieties grown in Spring 2007[z].

VARIETY	RELATIVE AMOUNT OF UNMARKETABLE FRUIT (%)[Z]						
	TC	BES	ZIP/CATF	SS+YS	CRK	OS	OTHER
ROUND TOMATOES							
BHN 745	133A[Z]	7.2AB	13.2AB	60.9A	30.5A	15.6A	6.0
FLA 8576	112A	6.6AB	30.3A	48.6A	11.8AB	8.5B	6.1
FLA 8579	78AB	7.0AB	8.3B	26.5B	11.4AB	19.7A	5.0
FLA 8580	48B	2.6B	7.4B	16.7B	7.9B	9.5B	4.0
HA 3074 ('INBAR')	42B	2.7B	8.0B	14.2B	7.4B	6.1B	3.4
HA 3075 ('OFRI')	45B	5.0B	4.4B	26.3AB	2.2B	6.1B	1.4
HA 3078	53B	11.6A	4.3B	14.5B	4.4B	14.2A	3.9
TYGRESS	75AB	2.9B	9.2AB	33.4AB	21.3A	6.0B	2.6
FLORIDA 47 (CONTROL)	70AB	3.2B	8.0B	15.6B	35.4A	4.6B	3.0
SIGNIFICANCE[Y]	**	**	**	**	**	**	NS
ROMA TOMATOES							
HA 3071	137	2.4	6.7	43.8	1.7	75.7	6.4
HA 3811	51	0.0	24.5	6.8	7.7	10.9	1.6
SIGNIFICANCE[Y]	**	NS	**	**	**	**	NS

[Z] RELATIVE TO TOTAL MARKETABLE YIELD
[Y] MEANS SEPARATION BY DUNCAN'S MULTIPLE RANGE TEST, P ≤ 0.05 LEVEL, MEANS FOLLOWED BY DIFFERENT LETTERS ARE STATISTICALLY DIFFERENT ; ** SIGNIFICANCE AT P ≤ 0.01; * SIGNIFICANCE AT P ≤ 0.05; NS = NOT SIGNIFICANT.

TABLE 5. Total culls (TC) and cull distribution in the categories of blossom end scar (BES), zipper and catface (Zip+CatF), sunscald and yellow shoulder (SS + YS), radial and concentric cracking (Crk), odd shape (OS) and other defects (Other) for tomato varieties grown in Spring 2008[z].

VARIETIES	UNMARKETABLE FRUIT BY TYPE[Z] (%)							
	TC	BES	ZIP+CATF	SC	OS	GW	CRK	OTHER
ROUND TOMATOES								
BHN 745	40.9BCD[Z]	2.3B	2.3B	17.9A	16.4A	0.6	1.4	0
BHN 765	4.8BC	2.8B	1.9B	21.2A	14.2A	1.5	3.2	0
FLA 8579	27.3CDEF	1.1B	0.9B	10.7B	13.1A	0.9	1.1	0
FLA 8632	25.2EF	2.0B	13.0A	5.9B	3.5B	0.3	1.6	0
FLA 8633	35.1CD	6.4A	1.6B	7.3B	15.4A	0.5	3.8	0
HA 3074 (INBAR)	45B	2.9B	3.9B	7.9B	5.9B	0.1	0.6	0
HA 3075 (OFRI)	53B	3.7B	1.3B	13.2A	9.9B	0.7	0.0	0
HA 3091	75AB	3.3B	6.2B	24.1A	17.4A	2.8	0.6	0
SAK 5421	70AB	7.3A	0.6B	20.6A	23.2A	0.9	0.1	0
SAK 5443	35.7CDE	8.4A	1.6B	14.2A	10.6	0.2	0.7	0
SECURITY 28	43.5BCD	3.2B	4.6B	10.8B	24.2A	0.6	0.2	0
TYGRESS	9.6G	0.2B	1.3B	3.0B	4.5B	0.0	0.4	0
SEBRING (CONTROL)	15.6FG	0.3B	1.8B	6.5B	6.1B	0.4	0.5	0
FL 47 (CONTROL)	16.5FG	1.3B	1.3B	4.8B	8.0B	0.5	0.4	0
SIGNIFICANCE[Y]	*	*	*	*	*	NS	NS	NS
ROMA TOMATOES								
SHANTY	130.3A	0.4	1.9	10.0A	112.9A	1.2	0.0	3.9
SAK 5808	10.0B	0.1	0.2	4.4B	5.2B	0.1	0.0	0
MARIANA (CONTROL)	14.2B	0.1	0.5	2.4B	10.8B	0.4	0.0	0
SIGNIFICANCE	*	NS	NS	*	**	NS	NS	**

[Z] RELATIVE TO TOTAL MARKETABLE YIELD
[Y] MEANS SEPARATION BY DUNCAN'S MULTIPLE RANGE TEST, P ≤ 0.05 LEVEL, MEANS FOLLOWED BY THE SAME LETTER ARE NOT STATISTICALLY DIFFERENT. ** SIGNIFICANCE AT P ≤ 0.01; * SIGNIFICANCE AT P ≤ 0.05; NS= NOT SIGNIFICANT.

names were not known to those making the ratings. Yield measures for marketable mature-green and colored tomatoes were done in the field according to USDA specifications for extra-large (5x6), large (6x6), and medium (6x7) fruit categories (USDA, 1997). Total non marketable tomato fruit numbers were recorded and categorized into blossom end rot, zippering, misshapen, rain check, gray wall, etc. as described by Gilreath et al. (2000). After harvest, tomatoes were placed in 25-lb boxes and transported to the Garguilo, Inc. packing house (Immokalee, FL). After 12 (in 2007) and 10 (2008) days of ethylene ripening treatment, post-harvest fruit quality measurements of firmness and color were made on 15 uniform tomatoes of each variety, at the BHN Research, Inc. (Immokalee, FL). Firmness was measured with a custom-made BHN instrument where measurements between 40 and 47 corresponded to "hard fruits" and measurements less than 39 were "soft fruits". Color was measured using a 1-to-10 scale (1=green; 6-7 = red; 10= purple).

Extension Activities. Well attended field days (124 and 65 attendees in 2007 and 2008, respectively) were held at IFAS/SWREC and growers cooperator in Immokalee.

RESULTS AND DISCUSSION

Whitefly population, TYCLV incidence and bacterial spot rating. Typical springs in South Florida are dry, with temperatures cool at the start and warm or hot at the end of the season. Changes in whitefly populations often follow those in temperature. Whitefly pressure was heavier in spring 2007 than in spring 2008. In 2007, the average whitefly count was 9.9 ± 0.38 (mean ± SE) adult per leaf, as compared to 0.8 ± 1.04 adult per leaf in 2008. The number of TYCLV symptomatic plants was lower in 2008 than in 2007 (Table 1). In 2007, symptoms of TYCLV were visible in the plots with the susceptible 'Florida 47' and HA 3811 varieties (Table 1). 'Tygress', a TYCLV-resistant variety, showed least virus symptoms although not significantly less than the remaining TYCLV-resistant varieties with the exception of FLA 8580. The only tomato plants showing TYCLV symptoms were those of the susceptible 'Florida 47', 'Sebring' and 'Mariana' varieties (Table

1). No symptomatic TYCLV tomato plants were found among resistant varieties. In 2008, the varieties with the highest bacterial spot ratings at the third harvest were BHN 765, HA 3091and HA 3074 ('Inbar'), 'Security 28', 'Tygress', and 'Sebring', while FLA 8632 had the significantly lowest incidence rating (Table 1). But, the incidence rating of FLA 8632 was not significantly different from that of BHN 745, FLA 8579, HA 3075 ('Ofri'), and Sak 5421. The incidence ratings of 'Florida 47', Sak 5443 and FLA 8633 were not significantly different from those of any other entry. HA 3074 ('Inbar';18.5% of the tomato plants affected by the disease) had the highest incidence of fusarium crown rot among the TYCLV varieties (all ranging from 0 to 5%). No significant differences were found in bacterial spot or fusarium crown rot incidence among Roma varieties.

Fruit yields. In general, the first harvest accounted approximately for 70%-90% of the total yield, while the second and third harvest accounted for only 30%-10%. Tomato round and Roma yield reduction was significant under higher virus pressure during 2007 as compared with a lower virus pressure during 2008 (Tables 2 and 3). Therefore, each year will be discussed separately. For the round tomato varieties in 2007, first harvest of extra-large fruit yields were higher for HA 3078 and HA 3074 ('Inbar') than for 'Florida 47' (P<0.05; Table 2). Total extra-large fruit yield for all varieties were greater than that of 'Florida 47'. Total yields were higher with HA 3078, 3074 ('Inbar'), 3075 ('Ofri') and 'Tygress' than with 'Florida 47'. Total yields ranged from 2,015 to 854 25-lb boxes/acre. Culls yields were greatest with BHN 745 than with the rest of the varieties. 'Florida 47' had the lowest unmarketable fruit production. HA 3071 produced higher first harvest and total yields and cull weights than HA 3811(P<0.05; Table 2).

For the round tomatoes in spring 2008, first harvest of extra-large fruit yields were higher for 'Security 28', HA 3091, 'Tygress', HA 3075 ('Ofri'), BHN 745, BHN 765, 'Florida 47', Sak 5443, Sak 5421and HA3074, than for FLA 8632 and FLA 8633 (P<0.05; Table 3). Total extra-large fruit categories were higher for 'Security 28', HA 3091, 'Florida 47', Sak 5443, 'Sebring' and HA 3075 ('Ofri') than those of FLA 8632, FLA 8633 and FLA 8579.

TABLE 6. Firmness and color of selected tomato varieties after exposure to ethylene and storage.

VARIETIES	FIRMNESS[Z] (PRESSURE RATING)	COLOR (RATING 1-10)
SPRING 2007, ROUND TOMATOES		
BHN 745	45.2C	6.0B
FLA 8576	45.0C	7.0A
FLA 8579	45.3C	5.5B
FLA 8580	45.2C	6.0B
HA 3074 ('INBAR')	45.7BC	5.0D
HA 3075 ('OFRI')	47.0AB	5.0D
HA 3078	45.2C	6.0B
TYGRESS	47.7A	4.0C
FLORIDA 47 (CONTROL)	44.2C	5.5C
SIGNIFICANCE[Y]	**	**
SPRING 2007, ROMA TOMATOES		
HA 3071	46.3	5.0B
HA 3811	45.6	7.0A
SIGNIFICANCE	NS	**
SPRING 2008, ROUND TOMATOES		
BHN 745	45.7BC	5.0D
BHN 765	45.0CD	5.0D
FLA 8632	43.0E	5.0D
FLA 8579	42.7E	4.5E
FLA 8633	43.0E	6.5A
HA 3091	44.8CD	5.5C
HA 3074 ('INBAR')	42.9E	6.0B
HA 3075 ('OFRI')	45.1CD	4.5E
SAK 5421	43.2E	5.0D
SAK 5443	45.1CD	6.0B
SECURITY 28	46.8AB	4.0F
TYGRESS	42.5E	4.5E
SEBRING (CONTROL)	47.1A	5.0D
FLORIDA 47 (CONTROL)	43.8DE	5.0D
SIGNIFICANCE	**	**
SPRING 2008, ROMA TOMATOES		
SHANTY	46.9A	6.0A
SAK 5808	44.5B	5.5B
MARIANA (CONTROL)	46.4A	5.0C
SIGNIFICANCE	**	**

[Z] MEASURED WITH A CUSTOM-MADE BHN INSTRUMENT WHERE MEASUREMENTS BETWEEN 40 AND 47 CORRESPONDED TO "HARD FRUITS" AND MEASUREMENTS LESS THAN 39 WERE "SOFT FRUITS"
[Y] MEANS SEPARATION BY DUNCAN'S MULTIPLE RANGE TEST, P ≤ 0.05 LEVEL, MEANS FOLLOWED BY THE SAME LETTER ARE NOT STATISTICALLY DIFFERENT. ** = SIGNIFICANCE AT P ≤ 0.01; * = SIGNIFICANCE AT P ≤ 0.05; NS = NOT SIGNIFICANT.

Cull yields were highest with HA 3091 and HA 3075 ('Ofri'), BHN 745 and 765, Sak 5443 and 'Security 28' than with 'Tygress', 'Sebring' and 'Florida 47'. FLA 8632 produced the highest medium fruit yield and lowest extra-large first harvest and total extra-large harvest. Differences among round varieties were not significant (P>0.05) for total large and season total fruit yields during spring 2008.

At first harvest, no significant differences were found in extra-large yields among Roma varieties (Table 3). Total extra-large fruit category was higher with 'Mariana' than with Sak 5808 and 'Shanty' (P<0.05). Total yield was higher with 'Mariana' and Sak 5808 than with 'Shanty'. Cull weights were higher with 'Shanty' than with 'Mariana' and Sak 5808. Total cull yields were overall higher in spring 2007 than 2008 (Tables 4 and 5).

In round tomatoes during spring 2007, the largest percentage of culls were BHN 745, FLA 8576 and 8580, Tygress, and FL47 than FLA 8580, HA 3074 ('Inbar') and HA 3080 ('Ofri') and HA 3078. The most common defect were zipper and catface (highest percentage for FLA 8576), sunscald and yellow shoulder (highest percentage for BNH 745, FLA 8576, HA 3075, and 'Tygress'), radial and concentric cracking (highest percentage for BHN 745, FLA 8576, FLA 8579, 'Tygress' and 'Florida 47'). For Roma varieties during spring 2007, the largest percentage of culls were HA 3071 than HA 3811. The most common defect types among TYCLV varieties were zipper and catface (for HA 3811) and sunscald and yellow shoulder and odd shape in HA 3071.

In round tomatoes during spring 2008, the largest percentage of culls was with HA 3091 and Sak 5421 and the lowest with 'Tygress'. The most common defect types were scars (highest percentages with BNH 745 and BHN 765, HA 3075, HA 3091, Sak 5421 and Sak 5443) and odd shape (highest percentages with BNH 745, BHN 765, FLA 8579, HA 3074, HA 3091, Sak 5421 and 'Security 28'.

In Roma tomatoes during spring 2008, the largest percentage of culls with 'Shanty' was greater than that with Sak 5808 and 'Mariana' (Control).

Post-harvest evaluation. In general for both years, the firmer fruits had the lowest color ratings (Table 6). In spring 2007, the round variety with the firmest fruit and the lowest color rating was 'Tygress', while the variety with the softest fruit and the highest color rating was FLA 8576. The rest of the varieties were intermediate in firmness and color. In 2007, no significant differences in firmness were found among the Roma varieties, but HA 3811 had a higher color rating than HA 3071.

During spring 2008, the firmest round varieties were 'Sebring' and 'Sec 28' and the varieties with lowest color rating were 'Sec 28' and 'Tygress'. The softest fruits were those of FLA 8632, FLA 8579, FLA 8633, HA 3074 ('Inbar'), Sak 5421, and 'Tygress'. The highest color rating was that of FLA 8633. The rest of the varieties were intermediate in firmness and color. The firmest Roma varieties were 'Shanty' and 'Mariana' while the highest color rating was that of 'Shanty' and the lowest that of 'Mariana'.

Field blind evaluations. In the spring 2008, the earliest variety rating was that of FLA 8633 and the latest was that of HA 3075 ('Ofri'), 'Tygress' and 'Florida 47'. The most vigorous plant rating was that of FLA 8632 and least vigorous were those of FLA 8579, HA 3091, HA 3074, HA3075 and 'Tygress'. The largest tomatoes were from HA 3091, HA 3075, Sak 5443 and Sec 28, while the smallest were those of FLA 8633. The firmest fruits were those of Sec 28, Sak 5443, HA 3074 and 'Tygress', while the softest were those of FLA 8633. The varieties rated with the highest fruit quality were 'Sebring', 'Florida 47', 'Tygress', Sak 5443 and HA 3074, and the lowest was FLA 8633. The highest yield potential ratings were those of Sak 5443, 'Security 28', BHN 765 and HA 3091, and the lowest was that of FLA 8632. 'Security 28' and Sak 5443 received the overall highest ratings, while FLA 8632 received the lowest.

The earliest Roma variety rating was with 'Shanty' and the latest was with Sak 5808. The most vigorous plant was 'Shanty' and the least vigorous were Sak 5808 and 'Mariana'. Ratings for the largest tomatoes were for 'Shanty' and 'Mariana' and the smallest for Sak 5808. No significant differences in firmness were found. Highest fruit quality ratings were for Sak 5808 and 'Mariana' while the lowest was for 'Shanty'. The highest yield potential rating was for 'Shanty' and the lowest for Sak 5808. 'Mariana' received the overall highest rating, while Sak 5808 and 'Shanty' received the lowest.

TABLE 7. Blind ratings (1 to 5 scale; 1= very poor and 5 = very good) by 28 participants, of the plants and fruits of selected tomato varieties grown on a commercial farm in Immokalee, FL, in Spring 2008.

VARIETIES	RATINGS						
	EARLINESS	PLANT VIGOR	FRUIT SIZE	FIRMNESS	FRUIT QUALITY	YIELD POTENTIAL	OVERALL RATING
2008, ROUND TOMATOES							
BHN 745	2.8EFG[z]	3.7C	3.1CD	3.6ABCD	3.4BCD	3.6DE	3.2B
BHN 765	3.5C	3.3D	3.6B	2.9EF	3.1DE	4.4AB	3.1BC
FLA 8579	4.1B	2.6E	2.2E	2.8F	3.2CD	3.6DE	2.4DE
FLA 8632	3.4CD	4.7A	1.3F	2.7F	3.2CD	1.8H	1.8F
FLA 8633	4.4A	4.2B	2.3E	2.2G	2.5F	2.8FG	2.2EF
HA 3091	3.7C	2.7E	4.0A	3.0EF	3.0DE	4.2ABC	2.7CD
HA 3074 ('INBAR')	2.9EF	2.6E	3.3C	3.7ABC	3.7AB	2.6G	3.0BC
HA 3075 ('OFRI')	2.4H	2.7E	4.1A	3.2DEF	3.2CD	3.9CD	3.2BC
SAK 5421	3.6C	4.1B	3.4BC	2.8F	2.7EF	4.1BC	3.1BC
SAK 5443	3.1DE	4.3B	4.1A	3.9AB	3.6ABC	4.5A	3.7A
SECURITY 28	3.5C	3.9BC	4.2A	4.1A	3.4BCD	4.4AB	3.8A
TYGRESS	2.5HG	2.4E	2.8D	3.7ABC	3.8AB	2.9F	2.9BC
SEBRING (CONTROL)	2.8EFG	4.3B	3.1CD	3.3CDE	3.9A	3.4E	3.1BC
FLORIDA 47 (CONTROL)	2.6FGH	3.3D	3.2C	3.5CDE	3.5ABC	3.7DE	3.2B
SIGNIFICANCEZ	**	**	**	**	**	**	**
2008, ROMA TOMATOES							
SHANTY	3.9A	3.0A	3.9A	3.6	1.8B	4.5A	2.2B
SAK 5808	2.0C	2.1B	2.7B	3.4	3.8A	2.9C	2.6B
MARIANA (CONTROL)	3.5B	2.1B	3.9A	3.5	3.8A	3.8B	3.6A
SIGNIFICANCE	**	**	**	NS	**	**	**

[z] MEANS SEPARATION BY DUNCAN'S MULTIPLE RANGE TEST, P ≤ 0.05 LEVEL, MEANS FOLLOWED BY THE SAME LETTER ARE NOT STATISTICALLY DIFFERENT. ** = SIGNIFICANCE AT P ≤ 0.01; * = SIGNIFICANCE AT P ≤ 0.05; NS = NOT SIGNIFICANT.

SUMMARY

1. The highest whitefly population and counts of TYCLV symptomatic plants were during the spring 2007 than 2008. The least symptomatic TYCLV plant under high virus pressure (spring 2007) was 'Tygress'.
2. Under high virus pressure during spring 2007, the highest extra-large and total yield yielding varieties were HA 3078, HA 3074 ('Inbar'), HA 3075 ('Ofri'). These varieties also had the lowest percentage of culls fruits. 'Tygress' had high yield as well, but high percent of cull fruits with sunscald and yellow shoulder. The best Roma variety was HA 3071, but it had a high percentage of cull fruits.
3. Under low virus pressure during spring 2008, no difference in total yield among TYCLV varieties were found, but based in extra-large fruit yield, the highest yielding varieties were 'Security 28', 'Tygress', BHN 745, BHN 765, HA 3091, 3075 ('Ofri'), HA 3074 ('Inbar'), Sak 5443 and Sak 5421. But, high percentages of

cull fruits were observed with HA 3091, Sak 5421, BHN 765, 'Security 28', BHN 745, Sak 5443 and HA 3075 ('Ofri') as compared to 'Sebring' and 'Florida 47', the controls. Most of the fruit defects in these TYCLV varieties were scar and oddly shaped fruits. Therefore, 'Tygress' and HA 3074 had the highest extra-large yield and the lowest percent of culls. The best Roma TYCLV variety was Sak 5808 based on total yield and low percentage of cull fruits.

4. In general for both years, the firmest fruits had the lowest color ratings. During 2007, the firmest round fruits were those of 'Tygress' and HA 3075 ('Ofri'), but 'Tygress' fruits had a low color rating. No differences were found in firmness, but HA 3811 had a higher color rating. During the spring 2008, the firmest fruits were those of 'Security 28', but they also had the lowest color rating. The firmest and highest color ratings among the Roma varieties were those of 'Shanty'.
5. Based the participant's blind ratings, the best round TYCLV varieties for the spring 2008 were 'Security 28', Sak 5443, HA 3074 ('Inbar'), and 'Tygress'. The best Roma variety was 'Shanty'.

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TOMATO PURPLE LEAF:

A NEW DISORDER OR DISEASE OF TOMATO?

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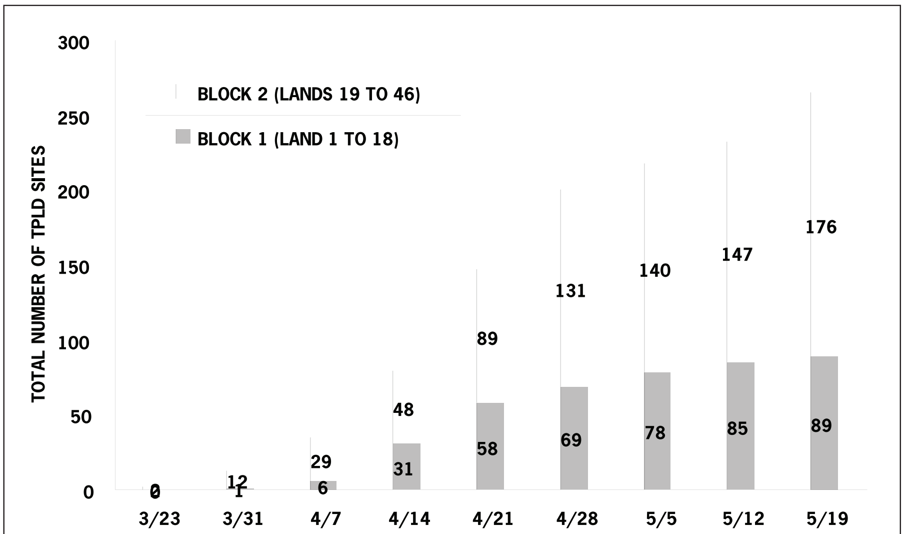
Tomato Purple Leaf Disorder (TPLD) was first observed in 2006 in isolated fields of Hillsborough and Manatee counties, but has since been found in numerous fields throughout both counties, in Miami-Dade county and recently in Suwannee county. Symptoms of TPLD first appear 6 to 8 weeks after transplanting and consist of an intense interveinal purpling of the upper surface of leaflets. Symptoms can begin as a purpling of the leaf margin or as purple blotches radiating from the main leaf vein. While the entire leaf blade gradually turns purple, the undersides of affected leaves and leaf veins do not. Symptom development appears to be related to light exposure, since shaded leaf tissues often remain green. No bronzing or deforming of the leaves has been observed. However, as the symptoms progress, affected leaves develop chlorosis and senesce prematurely, leading to an overall decline in the plant. While TPLD has been observed on all tomato types, symptoms appear to be most severe on indeterminate grape tomato varieties.

Symptoms were initially thought to be caused by a phosphorous deficiency. However, subsequent testing of 450 samples from plants with and without symptoms sampled in Homestead and Apollo Beach failed to reveal any nutritional deficiency. Spray damage was ruled out, since TPLD has been observed in fields with greatly different spray programs. Environmental factors such as ozone damage also were ruled out either through direct testing or reviewing field history. This has led to a focus on possible pathological agents. However, no known pathogen has been associated with TPLD. Testing for novel pathological agents is in progress (J. Polston et al. 2008, Proceedings of the Tomato Institute, p. 22).

MATERIALS AND METHODS

In Spring 2008, a field study was initiated to monitor the spread of TPLD from two plantings of 'Sweetheart' grape tomato at a farm with a history of TPLD in Apollo Beach. The first planting made on 11 Jan. consisted of nearly 14 acres divided by a tree row into a 6 and 8 acre block. The second planting made on 7 Mar. consisted of a single 4 acre block. The goal

FIGURE 1. Total incidences of TPLD over time in the first planting at Apollo Beach in 2008.



Z THE INCIDENCE OF TPLD WAS RECORDED USING A HANDHELD GPS UNIT TO MARK EACH SITE. EACH SITE REPRESENTS 1 TO 5 PLANTS.

FIGURE 2. New incidence of TPLD over time in the first planting at Apollo Beach in 2008[z].

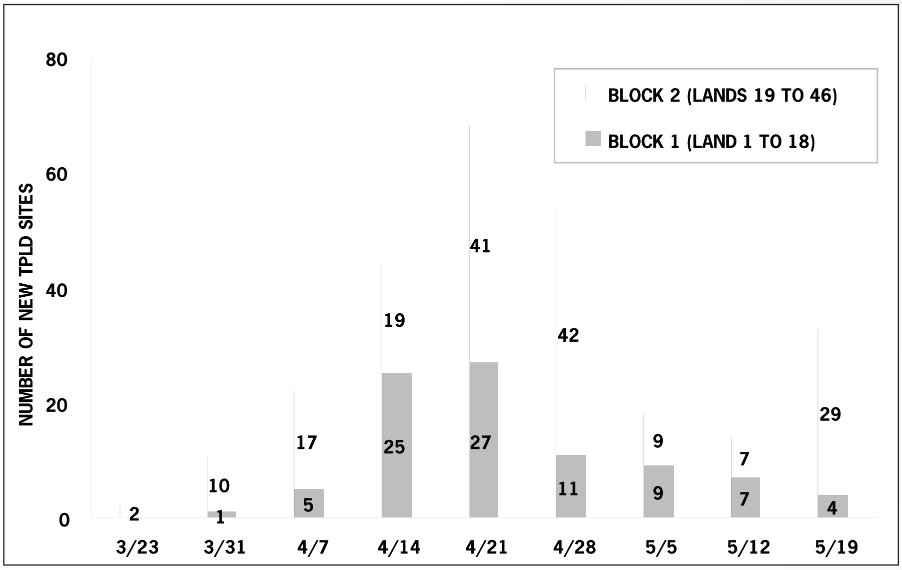
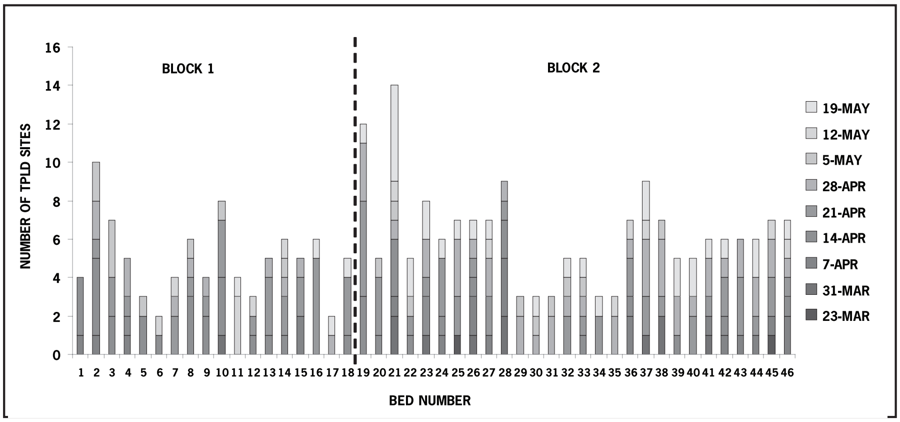


FIGURE LEGEND:
HT – HEALTHY TOMATO, PT – TLPD SYMPTOMATIC TOMATO, CE – CITRUS EXOCORDIS VIROID, CV – CITRUS VIROIDS CVD II

FIGURE 3. Distribution of TPLD sites across beds over time in the first planting at Apollo Beach[z].



[z] THE INCIDENCE OF TPLD WAS RECORDED USING A HANDHELD GPS UNIT TO MARK EACH SITE. EACH SITE REPRESENTS 1 TO 5 PLANTS.

of the study was to describe the distribution of TPLD in the field, using handheld global positioning system (GPS) units to map the incidence of symptoms during production of the crop. The severity and development of TPLD were also rated. Any pattern in the distribution or development of symptoms in relation to various production practices or environmental conditions could provide clues regarding the source and cause of TPLD.

RESULTS AND DISCUSSION

Apollo Beach – First Planting. The first planting of grape tomatoes was monitored from 18 Feb. to 19 May. The field was composed of 46 sets of 3 beds, oriented north-to-south and separated by a ditch. Block 1 consisted of the west side of the field (lands 1 to 18) and block 2 consisted of the east side of the field (lands 19 to 46). The ditch-side of every third bed was monitored for TPLD. Because spray damage was considered a possible cause of TPLD, the two blocks were managed differently. Block 1 received pesticide applications based on the recommendation of a commercial scout, while the grower's regular pesticide program was applied to block 2. However, in the end, there were few differences in the incidence or severity of TPLD between the two blocks.

The first symptoms of TPLD were observed on 23 Mar., coinciding with fruit set at 10 weeks after planting (WAT), on two plants in Block 1. The incidence of TPLD doubled every week before reaching a plateau on 4 WAT (Fig. 1). After 4 WAT, the number of new TPLD sites dropped until the final week of scouting when the number of new sites rose again (Fig. 2). By 19 May (18 WAT), 267 sites with TPLD were observed and recorded with GPS (Fig. 1). The intensity of TPLD increased with time as indicated by an increase in the severity of symptoms and an increase in the number of symptomatic plants at each GPS site, with each site representing 1 to 5 plants along 3 to 12 linear feet of bed. These data are consistent with an infectious disease, with increased symptoms over time and apparent spread to neighboring plants. Several plants also exhibited symptoms of TPLD and TYLCV indicating that co-infection is possible.

While the incidence of TPLD was monitored in the field with handheld GPS units, symptomatic leaves were carefully tagged at each site. The tagging allowed symptom development to be monitored at each GPS site over time. During the initial three weeks of scouting (23 Mar to 14 Apr.), new symptoms of TPLD were observed mostly at the bottom of the plants, while subsequent symptoms appeared to move up the plant. However, during the last three weeks (5 to 19 May), new symptoms appeared near the top of the plant.

Few differences in the frequency or distribution of TPLD were observed between Block 1 and 2 (Fig. 3). This suggests that the different pesticide programs had little impact on the development of TPLD. The incidence of TPLD was higher in Block 2. However, Block 2 was nearly 2 acres larger than Block 1. Based on GPS coordinates, the appearance of new TPLD sites over time occurred from East to West, following the contours of the field and the road along the south end of the field (Fig. 4). The most notable cluster of sites appeared in the southwest corner of Block 2. Certain beds remained free of TPLD until the last weeks of the trial. In many cases, the first incidence of TPLD in a bed occurred on the south end, with subsequent incidences appearing further north along the bed. These spatial patterns correspond with cultural operations, such as tying, spraying, topping and harvesting, which began on the south end of the field and typically proceeded from east to west. If TPLD is caused by an infectious agent, then the pattern of spread suggests that the agent is either transmitted mechanically or by a vector that moved in a northwest direction, possibly in response to cultural operations.

Apollo Beach - Second Planting. The field was composed of 15 sets of 3 beds oriented east-to-west and separated by a ditch. The north-side and south-side of every first and third bed, respectively, was monitored for TPLD beginning 8 May. The first symptoms of TPLD were observed on 8 WAT on 2 plants (on 8 May). The number of TPLD sites quickly increased to 178 by 16 June. Based on preliminary results, the severity and incidence of plants with TPLD at each site increased over time in a manner similar to the first planting, and several plants with symptoms of TPLD and TYLCV were observed (data not shown). However, unlike the first planting, initial symptoms appeared in the middle of the plants and later towards the top of plants.

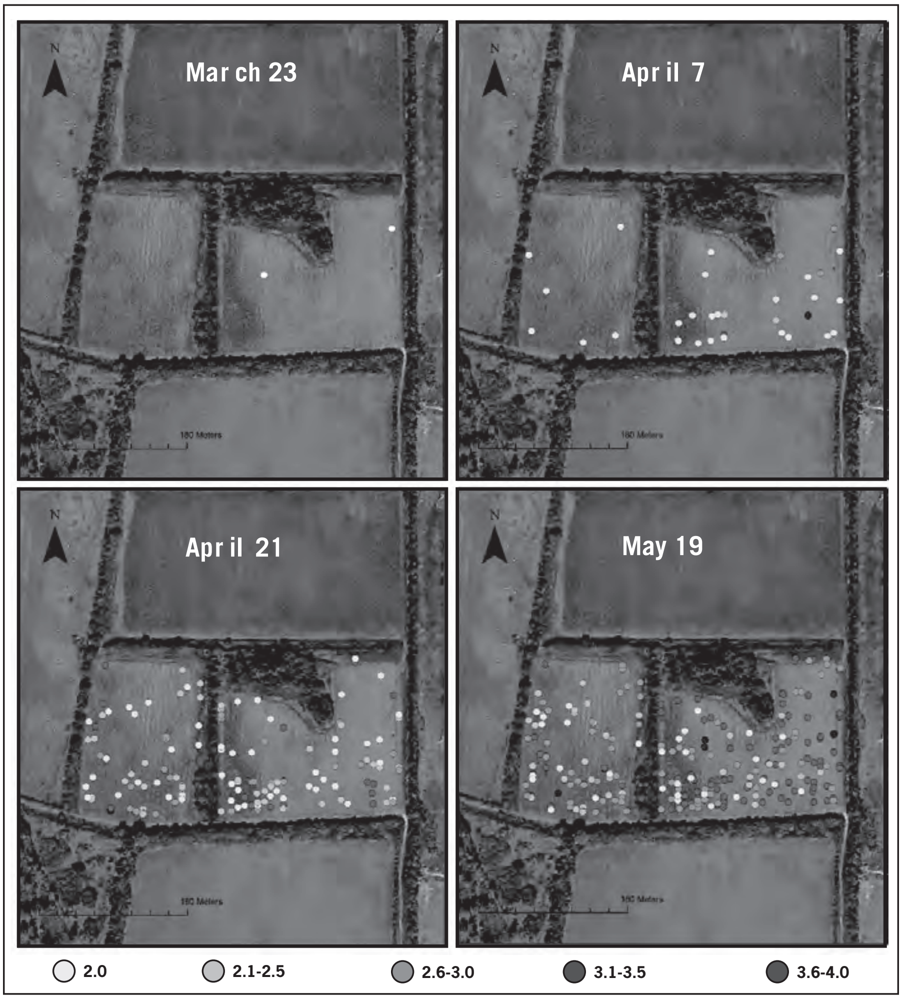
Rooted Field Cuttings. Several symptomatic cuttings of 'Sweetheart' grape tomato cultivar were collected in April from the first planting. The cuttings consisted of 4 to 6 inch stem segments with a single internode bearing one to two leaves. The basal end of each cutting was dipped in root tone to promote root development, planted in a pasteurized potting mix and maintained in a greenhouse facility at the GCREC in Balm. While symptoms of TPLD persisted in symptomatic tissues, new growth remained free of symptoms for the initial 3 to 4 weeks after rooting. Several cuttings also exhibited symptoms of TPLD and TYLCV. The appearance and persistence of TPLD in rooted cuttings maintained in a greenhouse support the hypothesis that TPLD is caused by a biological agent, and further rules out environmental factors and production-related practices such as fertilization and pesticide applications as the cause.

SUMMARY

Preliminary results from the Apollo Beach field study found that the distribution of TPLD over time was not random, but rather clustered along the southern edge of the field from east to west. This pattern corresponded with the direction of most farm operations and could be the result of mechanical transmission, the movement of a vector in response to cultural practices, or just chance. Results from the second planting should clarify these results, since the field is oriented east-to-west rather than north-to-south like the first planting. Little difference in the distribution of TPLD was observed over time between the two blocks, suggesting that TPLD is not related to the pesticide program.

The cause and economic impact of TPLD remains unclear. However, the development and persistence of symptoms on rooted field cuttings suggest that TPLD is caused by a biological agent. No known pathogen has been associated with TPLD, so current testing is focused on novel pathological agents (J. Polston et al. 2008, Proceedings of the Tomato Institute, p. 22). Results of transmission studies will also be important. If TPLD is mechanically transmitted then hygienic measures will be necessary to limit the spread of the pathological agent through equipment and personnel, while such practices would have little impact on an insect-vectored agent. In addition to understanding the mode of transmission, additional studies are necessary to determine the impact of TPLD on production. ✻

FIGURE 4. The spread of TPLD in the first planting at Apollo Beach[z].



[z] A RATING OF 2 = MILD PURPLING ON LEAVES; 2.6 TO 3.0 = STRONG PURPLING; AND 3.6 TO 4.0 = STRONG PURPLING AND CHLOROSIS.

SUDDEN DECAY
OF TOMATO FRUIT

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Sudden decay refers to a progressive decay of tomato fruit that begins within 12 h after harvest. Initial symptoms are water soaking around wounds or the stem scar. With packed fruit, wet patches may be observed on the external surfaces of the containers by the end of a 2-3day period in the ripening room. In boxes showing wet patches, one can observe fruit in various stages of decay that are emitting fluids that spread the pathogens to nearby sound fruit. Fruits in the wet boxes are unmarketable and must be repacked or discarded. Repacking is often not successful since incipient lesions may be not detected during the repack operation and sanitation is difficult at best. Several different pathogens may be involved. Critical factors leading to "sudden decay" are fruit condition and the storage environment. Both of these factors involve water.

Fruit naturally have different amounts of water. Tomatoes showing shrivel have insufficient water, whereas those with radial, concentric or cuticle cracks have had too much water, at least temporarily. Fruit cracking develops because the fruit surface has lost its elasticity and cannot expand enough to accommodate an influx of water and metabolites. This influx is often related to an imbalance in root uptake of water relative the water requirements of the plant. For example, heavy rainfall after a period of relative dryness floods the roots with water at a time when the needs of the canopy are reduced due to cloud cover and surface moisture. Since the root system does not have an on/off switch for water uptake, water continues to move through the vascular system ending up in intercellular spaces in the leaves as well as fruit. Fruits with excessive water at the time of harvest are injury prone and are more likely to absorb water after harvest. Excessive water compromises the resistance of green fruit to sour rot caused by *Geotrichum candidum* and appears to exacerbate all types of decay. In the field excessive water can lead to buckeye rot (*Phytophthora parasitica* or *P. capsici*) even on fruit that are not touching water puddles or the soil. Additionally, wet canopies enable populations of the pathogens responsible for progressive decays to develop on injuries and senescing tissues. Surges of water after a dry period can lead to fruit cracking and blossom end rot.

Free water on freshly harvested fruit enhances the risk of decay and an internalization of bacteria located on the fruit surface. Free water on wounds enables rapid soft rot development as well as internalization of the microbes on the wound. The source of the free water may be preexisting (harvest from wet plants), rainfall on bins or gondolas of fruit, or condensation (cool fruit introduced into warm humid air). Condensation can develop in palletized boxes of fruit if air temperatures outside of storages are warmer than the fruit, particularly if cool fruit are loaded into a warm truck trailer.

The effect of a water congestion of fruit and free water on fruit surfaces at harvest explains sporadic outbreaks of sour rot (*G. candidum*) in harvested tomatoes. Extensive research by Butler (1960) in California demonstrated that while ripe tomatoes were highly susceptible to sour rot, green fruit would not develop this decay unless chilled. Yet, market pathologists have described symptoms of sour rot on green tomatoes and often noted the disease appeared to start at the edge of the stem scar and progress in a sector toward the blossom end of the fruit (McColloch et al., 1968). Pritchard and Porte (1923) named the disease watery rot due to the copious amount of clear fluids that emanated from lesions. However, the disease progressed much more slowly than bacterial soft rot when fruit were allowed to dry and were held on a laboratory bench. The first description of the disease noted that ripe fruit were infected through cracks, whereas green fruit were relatively resistant (Poole, 1922). Butler observed that infections following the inoculation of green fruits became arrested.

Isolations of pathogens from several recent sporadic postharvest decay outbreaks in production areas ranging from the west coast of Florida, the Florida panhandle and the Delmarva Peninsula of Virginia yielded mostly *G. candidum* with low numbers of *Erwinia. carotovora* (bacterial soft rot). The decaying fruit developed extensive coverings of yeast-like fungi typical of *G. candidum*. The lesions were mostly on the fruit surface with penetration into locular cavities. It is likely that the clear fluid associated with these decay outbreaks was from lysis of the gel in the locular cavity. The decay failed to rapidly collapse the fruit as would occur with bacterial soft rot.

In certain citrus fruits, sour rot is a problem that is associated with high peel water content (Baudoin and Eckert, 1982). By contrast, wound inoculations of dry fruit produced mostly arrested lesions. When we congested green tomato fruit with water, sour rot infection became quite active encompassing large areas of the fruit (Fig. 1). These were clearly not arrested lesions. The amount of water infused into the fruit ranged from 2% to 6% of their initial weight. Both a soak in water and a pressure treatment on submerged tomatoes produced a similar effect. With the longer soak (overnight as compared with up to 60 min), surface cracks would radiate from some of the wounds. Fruits were inoculated prior to and after the soak treatment. In both treatments extensive decay developed although the lesions were smaller after the post versus pre-soak inoculation. Control fruit that had not been soaked before or after inoculation had arrested lesions despite storage in a water saturated atmosphere.

Clearly, the infusion of water into the fruit tissues was responsible for the sour rot development. Pin hole wounds developed into large brown lesions (>2-3 cm in diameter) within 72 hr after green fruit were soaked for 45 min in a spore suspension of *G. candidum*, whereas only arrested lesions were observed among fruit that had been soaked for 5 min. Thus, it was the soaking and likely penetration of water into the wound and not just inoculation that led to the lesion development.

The temperature and humidity of the storage environment are also important factors in rapidly developing decays. Both sour and soft rot progress more rapidly among fruit stored at 86°F (30°C) as compared with 68°F (20°F). Consequently, in times of high climatic temperatures, provision for uniformly cooling palletized stacks of packed tomatoes is highly desirable. Both diseases are favored by high humidity as well. However, reducing the humidity surrounding pallets of boxed tomatoes is not a viable control option. Moreover, humidity was not a factor in the development of sour rot among green tomatoes.

A more recent decay outbreak followed harvest of fruit during a cold period where temperatures were in the low 50's °F. Here, the lesions were internal and dark in color. The surface over the lesions was softened by not broken. Once again water congestion, injury and free water on fruit surfaces were implicated as critical factors. The problem occurred among pink tomatoes and was not as severe among the mature green fruit from the same harvest. The pathogens involved were likely *Alternaria alternata* (black mold rot) with probable assistance of soft rot bacteria. The internal lesions were largely confined to locular cavities and were linked to the fruit surface by pathogen growth down the stylar pore or vascular tissues beginning at the stem scar. This type of development would not be likely unless the fruit were wet for a period of time at or shortly after harvest. Fruit wetness could have been associated with harvest operations beginning before the plants were dry or cold fruit were packed into a warmer humid ripening/storage room. An additional feature was that many of the seeds in the affected locular cavities had lost their gel capsule, which could have occurred if the fruit were bruised. The grower indicated that he'd observed this in the past and that it was very transient, meaning it did not appear among fruit in subsequent harvests of the same field. ✻

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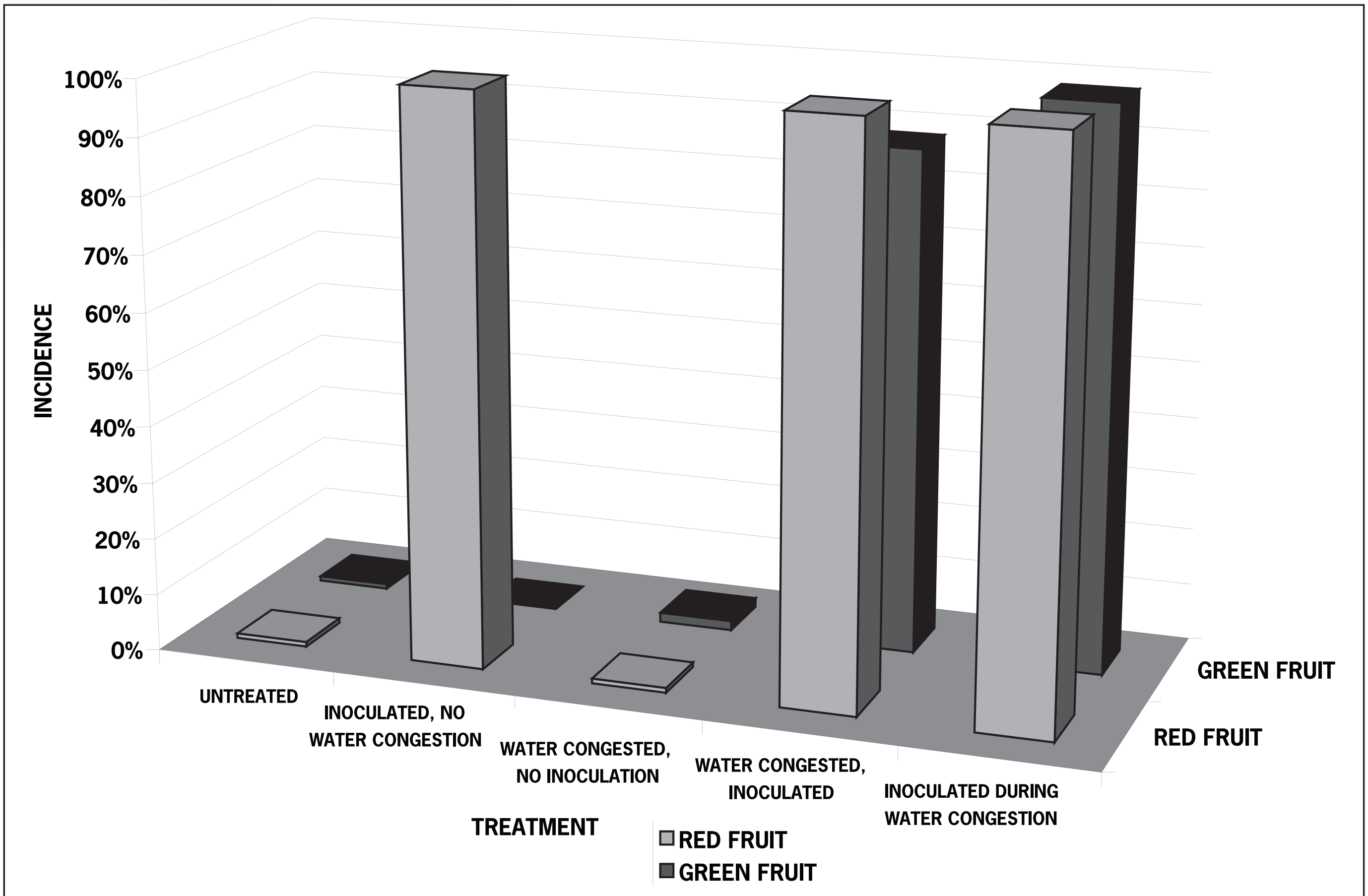
FIGURE 1. Sour rot development in green or red tomato fruit as a function of soaking the wounded fruit in water.



STUDIES TO DETERMINE
THE CAUSE OF TOMATO PURPLE LEAF DISORDER

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Tomato purple leaf disorder (TPLD) has been observed in tomato farms in Hillsborough and Manatee counties since 2006. The disorder can first be observed as an interveinal purple discoloration on the upper leaf surfaces. Leaves produced after the initial symptoms may have varying amounts of purple which can extend to the entire surface of the leaf. The intensity of the purple color and the extent of purpling vary among leaves and among cultivars. No deformation of the leaf has been observed, but affected leaves appear to decline and senesce prematurely. The amount or quality of light plays a role in the expression of the purpling; lower light levels often mean less or no purpling. For example when two leaves partially overlap, the TPLD only shows on the surface exposed to sunlight, leaving a shade of green tissue on the overlapped leaf.

There are no reports in the literature of a pathogen causing symptoms like those of TPLD. The results of studies conducted in the field earlier this year support the hypothesis that this disorder is the result of an infectious agent (G. Vallad et al 2008 Proceedings of the Tomato Institute, p. 17). One method to determine if an infectious agent is responsible for a set of symptoms is to demonstrate that the symptoms can be transferred to a non-symptomatic host though some means of transmission (such as mechanical, insect, or nematode).

STUDIES ON TRANSMISSION OF AN AGENT THAT CAUSES TPLD

Samples from symptomatic plants were collected from Homestead and inoculated to healthy 'Celebrity' tomato plants in Feb. 2008 using a standard protocol for an easily mechanically transmitted agent. Six weeks after inoculation, purpling symptoms were observed on the inoculated plants. This time to symptom appearance is consistent with observations from field studies (G. Vallad et al 2008 Proceedings of the Tomato Institute). This inoculation was repeated once more in Gainesville in May using tissue from symptomatic 'Celebrity' plants. The results suggest that a biological agent is responsible for the symptoms. This does not imply that the agent cannot be moved by other means, such as mites, insects, or pollen. Therefore a series of studies was conducted to identify a pathogen that can be associated with the purpling symptoms.

STUDIES CONDUCTED TO IDENTIFY A BIOLOGICAL AGENT

A wide array of laboratory and greenhouse studies were conducted to identify a biological agent associated with TPLD. Plant diseases can be caused by an array of pathogens, some of which can be cultured and readily identified and others which cannot be cultured, and therefore more challenging to detect. Fungi, bacteria, algae, phytoplasmas, viruses and viroids are known types of plant pathogens. However, only fungi, bacteria, viruses and viroids can be mechanically transmitted. In general, the smaller the size of the pathogen the more difficult the detection and recognition.

Fungi and Bacteria. Many fungi and bacteria can be transmitted by mechanical inoculation. Leaf, stem and root samples were collected from symptomatic and non-symptomatic plants and tested for the presence of a variety of fungi and bacteria. Standard microbiological techniques and diagnostic media were used to prepare and test various plant tissues. Although fungi and bacteria were recovered from symptomatic plants, there was no clear association of any of these pathogens with TPLD. Therefore, laboratory and greenhouse tests were conducted to test for the presence of a virus or viroid. PCR assays were conducted on three symptomatic samples for the presence of *Clavibacter michiganensis* subsp. *sepedonicus* and for Phytoplasmas, organisms similar but different from bacteria. All these tests were negative.

Viruses. Several techniques are available for the detection and identification of plant viruses. Two basic types of assays were conducted; those that look for evidence of any virus without any specificity for any particular virus ("Non-specific Assays") and those that detect a specific and well characterized virus ("Specific Assays"). Several of each of these types of assays were conducted with symptomatic and asymptomatic plant samples.

NON-SPECIFIC ASSAYS FOR VIRUSES

A. Inclusion Body Visualization. Symptomatic leaf samples were tested for the presence of inclusion bodies (structures produced by viruses inside plant cells) by treating the samples with particular stains and looking for the presence of stained inclusion bodies in the cells of affected plants using a compound light microscope. This approach can detect about 75% of known viruses and can give an indication if a virus is present and in general what family of virus it is. No inclusion bodies were observed.

B. Electron Microscopy. Another method which can demonstrate the presence of a virus is to examine sap from symptomatic plants with an electron microscope for the presence of virus particles. This method is effective for the detection of many plant viruses. No particles were seen from symptomatic plants.

C. dsRNA Analysis. Six symptomatic leaf samples were sent to R. Valverde an expert in the use of dsRNA for the identification of new viruses from Louisiana State University. This assay detects almost all viruses that produce a double strand of RNA (approximately 60% of known plant viruses). No virus was detected in the samples.

D. Broad-Spectrum PCR and RT-PCR Assays. There are 16 known families of plants viruses composed of 55 genera, and 22 genera not assigned to families. Broad-spectrum PCR and RT-PCR assays have been developed which will detect most (but not all) the viruses within 30 genera of plant viruses. These assays are very powerful because they can detect many different viruses with just a single test. In addition, if a virus sequence is detected the amplified piece of DNA can be cloned and sequenced. This sequence can be used to identify the virus to species or can be a starting point to obtain more of the viral sequence, which is essential for identification. The use of broad-spectrum PCR assays can rapidly identify a new virus that belongs to a well-characterized genera, but will not detect viruses from the remaining 47 genera or from unknown genera.

Samples were sent to AgDia and tested with all available (18) broad-spectrum PCR assays. PCR assays were conducted for viruses belonging to the following virus genera/families: *Geminiviridae (Begomovirus, Curtovirus), Bromoviridae* (4 *genera plus Ilarvirus), Flexiviridae (Carlavirus, Potexvirus*, and *Trichovirus genera), Closteroviridae (*3 *genera), Comoviridae (Comovirus, Fabavirus*, and *Nepovirus genera), Luteoviridae* (3 *genera), Potyviridae* (6 *genera), Togaviridae (Tobamovirus genus), Tombusviridae (Tombusvirus, Carmovirus*, and *Dianthovirus genera*), and *Tospovirus*.

Only one test was positive with all 6 symptomatic samples – the PCR for *Closteroviridae*. The DNA fragments generated by this PCR assay were cloned and sequenced. The sequences that were obtained were 92% to 99% identical to the Heat shock protein gene of *Tomato chlorosis virus*, which belongs in the genus *Crinivirus*.

SPECIFIC ASSAYS FOR VIRUSES

E. Enzyme-linked immunosorbent assay (ELISA). Six samples of symptomatic leaves were sent to Agdia to test for the presence of 16 specific tomato-infecting viruses using ELISA and nucleic acid hybridization assays. Although no known tomato virus causes symptoms of TPLD, it is possible that a new strain of a known viral pathogen was the cause. These tests would be likely to detect new strains of known viruses. The following viruses were tested for but were not detected in any of the samples: *Alfalfa mosaic virus, Cucumber mosaic virus, Impatiens necrotic spot virus, Pepino mosaic virus, Potato leaf roll virus, Potato virus X, Potato virus Y, Tobacco etch virus, Tobacco mosaic virus, Tobacco ringspot virus, Tobacco streak virus, Tomato aspermy virus, Tomato bushy stunt virus, Tomato mosaic virus, Tobacco ringspot virus*, and *Tomato spotted wilt virus*. An ELISA was also conducted which detects approximately 95% of all known Potyviruses. No virus was found consistently in all 6 leaves. This indicates that the causal agent is probably not one of these viruses.

F. Crinivirus polymerase chain reaction (PCR). Fifteen symptomatic samples were sent to W. Wintermantel, a specialist in Closterovirus identification. He used PCR tests that detect the coat protein and polymerase genes of Criniviruses. He detected Criniviruses in some of the field samples but not in any of the greenhouse samples. His results indicate that the presence of a Crinivirus, including Tomato chlorosis virus, is not associated with the purpling symptoms. Therefore a Crinivirus, including Tomato chlorosis virus, is not the cause of the symptoms of TPLD.

PCR primers designed from the AgDia generated sequence (*Tomato chlorosis virus Heat shock protein* gene) and primers to the Crinivirus polymerase (developed by W. Wintermantel) were tested on the same plant samples at the same time. PCR for actin, a plant gene, were used as an internal control (Table 1). The PCR for the *Tomato chlorosis virus Heat shock protein* gene was positive for all samples collected from symptomatic plants and for 2/4 plants that were not-inoculated and were not showing any symptoms at the time of sampling. These plants were collected and are being held for observation to determine if they were infected but just not showing symptoms yet.

TABLE 1. Summary of results of PCR assays for a Crinivirus in TPLD symptomatic plants

NO. OF SAMPLES TESTED	DATE COLLECTED	LOCATION	RESULTS NO. POSITIVE/ TOTAL NO. SAMPLES
1	15 DEC 2007	RUSKIN	0/1
5	19 FEB 2008	GAINESVILLE UF GNHS.	1/5
3	21 FEB 2008	RUSKIN	0/3
2	26 FEB 2008	RUSKIN	0/2
4	25 MARCH 2008	HOMESTEAD	2/4

Since the results of W. Wintermantel and AgDia are at odds, and could be due to the fact the different tests were conducted at different locations, we conducted further tests to try to resolve these differences. We designed primers to the sequence obtained from the AgDia assays and tested plants with and without purpling symptoms with these primers and with primers for the ToCV polymerase gene. We obtained somewhat similar results—the primers for the heat shock protein gene gave a positive result while the polymerase primers were always negative (Table 2). In two cases asymptomatic plants were positive using heat shock primers. These plants were set aside and within four weeks the 'Celebrity' showed symptoms of purpling, while the symptoms on the 'FL Lanai' were inconclusive. These results are not clear, but could be explained by the presence of a unique crinivirus which has a genome that is identical in one part to ToCV but the rest is unique. But there may be other explanations and further testing is needed.

Viroids. The ease of transmission, the nature of the symptoms, and the absence of clear evidence for a virus suggest the possibly of a viroid as the causal agent. Viroids, like *Potato spindle tuber viroid*, are small circular pieces of RNA. They differ from viruses in that they have no coat protein and they are unable to produce any proteins. Viroids are pollen- and seed-borne, and are very easily mechanically transmitted. There are about 30 known viroids, but there are probably many awaiting discovery. New viroids can be very difficult to detect and identify. They can be detected by RT-PCR if the sequence of the viroid is known or is similar to a known viroid, and by hybridization assays if their sequence is similar to the viroid sequence used as the probe. They can also be detected by techniques which preferentially extract and concentrate small RNAs from plants. The latter technique is the one that must be used for new viroids.

G. RT-PCR Assays. Three symptomatic samples were tested by RT-PCR using viroid-specific or group specific primers. These RT-PCR assays are used routinely to assay citrus for viroids (laboratory of P. Sieburth, Citrus Budwood Testing Program). These assays would detect the following viroids (or viroids with similar sequences): *Citrus exocortis viroid* (CEVd), *Bent leaf viroid* (CVd I), *Citrus Viroid One* (CVd II), *Citrus Viroid three* (CVd III), *Citrus viroid four* (CVd IV), and *Citrus Viroid five* (CVd V). All RT-PCR tests were negative indicating that none of these five viroids or related viroids was present in the TPLD samples.

In addition, RT-PCR tests were conducted that were designed to amplify viroid sequences that were more distantly related to known viroids. Transcription was conducted using random hexamers, followed by viroid group specific primers. This is an approach that has successfully amplified new viroids. We used internal positive controls of CEVd and CVd II plus CVd III. The assay detected the known viroids but did not detect any viroid sequences from the symptomatic tissue.

H. Nucleic Acid Hybridization. Nine symptomatic samples were tested using probes made from three known viroids: *Chrysanthemum chlorotic mottle viroid* (CChMVd), *Chrysanthemum stunt viroid* (CSVd), and *Potato spindle tuber viroid* (PSTVd). All samples were negative which indicates that none of the three virioids or closely related viroids were present in the symptomatic tissue.

I. Extraction of small dsRNAs. Several different techniques which have been used to successfully purify viroid RNA (small circular double stranded RNA) were conducted on symptomatic and healthy tomato tissues. One extraction technique revealed the presence of dsRNA of a size consistent with viroids. Bands of dsRNA were seen in extracts from symptomatic tomato but not healthy tomato samples. Multiple bands of dsRNA were seen in native gels as expected and like the extract from CEVd-infected citrus (gel not shown). Evidence of dsRNA could be seen in the lithium pellet from the extraction technique is consistent with dsRNA of viroids that are similar to viroids in the *Asunviroidae* (type member: *Avocado sunblotch viroid*). A faint but visible band was observed in the denaturing gel from the lithium pellet. This band of dsRNA was similar in size to that of the extract containing CVd II plus CVd III, one of which belongs to the *Asunviroidae* family. These results suggest the presence of a viroid that belongs to the *Asunviroidae* family.

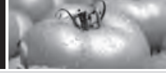
The extractions were conducted with only a sample from a single TPLD affected tomato. This work must be repeated with more samples to associate the presence of this viroid with the purpling symptoms. It is possible that a viroid is present in some plants, but has nothing to do with the purpling symptoms. If there is a good association, then the dsRNA in these bands must be transcribed into DNA, cloned and sequenced in order to identify the viroid.

SUMMARY

The ability to transmit the TPLD symptoms from one to plant to another indicates that a pathogen is probably responsible for the disorder. Many different assays were conducted to determine the identity of the pathogen. The results suggest that the agent is most likely a virus or viroid. It is unlikely that this agent is a virus or viroid known to infect tomato. The results are not conclusive at this point and suggest both a virus and a viroid may be responsible. The virus appears to have a gene essentially identical to that of *Tomato chlorosis virus*, but the rest of the genome is likely to be very different. It is not clear if the virus is a Crinivirus, as most of the tests for Criniviruses indicated that a crinivirus was not present. If the causal agent turns out to be a viroid then it is probably one that belongs to the *Asunviroidae* family. More research will be necessary to clarify the current results and confirm the identity of the causal agent. ✻

TABLE 2. Comparison of PCR results using Primers to the Tomato chlorosis virus Heat Shock Protein and to the Crinivirus polymerase on plants with and without purpling symptoms.

PRIMER TARGET	PLANTS WITHOUT SYMPTOMS OF PURPLING				PLANTS WITH SYMPTOMS OF PURPLING			
	FLA LANAI NON-INOC.	FLA7613 NON-INOC.	CELEBRITY NON-INOC.	NICOTIANA GLUTINOSA NON-INOC.	CELEBRITY INOC.	CELEBRITY INOC.	CELEBRITY INOC.	NICOTIANA GLUTINOSA INOC.
ACTIN	+	+	+	+	+	+	+	+
TOCV HEAT SHOCK PROTEIN	+	-	-	+	+	+	+	+
CRINIVIRUS POLYMERASE	-	-	-	-	-	-	-	-



TOMATO VARIETIES

FOR FLORIDA

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Variety selections, often made several months before planting, are one of the most important management decisions made by the grower. Failure to select the most suitable variety or varieties may lead to loss of yield or market acceptability. The following characteristics should be considered in selection of tomato varieties for use in Florida.

Yield - The variety selected should have the potential to produce crops at least equivalent to varieties already grown. The average yield in Florida is currently about 1400 25-pound cartons per acre. The potential yield of varieties in use should be much higher than average.

Disease Resistance - Varieties selected for use in Florida must have resistance to Fusarium wilt, race 1, race 2 and in some areas race 3; Verticillium wilt (race 1); Gray leaf spot; and some tolerance to Bacterial soft rot. Available resistance to other diseases may be important in certain situations, such as Tomato yellow leaf curl in south and central Florida and Tomato spotted wilt and Bacterial wilt resistance in northwest Florida.

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

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

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

Current Variety Situation - Many tomato varieties are grown commercially in Florida, but only a few represent most of the acreage. In years past we have been able to give a breakdown of which varieties are used and predominantly where they were being used but this information is no longer available through the USDA Crop Reporting Service.

Tomato Variety Trial Results - Table 1 shows results of spring trials for 2007 and Table 2 shows results of fall trial of 2007 conducted at the North Florida Research and Education Center, Quincy.

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

LARGE FRUITED VARIETIES

AMELIA. *Vigorous determinate, main season, jointed hybrid. Fruit are firm and aromatic suitable for green or vine ripe. Good*

TABLE 1. Tomato variety trial results, Spring 2007. NFREC, Quincy.

ENTRY	SOURCE	MARKETABLE YIELD (25 CARTONS/A)				MARKETABLE FRUIT (%)	FRUIT WT. (OZ)
		MEDIUM	LARGE	EXTRA LARGE	TOTAL		
FLETCHER	NCS	73 C-F [z]	241 D-G	2732 A	3046 A	84.1 A	8.0 B-E
BHN 640	BHN	129 B	391 AB	2458 AB	2978 A	76.6 A-D	7.1 DE
BHN 444	BHN	68 D-F	234 D-H	2358 A-D	2660 AB	76.2 A-D	7.9 C-E
BHN 602	BHN	44 D-G	271 C-F	2295 A-D	2610 AB	77.7 A-D	7.8 C-E
FLA. 7964	GCREC	58 D-G	297 B-E	2194 A-E	2549 AB	73.1 B-E	6.8 DE
QUINCY	SEMINIS	41 D-G	185 F-G	2318 A-D	2544 AB	77.1 A-D	8.2 B-E
FTM-05-S145	SAKATA	8 G	53 KL	2433 A-C	2494 AB	73.2 B-E	9.4 AB
FLA. 8363	GCREC	27 E-G	175 F-J	2277 A-D	2479 A-D	70.9 B-F	8.1 B-E
FTM-05-S142	SAKATA	116 BC	345 A-C	1999 A-E	2460 AB	80.1 AB	7.3 C-E
FTM-05-S230	SAKATA	150 AB	331 A-D	1946 B-E	2427 A-C	71.5 B-F	7.0 DE
NC 0718	NCS	42 D-G	143 G-L	2218 A-E	2403 A-C	71.6 B-F	8.3 B-D
RED DEFENDER	HARRIS MORAN	68 D-F	206 E-I	2043 A-E	2317 A-C	71.9 B-F	6.9 DE
MOUNTAIN GLORY	NCS	49 D-G	166 F-J	2082 A-E	2297 A-C	78.1 A-C	7.4 C-E
AMELIA	HARRIS MORAN	34 D-G	130 H-L	2088 A-E	2252 A-C	79.2 AB	8.9 A-C
BELLA ROSA	SAKATA	37 D-G	143 G-L	2062 A-E	2242 A-C	71.2 B-F	8.2 B-E
FTM-05-S468	SAKATA	178 A	406 A	1654 C-F	2238 A-C	72.7 B-F	6.6 E
FLA. 8367	GCREC	23 FG	118 I-L	1902 B-E	2043 B-D	63.3 F	8.0 B-E
RFT 4974	SYNGENTA	46 D-G	174 F-J	1778 B-F	1998 B-D	64.7 EF	7.8 C-E
REDLINE	SYNGENTA	41 D-G	171 F-J	1769 B-F	1981 B-D	68.9 C-F	7.2 DE
NC 05137	NCS	75 C-E	215 E-I	1677 B-F	1967 B-D	75.6 A-D	7.2 DE
NC 056	NCS	42 D-G	155 G-K	1759 B-F	1956 B-D	73.2 B-E	7.6 C-E
SVR 01721400	SEMINIS	11 G	46 L	1884 B-E	1941 B-D	66.3 EF	9.9 A
CRISTA	HARRIS MORAN	80 CD	161 G-J	1657 C-F	1898 B-D	76.0 A-D	7.5 C-E
NC 05232	NCS	74 C-F	196 E-J	1610 D-F	1880 B-D	78.3 AB	7.5 C-E
TALLADEGA	SYNGENTA	30 D-G	132 G-L	1482 EF	1644 CD	68.5 D-F	7.7 C-E
PHOENIX	SEMINIS	34 D-G	127 H-L	1117 F	1278 D	65.5 EF	7.8 C-E
FL 47	SEMINIS	25 E-G	93 J-L	388 G	506 E	50.0 G	7.0 DE

[z] MEAN SEPARATION BY DUNCAN'S MULTIPLE RANGE TEST, 5 % LEVEL; IN-ROW SPACING 20 INCHES, BETWEEN ROW SPACING 6 FEET, DRIP IRRIGATION UNDER BLACK POLYETHYLENE MULCH, FERTILIZER APPLIED 195-60-195 LBS/A N-P_2O_5-K_2O, TRANSPLANTED 23 MARCH 2007, 2 HARVESTS 18 AND 27 JUNE.

TABLE 2. Tomato variety trial results, Fall 2007. NFREC, Quincy.

ENTRY	SOURCE	MARKETABLE YIELD (25 LB BOXES/A)			MARKETABLE FRUIT	FRUIT WT.
		LARGE	EXTRA LARGE	TOTAL	(%)	(OZ)
FLA 8363	GCREC	244 B-D [z]	1094 A	1455 A	74.7 AB	6.8 AB
BHN 602	BHN	263 BC	1056 AB	1422 A	61.3 DE	7.1 A
RED DEFENDER	HARRIS MORAN	421 A	727 B-F	1388 A	69.5 A-D	5.7 F-H
BELLA ROSA	SAKATA	263 BC	1001 A-C	1368 AB	68.0 A-D	6.8 AB
TALLADEGA	SYNGENTA	261 BC	931 A-D	1302 A-C	66.0 B-D	6.9 AB
FLA 8314	GCREC	244 B-D	912 A-D	1263 A-D	68.0 A-D	6.6 A-C
FLA 8367	GCREC	296 B	750 B-F	1180 A-E	76.5 A	6.2 B-F
NC 05232	NCS	201 B-E	874 A-E	1170 A-E	73.8 AB	6.7 A-C
QUINCY	SEMINIS	234 B-E	674 C-G	1067 A-F	71.4 A-C	6.3 B-F
RFT 4971	SYNGENTA	247 B-D	687 C-F	1064 A-F	63.2 C-E	6.3 B-E
CRISTA	HARRIS MORAN	242 B-D	687 C-F	1036 A-F	68.8 A-D	6.5 A-C
PHOENIX	SEMINIS	233 B-E	635 D-G	956 B-F	61.5 C-E	6.4 B-D
FLA 8413	GCREC	163 C-E	652 C-G	914 C-F	67.8 A-D	6.7 A-C
SOLAR FIRE	HARRIS MORAN	240 B-D	558 E-H	895 C-F	62.6 C-E	6.3 B-F
RFT 4974	SYNGENTA	208 B-E	548 E-H	873 D-F	66.1 B-D	6.4 B-D
FLETCHER	NCS	250 B-D	433 F-H	839 EF	63.8 CD	5.7 F-H
FL 91	SEMINIS	149 DE	556 E-H	783 EF	59.7 DE	6.6 A-C
TASTY-LEE	GCREC	253 B-D	331 GH	749 F	62.1 C-E	5.4 GH
FL 47	SEMINIS	215 B-E	405 F-H	743 F	65.3 B-D	5.8 D-G
AMELIA	HARRIS MORAN	133 E	526 E-H	730 F	61.6 C-E	6.7 A-C
MOUNTAIN GLORY	NCS	173 C-E	418 F-H	705 F	61.4 DE	6.0 C-F
INBAR	HAZERA	218 B-E	263 H	643 F	54.1 E	5.1 H

[z] MEAN SEPARATION BY DUNCAN'S MULTIPLE RANGE TEST, 5 % LEVEL. IN-ROW SPACING 20 INCHES, BETWEEN ROW SPACING 6 FEET, DRIP IRRIGATION UNDER WHITE ON BLACK VIF MULCH, FERTILIZER APPLIED 195-60-195 LBS/A OF N-P2O5-K2O, TRANSPLANTED 2 AUG 2007, 3 HARVESTS; 22 OCT - 7 NOV 2007.

crack resistance. Resistant: Verticillium wilt (race 1), Fusarium wilt (race 1,2,3), root-knot nematode , Gray leaf spot and Tomato spotted wilt. (Harris Moran)

BELLA ROSA. *Heat tolerant determinate type. Produces large to extra-large, firm, uniformly green and shaped fruit. Resistant: Verticillium wilt (race 1), Fusarium wilt (race 1,2), Tomato spotted wilt. (Sakata)*

BHN 586. *Midseason maturity. Fruit are large to extra-large, deep globed shaped with firm, uniform green fruits well suited for mature green or vine-ripe production. Determinate, medium to tall vine. Resistant: Verticillium wilt (race 1), Fusarium wilt (race 1,2) Fusarium crown rot and root-knot nematode. (BHN)*

BHN 602. *Early-midseason maturity. Fruit are globe shape but larger than BHN 640, and green shouldered. Resistant: Verticillium wilt (race 1), Fusarium wilt (race 1,2,3) and Tomato spotted wilt. (BHN)*

BHN 640. *Early-midseason maturity. Fruit are globe shape but tend to slightly elongate, and green shouldered. Resistant: Verticillium wilt (race 1), Fusarium wilt (race 1,2,3) and Tomato spotted wilt. (BHN)*

CRISTA. *Midseason maturity. Large, deep globe fruit with tall robust plants. Does best with moderate pruning and high fertility. Good flavor, color and shelf-life. Resistant: Verticillium wilt (race 1), Fusarium wilt (race 1,2,3), Tomato spotted wilt and root-knot nematode. (Harris Moran)*

CROWN JEWEL. *Uniform fruit have a deep oblate shape with good firmness, quality and uniformly-colored shoulders. Determinate with medium-tall bush. Resistant: Verticillium wilt (race 1), Fusarium wilt (race 1,2) Fusarium crown rot, Alternaria stem canker and Gray leaf spot. (Seminis)*

FLETCHER. *Midseason maturity. Large, globe to deep oblate fruit with compact plants. Does best with moderate pruning and high fertility. Good flavor, color and shelf-life. For vine ripe use only due to nipple characteristic on green fruit. Resistant: Verticillium wilt (race 1), Fusarium wilt (race 1,2,3), Tomato spotted wilt and root-knot nematode.*

FLORA-LEE. *It was released for the premium tomato market. A midseason, determinate, jointed hybrid with moderate heat-tolerance. Fruit are uniform green with a high lycopene content and deep red interior color due to the crimson gene. Resistant: Fusarium wilt (race 1,2,3), Verticillium wilt (race 1), and Gray leaf spot. For Trial.*

FLORIDA 47. *A late midseason, determinate, jointed hybrid. Uniform green, globe-shaped fruit. Resistant: Fusarium wilt (race 1,2), Verticillium wilt (race 1), Alternaria stem canker, and Gray leaf spot. (Seminis)*

FLORIDA 91. *Uniform green fruit borne on jointed pedicels. Determinate plant. Good fruit setting ability under high temperatures. Resistant: Verticillium wilt (race 1), Fusarium wilt (race 1,2), Alternaria stem canker, and Gray leaf spot. (Seminis)*

HA 3073. *A midseason, determinate, jointed hybrid. Fruit are large, firm, slightly oblate and are uniformly green. Resistant: Resistant: Verticillium wilt (race 1), Fusarium wilt (race 1,2), Gray leaf spot, Tomato yellow leaf Curl and Tomato mosaic. (Hazera)*

LINDA. *Main season. Large round, smooth, uniform shouldered fruit with excellent firm-*

ness and a small blossom end scar. Strong determinate bush with good cover. Resistant: Verticillium wilt (race 1), Fusarium wilt (race 1,2), Alternaria stem canker and Gray leaf spot. (Sakata)

PHOENIX. *Early mid-season. Fruit are large to extra-large, high quality, firm, globe-shaped and are uniformly-colored. "Hot-set" variety. Determinate, vigorous vine with good leaf cover for fruit protection. Resistant: Verticillium wilt (race 1), Fusarium wilt (race 1,2), Alternaria stem canker and Gray leaf spot. (Seminis)*

QUINCY. *Full season. Fruit are large to extra-large, excellent quality, firm, deep oblate shape and uniformly colored. Very strongly determinate plants. Resistant: Verticillium wilt (race 1), Fusarium wilt (race 1,2), Alternaria stem canker, Tomato spotted wilt and Gray leaf spot. (Seminis)*

RPT 6153. *Main season. Fruit have good eating quality and fancy appearance in a large sturdy shipping tomato and are firm enough for vine-ripe. Large determinate plants. Resistant: Verticillium wilt (race 1), Fusarium wilt (race 1,2) and Gray leaf spot. (Seedway)*

SANIBEL. *Main season. Large, firm, smooth fruit with light green shoulder and a tight blossom end. Large determinate bush. Resistant: Verticillium wilt (race 1), Fusarium wilt (race 1,2), root-knot nematodes, Alternaria stem canker and Gray leaf spot. (Seminis)*

SEBRING. *A late midseason determinate, jointed hybrid with a smooth, deep oblate, firm, thick walled fruit. Resistant: Verticillium wilt (race 1), Fusarium wilt (race 1,2,3), Fusarium crown rot and Gray leaf spot. (Syngenta)*

SECURITY 28. *An early season determinate variety with a medium vine and good leaf cover adapted to different growing conditions. Produces extra large, round and firm fruit. Resistant: Alternaria stem canker, Fusarium wilt (race 1 and 2), Gray leaf spot, Tomato yellow leaf curl and Verticillium wilt (race 1). (Harris Moran)*

SOLAR FIRE. *An early, determinate, jointed hybrid. Has good fruit setting ability under high temperatures. Fruit are large, flat-round, smooth, firm, light green shoulder and blossom scars are smooth. Resistant: Verticillium wilt (race 1), Fusarium wilt (race 1, 2 and 3) and gray leaf spot. (Harris Moran)*

SOLIMAR. *A midseason hybrid producing globe-shaped, green shouldered fruit. Resistant: Verticillium wilt (race 1), Fusarium wilt (race 1 and 2), Alternaria stem canker, gray leaf spot. (Seminis)*

SORAYA. *Full season. Fruit are high quality, smooth and tend toward large to extra-large. Continuous set. Strong, large bush. Resistant: Verticillium wilt (race 1), Fusarium wilt (race 1,2,3), Fusarium crown rot and Gray leaf spot. (Syngenta Rogers Seed)*

TALLADEGA. *Midseason. Fruit are large to extra-large, globe to deep globe shape. Determinate bush. Has some hot-set ability. Performs well with light to moderate pruning. Resistant: Verticillium wilt (race 1), Fusarium wilt (race 1,2), Tomato spotted wilt and Gray leaf spot. (Syngenta Rogers Seed)*

TYGRESS. *A midseason, jointed hybrid producing large, smooth firm fruit with good packouts. Resistant: Verticillium wilt (race 1), Fusarium wilt (race 1 and 2), gray leaf spot, Tomato mosaic and Tomato yellow leaf curl. (Seminis)*

PLUM TYPE VARIETIES

BHN 410. *Midseason. Large, smooth, blocky, jointless fruit tolerant to weather cracking. Compact to small bush with concentrated high yield. Resistant: Verticillium wilt (race 1), Fusarium wilt (race 1,2), Bacterial speck (race 0) and Gray leaf spot. (BHN Seed)*

BHN 411. *Midseason. Large, smooth, jointless fruit is tolerant to weather cracks and has reduced tendency for graywall. Compact plant with concentrated fruit set. Resistant: Verticillium wilt (race 1), Fusarium wilt (race 1,2), Bacterial speck (race 0) and Gray leaf spot. (BHN Seed)*

BHN 685. *Midseason. Large to extra-large, deep blocky, globe shaped fruit. Determinate, vigorous bush with no pruning recommended. Resistant: Verticillium wilt (race 1), Fusarium wilt (race 1,2,3) and Tomato spotted wilt. (BHN Seed)*

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

MONICA. *Midseason. Fruit are elongated, firm, extra-large and uniform green color. Vigorous bush with good cover. Resistant: Verticillium wilt (race 1), Fusarium wilt (race 1,2), Bacterial speck (race 0) and Gray leaf spot. (Sakata)*

PLUM DANDY. *Medium to large determinate plants. Rectangular, blocky, defect-free fruit for fresh-market production. When grown in hot, wet conditions, it does not set fruit well and is susceptible to bacterial spot. For winter and spring produc*tion in Florida. Resistant: Verticillium wilt, Fusarium wilt (race 1), Early blight, and rain checking. (Harris Moran)

SUNOMA. Main season. Fruit are medium-large, elongated and cylindrical. Plant maintains fruit size through multiple harvests. Determinate plant with good fruit cover. Resistant: Verticillium wilt (race 1), Fusarium wilt (race 1,2), Bacterial speck (race 0), root-knot nematodes, Tomato mosaic and Gray leaf spot. (Seminis)

CHERRY TYPE VARIETIES

BHN 268. *Early. An extra firm cherry tomato that holds, packs and ships well. Determinate, small to medium bush with high yields. Resistant: Verticillium wilt (race 1), Fusarium wilt (race 1). (BHN Seed)*

CAMELIA. *Midseason. Deep globe, cocktail-cherry size with excellent firmness and long shelf life. Indeterminate bush. Outdoor or greenhouse production. Verticillium wilt (race 1), Fusarium wilt (race 1) and Tobacco mosaic. (Siegers Seed)*

CHERRY BLOSSOM. *70 days. Large cherry, holds and yields well. Determinate bush. Resistant: Verticillium wilt (race 1), Fusarium wilt (race 1,2), Bacterial speck (race 0), root-knot nematodes, Alternaria stem canker and Gray leaf spot. (Seedway)*

MOUNTAIN BELLE. *Vigorous, determinate* *type plants. Fruit are round to slightly ovate with uniform green shoulders borne on jointless pedicels. Resistant: Fusarium wilt (race 2), Verticillium wilt (race 1). (Syngenta Rogers Seed)*

SUPER SWEET 100 VF. *Produces large clusters of round uniform fruit with high sugar levels. Fruit somewhat small and may crack during rainy weather. Indeterminate vine with high yield potential. Resistant: Verticillium wilt (race 1) and Fusarium wilt (race 1). (Siegers Seed, Seedway)*

SHIREN. *Compact plant with high yield potential and nice cluster. Resistant: Fusarium wilt (race 1,2), root-knot nematodes and Tomato mosaic. (Hazera)*

GRAPE-TOMATO TYPE VARIETIES

BRIXMORE. *Very early. Indeterminate. Very uniform in shape and size, deep glossy red color with very high early and total yield. High brix and excellent firm flavor. Resistant: Verticillium wilt (race 1), root-knot nematodes and Tomato mosaic. (Harris Moran)*

CUPID. *Early. Vigorous, indeterminate bush. Oval-shaped fruit have an excellent red color and a sweet flavor. Resistant: Fusarium wilt (race 1,2), Bacterial speck (intermediate resistance race 0) and Gray leaf spot. (Seminis)*

JOLLY ELF. *Early season. Determinate plant. Extended market life with firm, flavorful grape-shaped fruits. Average 10% brix. Resistant: Verticillium wilt (race 1), Fusarium wilt (race 2) and cracking. (Siegers Seed, Seedway)*

SANTA. *75 days. Vigorous indeterminate bush. Firm elongated grape-shaped fruit with outstanding flavor and up to 50 fruits per truss. Resistant: Verticillium wilt (race 1), Fusarium wilt (race 1), root-knot nematodes and Tobacco mosaic. (Thompson and Morgan)*

ST NICK. *Mid-early season. Indeterminate bush. Oblong, grape-shaped fruit with brilliant red color and good flavor. Up to 10% brix. (Siegers Seed)*

SMARTY. *69 days. Vigorous, indeterminate bush with short internodes. Plants are 25% shorter than Santa. Good flavor, sweet and excellent flavor. (Seedway)*✻

WATER MANAGEMENT

FOR TOMATO

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

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

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

TOMATO WATER REQUIREMENT

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

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

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

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

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

Typical CF values for fully-grown tomato should not exceed 0.75 (Locascio and Smajstrla, 1996). A third method for estimated tomato crop water requirement is to use modified Bellani plates also known as atmometers. A common model of atmomter used in Florida is the ETgage. This device consists of a canvas-covered ceramic evaporation plate mounted on a water reservoir. The green fabric creates a diffusion barrier that controls evaporation at a rate similar to that of well water plants. Water loss through evaporation can be read on a clear sight tube mounted on the side of the device. Evaporation from the ETgage (ETg) was well correlated to ETo except on rainy days, but overall, the ETgage tended to underestimate ETo (Irmak et al., 2005). On days with rainfall less than 0.2 inch/day, ETo can be estimated from ETg as: ETo = 1.19 ETg. When rainfall exceeds 0.2inch/day, rain water wets the canvas which interferes with the flow of water out of the atmometers, and decreases the reliability of the measurement.

TOMATO IRRIGATION REQUIREMENT

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

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

IRRIGATION SCHEDULING FOR TOMATO

For seepage irrigated crops, irrigation scheduling recommendations consist of maintaining the water table near the 18-inch depth shortly after transplanting and near the 24- inch depth thereafter (Stanley and Clark, 2003). The actual

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

WATER MANAGEMENT LEVEL	WATER MANAGEMENT RATING	IRRIGATION SCHEDULING METHOD
0	NONE	GUESSING (IRRIGATE WHENEVER)
1	VERY LOW	USING THE >FEEL AND SEE= METHOD
2	LOW	USING SYSTEMATIC IRRIGATION (EXAMPLE: 2 HRS EVERY DAY)
3	INTERMEDIATE	USING A SOIL MOISTURE MEASURING TOOL TO START IRRIGATION
4	ADVANCED	USING A SOIL MOISTURE MEASURING TOOL TO SCHEDULE IRRIGATION AND APPLY AMOUNTS BASED ON A BUDGETING PROCEDURE
5	RECOMMENDED	USING TOGETHER A WATER USE ESTIMATE BASED ON TOMATO PLANT STAGE OF GROWTH, A MEASUREMENT OF SOIL WATER MOISTURE, DETERMINING RAINFALL CONTRIBUTION TO SOIL MOISTURE, AND HAVING A GUIDELINE FOR SPLITTING IRRIGATION. IN ADDITION, BMPS HAVE SOME RECORD KEEPING REQUIREMENTS

TABLE 2. Summary of irrigation management guidelines for tomato.

IRRIGATION MANAGEMENT COMPONENT	IRRIGATION SYSTEM[Z]	
	SEEPAGE[Y]	DRIP[X]
1- TARGET WATER APPLICATION RATE	KEEP WATER TABLE BETWEEN 18 AND 24 INCH DEPTH	HISTORICAL WEATHER DATA OR CROP EVAPOTRANSPIRATION (ETC) CALCULATED FROM REFERENCE ET OR CLASS A PAN EVAPORATION
2- FINE TUNE APPLICATION WITH SOIL MOISTURE MEASUREMENT	MONITOR WATER TABLE DEPTH WITH OBSERVATION WELLS	MAINTAIN SOIL WATER TENSION IN THE ROOT ZONE BETWEEN 8 AND 15 CBAR
3- DETERMINE THE CONTRIBUTION OF RAINFALL	TYPICALLY, 1 INCH RAINFALL RAISES THE WATER TABLE BY 1 FOOT	POOR LATERAL WATER MOVEMENT ON SANDY AND ROCKY SOILS LIMITS THE CONTRIBUTION OF RAINFALL TO CROP WATER NEEDS TO (1) FOLIAR ABSORPTION AND COOLING OF FOLIAGE AND (2) WATER FUNNELED BY THE CANOPY THROUGH THE PLAN HOLE.
4- RULE FOR SPLITTING IRRIGATION	NOT APPLICABLE	IRRIGATIONS GREATER THAN 12 AND 50 GAL/100FT (OR 30 MIN AND 2 HRS FOR MEDIUM FLOW RATE) WHEN PLANTS ARE SMALL AND FULLY GROWN, RESPECTIVELY ARE LIKELY TO PUSH THE WATER FRONT BEING BELOW THE ROOT ZONE
5-RECORD KEEPING	IRRIGATION AMOUNT APPLIED AND TOTAL RAINFALL RECEIVED[W] DAYS OF SYSTEM OPERATION	IRRIGATION AMOUNT APPLIED AND TOTAL RAINFALL RECEIVED[W] DAILY IRRIGATION SCHEDULE

[Z] EFFICIENT IRRIGATION SCHEDULING ALSO REQUIRES A PROPERLY DESIGNED AND MAINTAINED IRRIGATION SYSTEMS
[Y] PRACTICAL ONLY WHEN A SPODIC LAYER IS PRESENT IN THE FIELD
[X] ON DEEP SANDY SOILS
[W] REQUIRED BY THE BMPS

depth of the water table may be monitored with shallow observation wells (Smajstrla, 1997).

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

SOIL MOISTURE MEASUREMENT

Soil water tension (SWT) represents the magnitude of the suction (negative pressure) the plant roots have to create to free soil water from the attraction of the soil particles, and move it into its root cells. The dryer the soil, the higher the suction needed, hence, the higher SWT. SWT is commonly expressed in centibars

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

TOMATO GROWTH STAGE	PLASTICULTURE
1	0.30
2	0.40
3	0.90
4	0.90
5	0.75

[z] ACTUAL VALUES WILL VARY WITH TIME OF PLANTING, LENGTH OF GROWING SEASON AND OTHER SITE-SPECIFIC FACTORS. KC VALUES SHOULD BE USED WITH ET_O VALUES IN TABLE 4 TO ESTIMATED CROP EVAPOTRANSPIRATION (ETC)

(cb) or kiloPascals (kPa; 1cb = 1kPa). For tomatoes grown on the sandy soils of Florida, SWT in the rooting zone should be maintained between 6 (field capacity) and 15 cb.

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

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

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

Times domain reflectometry (TDR) is not a new method for measuring soil moisture but its use in vegetable production has been limited in the past. The recent availability of inexpensive equipment ($400 to $550/unit) has increased the potential of this method to become practical for tomato growers. A TDR unit is comprised of three parts: a display unit, a sensor, and two rods. Rods may be 4 inches or 8 inches in length based on the depth of the soil. Long rods may be used in all the sandy soils of Florida, while the short rods may be used with the shallow soils of Miami-Dade county.

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

TDR actually determines percent soil moisture (volume of water per volume of soil). In theory, a soil water release curve has to be used to convert soil moisture in to SWT. However, because TDR provides an average soil moisture reading over the entire length of the rod (as opposed to

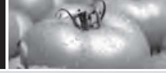
TABLE 4. Historical Penman-method reference ET (ETo) for four Florida locations (in gallons per acre per day)

MONTH	TALLAHASSEE	TAMPA	WEST PALM BEACH	MIAMI
JANUARY	1,630	2,440	2,720	2,720
FEBRUARY	2,440	3,260	3,530	3,530
MARCH	3,260	3,800	4,340	4,340
APRIL	4,340	5,160	5,160	5,160
MAY	4,890	5,430	5,160	5,160
JUNE	4,890	5,430	4,890	4,890
JULY	4,620	4,890	4,890	4,890
AUGUST	4,340	4,620	4,890	4,620
SEPTEMBER	3,800	4,340	4,340	4,070
OCTOBER	2,990	3,800	3,800	3,800
NOVEMBER	2,170	2,990	3,260	2,990
DECEMBER	1,630	2,170	2,720	2,720

[z] ASSUMING WATER APPLICATION OVER THE ENTIRE AREA WITH 100% EFFICIENCY

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

WETTING WIDTH (FT)	GAL/100FT TO WET DEPTH OF 1 FT	GAL/100FT TO WET DEPTH OF 1.5 FT	GAL/100FT TO WET DEPTH OF 2 FT	GAL/ACRE TO WET DEPTH OF 1 FT	GAL/ACRE TO WET DEPTH OF 1.5FT	GAL/ACRE TO WET DEPTH OF 2 FT
1.0	24	36	48	1,700	2,600	3,500
1.5	36	54	72	2,600	3,900	5,200



the specific depth used for tensiometers), it is not practical to simply convert SWT into soil moisture to compare readings from both methods. Preliminary tests with TDR probes have shown that best soil monitoring may be achieved by placing the probe vertically, approximately 6 inches away from the drip tape on the opposite side of the tomato plants. For fine sandy soils, 9% to 15% appears to be the adequate moisture range. Tomato plants are exposed to water stress when soil moisture is below 8%. Excessive irrigation may result in soil moisture above 16%.

GUIDELINES FOR SPLITTING IRRIGATION

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

UNITS FOR MEASURING IRRIGATION WATER

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

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

EXAMPLE

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

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

IRRIGATION AND BEST MANAGEMENT PRACTICES

As an effort to clean impaired water bodies, federal legislation in the 70's, followed by state legislation in the 90's and state rules since 2000 have progressively shaped the Best Management Practices (BMP) program for vegetable production in Florida. Section 303(d) of the Federal Clean Water Act of 1972 required states to identify impaired water bodies and establish Total Maximum Daily Loads (TMDL) for pollutants entering these water bodies. In 1987, the Florida legislature passed the Surface Water Improvement and Management Act requiring the five Florida water management districts to develop plans to clean up and preserve Florida lakes, bays, estuaries, and rivers. In 1999, the Florida Watershed Restoration Act defined a process for the development of TMDLs. More recently, the "Florida vegetable and agronomic crop water quality/quantity Best Management Practices" manual was adopted by reference and by rule 5M-8 in the Florida Administrative Code on Feb.9, 2006 (FDACS, 2005). The manual which is available at www.floridaagwaterpolicy.com, provides background on the state-wide BMP program for vegetables, lists all the possible BMPs, provides a selection mechanism for building a customized BMP plan, outlines record-keeping requirements, and explains how to participate in the BMP program. By definition, BMPs are specific cultural practices that aim at reducing nutrient load while maintaining or increasing productivity. Hence, BMPs are tools to achieve the TMDL. Vegetable growers who elect to participate in the BMP program receive three statutory benefits: (1) a waiver of liability from reimbursement of cost and damages associated with the evaluation, assessment, or remediation of contamination of ground water (Florida Statutes 376.307); (2) a presumption of compliance with water quality standards (F.S. 403.067 (7)(d)), and (3); an eligibility for cost-share programs (F.S. 570.085 (1)).

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

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FERTILIZER AND NUTRIENT MANAGEMENT FOR TOMATO

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Fertilizer and nutrient management are essential components of successful commercial tomato production. This article presents the basics of nutrient management for the different production systems used for tomato in Florida.

CALIBRATED SOIL TEST: TAKING THE GUESSWORK OUT OF FERTILIZATION

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

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

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

LIMING

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

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

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

PRODUCTION SYSTEM	NUTRIENT	RECOMMENDED BASE FERTILIZATION[Z]								RECOMMENDED SUPPLEMENTAL FERTILIZATION[Z]		
		TOTAL (LBS/A)	PREPLANT[Y] (LBS/A)	INJECTED[X] (LBS/A/DAY) WEEKS AFTER TRANSPLANTING[W]					LEACHING RAIN[R,S]	MEASURED "LOW" PLANT NUTRIENT CONTENT[U,S]	EXTENDED HARVEST SEASON[S]
				1-2	3-4	5-11	12	13			
DRIP IRRIGATION, RAISED BEDS, AND POLYETHYLENE MULCH	N	200	0-50	1.5	2.0	2.5	2.0	1.5	N/A	1.5 TO 2 LBS/A/DAY FOR 7DAYS[T]	1.5-2 LBS/A/DAY[P]
	K_2O	220	0-50	2.5	2.0	3.0	2.0	1.5	N/A	1.5-2 LBS/A/DAY FOR 7DAYS[T]	1.5-2 LBS/A/DAY[P]
SEEPAGE IRRIGATION, RAISED BEDS, AND POLYETHYLENE MULCH	N	200	200[V]	0	0	0	0	0	30 LBS/A[Q]	30 LBS/A[T]	30 LBS/A[P]
	K2O	220	220[V]	0	0	0	0	0	20 LBS/A[Q]	20 LBS/A[T]	20 LBS/A[P]

[Z] 1 A = 7,260 LINEAR BED FEET PER ACRE (6-FT BED SPACING); FOR SOILS TESTING >VERY LOW= IN MEHLICH 1 POTASSIUM (K2O).
[Y] APPLIED USING THE MODIFIED BROADCAST METHOD (FERTILIZER IS BROADCAST WHERE THE BEDS WILL BE FORMED ONLY, AND NOT OVER THE ENTIRE FIELD). PREPLANT FERTILIZER CANNOT BE APPLIED TO DOUBLE/TRIPLE CROPS BECAUSE OF THE PLASTIC MULCH; HENCE, IN THESE CASES, ALL THE FERTILIZER HAS TO BE INJECTED.
[X] THIS FERTIGATION SCHEDULE IS APPLICABLE WHEN NO N AND K2O ARE APPLIED PREPLANT. REDUCE SCHEDULE PROPORTIONALLY TO THE AMOUNT OF N AND K2O APPLIED PREPLANT. FERTILIZER INJECTIONS MAY BE DONE DAILY OR WEEKLY. INJECT FERTILIZER AT THE END OF THE IRRIGATION EVENT AND ALLOW ENOUGH TIME FOR PROPER FLUSHING AFTERWARDS.
[W] FOR A STANDARD 13 WEEK-LONG, TRANSPLANTED TOMATO CROP GROWN IN THE SPRING.
[V] SOME OF THE FERTILIZER MAY BE APPLIED WITH A FERTILIZER WHEEL THOUGH THE PLASTIC MULCH DURING THE TOMATO CROP WHEN ONLY PART OF THE RECOMMENDED BASE RATE IS APPLIED PREPLANT. RATE MAY BE REDUCED WHEN A CONTROLLED-RELEASE FERTILIZER SOURCE IS USED.
[U] PLANT NUTRITIONAL STATUS MAY BE DETERMINED WITH TISSUE ANALYSIS OR FRESH PETIOLE-SAP TESTING, OR ANY OTHER CALIBRATED METHOD. THE >LOW= DIAGNOSIS NEEDS TO BE BASED ON UF/IFAS INTERPRETATIVE THRESHOLDS.
[T] PLANT NUTRITIONAL STATUS MUST BE DIAGNOSED EVERY WEEK TO REPEAT SUPPLEMENTAL APPLICATION.
[S] SUPPLEMENTAL FERTILIZER APPLICATIONS ARE ALLOWED WHEN IRRIGATION IS SCHEDULED FOLLOWING A RECOMMENDED METHOD. SUPPLEMENTAL FERTILIZATION IS TO BE APPLIED IN ADDITION TO BASE FERTILIZATION WHEN APPROPRIATE. SUPPLEMENTAL FERTILIZATION IS NOT TO BE APPLIED >IN ADVANCE= WITH THE PREPLANT FERTILIZER.
[R] A LEACHING RAIN IS DEFINED AS A RAINFALL AMOUNT OF 3 INCHES IN 3 DAYS OR 4 INCHES IN 7 DAYS.
[Q] SUPPLEMENTAL AMOUNT FOR EACH LEACHING RAIN
[P] PLANT NUTRITIONAL STATUS MUST BE DIAGNOSED AFTER EACH HARVEST BEFORE REPEATING SUPPLEMENTAL FERTILIZER APPLICATION.

modification, but magnesium is low, apply magnesium sulfate or potassium-magnesium sulfate.

Changes in soil pH may take several weeks to occur when carbonate-based liming materials are used (calcitic or dolomitic limestone). Oxide-based liming materials (quick lime -CaO- or dolomitic quick lime -CaO, MgO-) are fast reacting and rapidly increase soil pH. Yet, despite these advantages, oxide-based liming materials are more expensive than the traditional liming materials, and therefore are not routinely used.

The increase in pH induced by liming materials is not due to the presence of calcium or magnesium. Instead, it is the carbonate ("CO3") and oxide ("O") part of CaCO3 and "CaO", respectively, that raises the pH. Through several chemical reactions that occur in the soil, carbonates and oxides release OH- ions that combine with H+ to produce water. As large amounts of H+ react, the pH rises. A large fraction of the Ca and/or Mg in the liming materials gets into solution and binds to the sites that are freed by H+ that have reacted with OH-.

FERTILIZER-RELATED PHYSIOLOGICAL DISORDERS

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

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

Factors that impair the ability of tomato plants to obtain water will increase the risk of BER. These factors include damaged roots from flooding, mechanical damage or nematodes, clogged drip emitters, inadequate water applications, alternating dry-wet periods, and even prolonged overcast periods. Other causes for BER include high fertilizer rates, especially potassium and nitrogen.

Calcium levels in the soil should be adequate when the Mehlich-1 index is 300 to 350 ppm, or above. In these cases, added gypsum (calcium sulfate) is unlikely to reduce BER. Foliar sprays of Ca are unlikely to reduce BER because Ca does not move out of the leaves to the fruit.

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

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

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

		N	P	K	CA	MG	S	FE	MN	ZN	B	CU	MO
		%						PPM					
MRM[z] LEAF 5-LEAF STAGE	DEFICIENT	<3.0	0.3	3.0	1.0	0.3	0.3	40	30	25	20	5	0.2
	ADEQUATE RANGE	3.0 5.0	0.3 0.6	3.0 5.0	1.0 2.0	0.3 0.5	0.3 0.8	40 100	30 100	25 40	20 40	5 15	0.2 0.6
	HIGH	>5.0	0.6	5.0	2.0	0.5	0.8	100	100	40	40	15	0.6
MRM LEAF FIRST FLOWER	DEFICIENT	<2.8	0.2	2.5	1.0	0.3	0.3	40	30	25	20	5	0.2
	ADEQUATE RANGE	2.8 4.0	0.2 0.4	2.5 4.0	1.0 2.0	0.3 0.5	0.3 0.8	40 100	30 100	25 40	20 40	5 15	0.2 0.6
	HIGH	>4.0	0.4	4.0	2.0	0.5	0.8	100	100	40	40	15	0.6
	TOXIC (>)								1500	300	250		
MRM LEAF EARLY FRUIT SET	DEFICIENT	<2.5	0.2	2.5	1.0	0.25	0.3	40	30	20	20	5	0.2
	ADEQUATE RANGE	2.5 4.0	0.2 0.4	2.5 4.0	1.0 2.0	0.25 0.5	0.3 0.6	40 100	30 100	20 40	20 40	5 10	0.2 0.6
	HIGH	>4.0	0.4	4.0	2.0	0.5	0.6	100	100	40	40	10	0.6
	TOXIC (>)										250		
MRM LEAF FIRST RIPE FRUIT	DEFICIENT	<2.0	0.2	2.0	1.0	0.25	0.3	40	30	20	20	5	0.2
	ADEQUATE RANGE	2.0 3.5	0.2 0.4	2.0 4.0	1.0 2.0	0.25 0.5	0.3 0.6	40 100	30 100	20 40	20 40	5 10	0.2 0.6
	HIGH	>3.5	0.4	4.0	2.0	0.5	0.6	100	100	40	40	10	0.6
MRM LEAF DURING HARVEST PERIOD	DEFICIENT	<2.0	0.2	1.5	1.0	0.25	0.3	40	30	20	20	5	0.2
	ADEQUATE RANGE	2.0 3.0	0.2 0.4	1.5 2.5	1.0 2.0	0.25 0.5	0.3 0.6	40 100	30 100	20 40	20 40	5 10	0.2 0.6
	HIGH	>3.0	0.4	2.5	2.0	0.5	0.6	100	100	40	40	10	0.6

[z]MRM=MOST RECENTLY MATURED LEAF.

containing fungicides need to consider these sources when calculating fertilizer micronutrient needs.

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

FERTILIZER APPLICATION

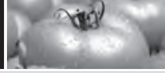
Mulch Production with Seepage Irrigation. Under this system, the crop may be supplied with all of its soil requirements before the mulch is applied (Table 1). It is difficult to correct a deficiency after mulch application, although a liquid fertilizer injection wheel can facilitate sidedressing through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

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

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

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

STAGE OF GROWTH	SAP CONCENTRATION (PPM)	
	NO3-N	K
FIRST BUDS	1000-1200	3500-4000
FIRST OPEN FLOWERS	600-800	3500-4000
FRUITS ONE-INCH DIAMETER	400-600	3000-3500
FRUITS TWO-INCH DIAMETER	400-600	3000-3500
FIRST HARVEST	300-400	2500-3000
SECOND HARVEST	200-400	2000-2500



moisture devices may be found in Munoz-Carpena (2004).

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

Successful crops have resulted where the total amounts of N and K2O were applied through the drip system. Some growers find this method helpful where they have had problems with soluble-salt burn. This approach would be most likely to work on soils with relatively high organic matter and some residual potassium. However, it is important to begin with rather high rates of N and K2O to ensure young transplants are established quickly. In most situations, some preplant N and K fertilizers are needed.

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

SOURCES OF N-P2O5-K2O

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

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

TABLE 4. Progressive levels of nutrient management for tomato production.

NUTRIENT MANAGEMENT	DESCRIPTION
RATING	
NONE	GUESSING
VERY LOW	SOIL TESTING AND STILL GUESSING
LOW	SOIL TESTING AND IMPLEMENTING "A" RECOMMENDATION
INTERMEDIATE	SOIL TESTING, UNDERSTANDING IFAS RECOMMENDATIONS, AND CORRECTLY IMPLEMENTING THEM
ADVANCED	SOIL TESTING, UNDERSTANDING IFAS RECOMMENDATIONS, CORRECTLY IMPLEMENTING THEM, AND MONITORING CROP NUTRITIONAL STATUS
RECOMMENDED	SOIL TESTING, UNDERSTANDING IFAS RECOMMENDATIONS, CORRECTLY IMPLEMENTING THEM, MONITORING CROP NUTRITIONAL STATUS, AND PRACTICE YEAR-ROUND NUTRIENT MANAGEMENT AND/OR FOLLOWING BMPS (INCLUDING ONE OF THE RECOMMENDED IRRIGATION SCHEDULING METHODS).

[z]THESE LEVELS SHOULD BE USED TOGETHER WITH THE HIGHEST POSSIBLE LEVEL OF IRRIGATION MANAGEMENT

All sources of potassium can be used for tomato. Potassium sulfate, sodium-potassium nitrate, potassium nitrate, potassium chloride, monopotassium phosphate, and potassium-magnesium sulfate are all good K sources. If the soil test predicted amounts of K2O are applied, then there should be no concern for the K source or its associated salt index.

SAP TESTING AND TISSUE ANALYSIS

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

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

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

SUPPLEMENTAL FERTILIZER APPLICATIONS

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

LEVELS OF NUTRIENT MANAGEMENT FOR TOMATO PRODUCTION

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

ADDITIONAL READINGS:

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Studstill, D., E. Simonne, R. Hochmuth, and T. Olczyk. 2006. Calibrating sap-testing meters. EDISHS 1074, http://edis.ifas.ufl.edu/HS328.

WEED CONTROL IN TOMATO

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

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

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

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

Field ditches and canals present special considerations because many herbicides are not labeled for use on aquatic sites. Where herbicidal spray may contact water and be in close proximity to tomato plants, for all practical purposes, growers probably would be wise to use Diquat only. On canals where drift onto the crop is not a problem and weeds are more woody, Rodeo, a systemic herbicide, could be used. Other herbicide possibilities exist, as listed in Table 1. Growers are cautioned against using Arsenal on tomato farms because tomatoes are very sensitive to this herbicide. Particular caution should be exercised if Arsenal is used on seepage irrigated farms because it has been observed to move in some situations.

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

The greatest row middle weed problem confronting the tomato industry today is nightshade. Nightshade has developed varying levels of resistance to some post-emergent herbicides in different areas of the state. Best control with post-emergence (directed) contact herbicides is obtained when the nightshade is 4 to 6 inches tall, rapidly growing and not stressed. Two applications in about 50 gallons per acre using a good surfactant are usually necessary.

With post-directed contact herbicides, several studies have shown that gallonage above 60 gallons per acre will actually dilute the herbicides and therefore reduce efficacy. Good leaf coverage can be obtained with volumes of 50 gallons or less per acre. A good surfactant can do more to improve the wetting capability of a spray than can increasing the water volume. Many adjuvants are available commercially. Some adjuvants contain more active ingredient than others and herbicide labels may specify a minimum active ingredient rate for the adjuvant in the spray mix. Before selecting an adjuvant, refer to the herbicide label to determine the adjuvant specifications.

POSTHARVEST VINE DESSICATION

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

The importance of rapid vine destruction cannot be overstressed. Merely turning off the irrigation and allowing the crop to die will not do; application of a desiccant followed by burning is the prudent course. ✻

TABLE 1. Chemical weed controls for tomatoes.

HERBICIDE	LABELED CROPS	TIME OF APPLICATION TO CROP	RATE (LBS. AI./ACRE)	
			MINERAL	MUCK
CARFENTRAZONE (AIM)	TOMATO	PREPLANT DIRECTED-HOODED ROW-MIDDLES	0.031	0.031
Remarks: Aim may be applied as a preplant burndown treatment and/or as a post-directed hooded application to row middles for the burndown of emerged broadleaf weeds. May be tank mixed with other registered herbicides. May be applied at up to 2 oz (0.031 lb ai). Use a quality spray adjuvant such as crop oil concentrate (COC) or non-ionic surfactant at recommended rates.				
CLETHODIM (SELECT 2 EC) (ARROW) (SELECTMAX)	TOMATOES	POSTEMERGENCE	0.9-.25	----
Remarks: Postemergence control of actively growing annual grasses. Apply at 6-16 fl oz/acre. Use high rate under heavy grass pressure and/or when grasses are at maximum height. Always use a crop oil concentrate at 1% v/v in the finished spray volume, or a non-ionic Surfactant with SelectMAX. Do not apply within 20 days of tomato harvest.				
DCPA (DACTHAL W-75)	ESTABLISHED TOMATOES	POSTTRANSPLANTING AFTER CROP ESTABLISHMENT (NON-MULCHED)	6.0-8.0	----
Remarks: Controls germinating annuals. Apply to weed-free soil 6 to 8 weeks 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.				
EPTC (EPTAM 7E)	TOMATOES	PRETRANSPLANT	2.62-3.5	----
Remarks: Labeled for transplanted tomatoes grown on plastic mulch. Apply 3-4 pints/A to the bed top and shoulders immediately prior to the installation of the mulch. Do not transplant the tomato plants for a minimum of 14 days following the application. A 24c special local needs label for Florida.				
FLUMIOXAZIN (CHATEAU)	FRUITING VEGETABLES TOMATOES	DIRECTED ROW-MIDDLES	0.125	----
Remarks: Chateau may be applied up to 4 ox product/application to row middles of raised plastic mulched beds that are at least 4 inches higher than the treated row middle and the mulched bed must be a minimum of a 24-inch bed width. Do not apply after crops are transplanted. All applications must be made with shielded or hooded equipment. For control of emerged weeds, a burn down herbicide may be tank-mixed. Label is a Third-Party registration (TPR, Inc.). Use without a signed authorization and waiver of liability is a misuse of the product.				
GLYPHOSATE (ROUNDUP, DURANGO, TOUCHDOWN, GLYPHOMAX)	TOMATOES	CHEMICAL FALLOW PREPLANT, PREEMERGENCE, PRETRANSPLANT	0.3-1.0	----
Remarks: Roundup, Glyphomax and Touchdown have several formulations. Check the label of each for specific labeling directions.				
HALOSULFURON (SANDEA)	TOMATOES	PRETRANSPLANT POSTEMERGENCE ROW MIDDLES	0.024-0.036	----
Remarks: A total of 2 applications of Sandea may be applied as either one pre-transplant soil surface treatment at 0.5-0.75 oz. product; one over-the-top application 14 days after transplanting at 0.5-0.75 oz. product; and/or postemergence applications(s) of up to 1 oz. product (0.047 lb ai) to row middles. A 30-day PHI will be observed. For postemergence and row middle applications, a surfactant should be added to the spray mix.				
LACTOFEN (COBRA)	FRUITING VEGETABLES	ROW MIDDLES	0.25-0.5	----
Remarks: Third Party label for use pre-transplant or post transplant shielded or hooded to row middles. Apply 16 to 32 fluid oz per acre. A minimum of 24 fl oz is required for residual control. Add a COC or non-ionic surfactant for control of emerged weeds. 1 pre and 1 post application may be made per growing season. Cobra contacting green foliage or fruit can cause excessive injury. Drift of Cobra treated soil particles onto plants can cause contact injury. Do not apply within 30 days of harvest. The supplemental label must be in the possession of the user at the time of application.				
S-METOLACHLOR (DUAL MAGNUM)	TOMATOES	PRETRANSPLANT- ROW MIDDLES	1.0-1.3	----
Remarks: Apply Dual Magnum preplant non-incorporated to the top of a pressed bed as the last step prior to laying plastic. May also be used to treat row middles. Label rates are 1.0-1.33 pts/A if organic matter is less than 3%. Research has shown that the 1.33 pt may be too high in some Florida soils except in row middles. Good results have been seen at 0.6 pts to 1.0 pints especially in tank mix situations under mulch. Use on a trial basis.				
METRIBUZIN (SENCOR DF) (SENCOR 4)	TOMATOES	POSTEMERGENCE POSTTRANSPLANTING AFTER ESTABLISHMENT	0.25 - 0.5	----
Remarks: Controls small emerged weeds after transplants are established or when direct-seeded plants reach 5 to 6 true leaf stage. Apply in single or multiple applications with a minimum of 14 days between treatments and a maximum of 1.0 lb ai/acre within a crop season. Avoid applications for 3 days following cool, wet or cloudy weather to reduce possible crop injury.				
METRIBUZIN (SENCOR DF) (SENCOR 4)	TOMATOES	DIRECTED SPRAY IN ROW MIDDLES	0.25 - 1.0	----
Remarks: Apply in single or multiple applications with a minimum of 14 days between treatments and maximum of 1.0 lb ai/acre within crop season. Avoid applications for 3 days following cool, wet or cloudy weather to reduce possible crop injury. Label states control of many annual grasses and broadleaf weeds including, lambsquarter, fall panicum, Amaranthus sp., Florida pusley, common ragweed, sicklepod, and spotted spurge.				

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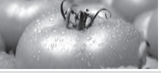
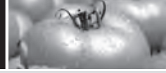


TABLE 1. (CONTINUED) Chemical weed controls for tomatoes.

HERBICIDE	LABELED CROPS	TIME OF APPLICATION TO CROP	RATE (LBS. AI./ACRE)	
			MINERAL	MUCK
NAPROPAMID (DEVRINOL 50DF)	TOMATOES	PREPLANT INCORPORATED	1.0-2.0	----
Remarks: Apply to well worked soil that is dry enough to permit thorough incorporation to a depth of 1 to 2 inches. Incorporate same day as applied. For direct-seeded or transplanted tomatoes.				
NAPROPAMID (DEVRINOL 50DF)	TOMATOES	SURFACE TREATMENT	2.0	----
Remarks: Controls germinating annuals. Apply to bed tops after bedding but before plastic application. Rainfall or overhead-irrigate sufficient to wet soil 1 inch in depth should follow treatment within 24 hours. May be applied to row middles between mulched beds. A special Local Needs 24(c) Label for Florida. Label states control of weeds including Texas panicum, pigweed, purslane, Florida pusley, and signalgrass.				
OXYFLUORFEN (GOAL 2XL) (GOALTENDER)	TOMATOES	FALLOW BED	0.25-0.5	----
Remarks: Must have a 30-day treatment–planting interval for transplanted tomatoes. Apply as a preemergence broadcast to preformed beds or banded treatment at 1-2 pt/A or 1/2 to 1 pt/A for Goaltender. Mulch may be applied any time during the 30-day interval.				
PARAQUAT (GRAMOXONE INTEON) (FIRESTORM)	TOMATOES	PREMERGENCE; PRETRANSPLANT	0.62-0.94	----
Remarks: Controls emerged weeds. Use a non- ionic spreader and thoroughly wet weed foliage.				
PARAQUAT (GRAMOXONE INTEON) (FIRESTORM)	TOMATOES	POST DIRECTED SPRAY IN ROW MIDDLES	0.47	----
Remarks: Controls emerged weeds. Direct spray over emerged weeds 1 to 6 inches tall in row middles between mulched beds. Use a non-ionic spreader. Use low pressure and shields to control drift. Do not apply more than 3 times per season.				
PARAQUAT (GRAMOXONE INTEON) (FIRESTORM)	TOMATOES	POSTHARVEST DESICCATION	0.62-0.93	0.46-0.62
Remarks: Broadcast spray over the top of plants after last harvest. Gramoxone label states use of 2-3 pts. Use a non-ionic surfactant at 1 pt/100 gals to 1 qt/100 gals spray solution. Thorough coverage is required to ensure maximum herbicide burndown. Do not use treated crop for human or animal consumption.				
PELARGONIC ACID (SCYTHE)	FRUITING VEGETABLES (TOMATO)	PREPLANT PREEMERGENCE DIRECTED-SHIELDED	3-10% V/V	----
Remarks: Product is a contact, nonselective, foliar applied herbicide. There is no residual control. May be tank mixed with several soil residual compounds. Consult the label for rates. Has a greenhouse and growth structure label.				
PENDIMETHALIN PROWL H_2O	TOMATOES	POST-DIRECTED ROW MIDDLES	0.0475-0.72	----
Remarks: May be applied pre-transplant but not under mulch. May be applied at 1.0 to 1.5 pts/A to row middles. Do not apply within 70 days of harvest.				
RIMSULFURON (MATRIX)	TOMATOES	POSTTRANSPLANT AND DIRECTED-ROW MIDDLES	0.25-0.5 OZ	----
Remarks: Matrix may be applied preemergence (seeded), postemergence, posttransplant and applied directed to row middles. May be applied at 1-2 oz. product (0.25-0.5 oz ai) in single or sequential applications. A maximum of 4 oz. product per acre per year may be applied. For post (weed) applications, use a non-ionic surfactant at a rate of 0.25% v/v. for preemergence (weed) control, Matrix must be activated in the soil with sprinkler irrigation or rainfall. Check crop rotational guidelines on label.				
SETHOXYDIM (POAST)	TOMATOES	POSTEMERGENCE	0.188 - 0.28	----
Remarks: Controls actively growing grass weeds. A total of 4 1/2 pts. product per acre may be applied in one season. Do not apply within 20 days of harvest. Apply in 5 to 20 gallons of water adding 2 pts. of crop oil concentrate per acre. Unsatisfactory results may occur if applied to grasses under stress. Use 0.188 lb ai (1 pt.) to seedling grasses and up to 0.28 lb ai (1 1/2 pts.) to perennial grasses emerging from rhizomes etc. Consult label for grass species and growth stage for best control.				
TRIFLOXYSULFURON (ENVOKE)	TOMATOES (TRANSPLANTED)	POST DIRECTED	0.007-0.014	----
Remarks: Envoke can be applied at 0.1 to 0.2 oz product/A post-directed to transplanted tomatoes for control of nutsedge, morningglory, pigweeds and other weeds listed on the label. Applications should be made prior to fruit set and at least 45 days prior to harvest. A non-ionic surfactant should be added to the spray mix.				
TRIFLURALIN (TREFLAN HFP) (TREFLAN TR-10) (TRIFLURALIN 4EC)	TOMATOES (EXCEPT DADE COUNTY)	PRETRANSPLANT INCORPORATED	0.5	----
Remarks: Controls germinating annuals. Incorporate 4 inches or less within 8 hours of application. Results in Florida are erratic on soils with low organic matter and clay contents. Note label precautions against planting noncrops within 5 months. Do not apply after transplanting.				



TOMATO FUNGICIDES

AND OTHER DISEASE MANAGEMENT PRODUCTS (UPDATED MAY 2008)

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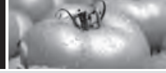
BE SURE TO READ A CURRENT PRODUCT LABEL BEFORE APPLYING ANY CHEMICAL.

CHEMICAL	FUNGICIDE GROUP[1]	MAXIMUM RATE / ACRE		MIN. DAYS TO HARVEST	PERTINENT DISEASES OR PATHOGENS	REMARKS[2]
		APPLIC.	SEASON			
Manex 4 F (maneb)	M3	2.4 qts.	16.8 qts.	5	Early blight Late blight Gray leaf spot Bacterial spot[3]	See label for details
Dithane, Manzate or Penncozeb 75 DFs (mancozeb)	M3	3 lbs.	22.4 lbs.	5		
Maneb 80 WP (maneb)	M3	3 lbs	21 lbs.	5		
Dithane F 45 or Manex II 4 FLs (mancozeb)	M3	2.4 pts.	16.8 qts.	5		
Dithane M-45, Penncozeb 80, or Manzate 80 WPs (mancozeb)	M3	3 lbs.	21 lbs.	5		
Maneb 75 DF (maneb)	M3	3 lbs.	22.4 lbs.	5		
Bonide Mancozeb FL (mancozeb)	M3	5 tsp/ gal		5	Anthracnose Early blight Gray leaf spot Late blight Leaf mold Septoria leaf spot	See label for details.
Ziram (ziram)	M3	4 lbs	24 lbs	7	Anthracnose Early blight Septoria leaf spot	Do not use on cherry tomatoes. See label for details.
Equus 7204, Echo 720, Chloro Gold 720 6 Fls (chlorothalonil)	M5	3 pts. or 2.88 pts.	20.1 pts.	2	Early blight Late blight Gray leaf spot Target spot	Use higher rates at fruit set and lower rates before fruit set, see label
Echo 90 DF or Equus 82.5DF (chlorothalonil)	M5	2.3 lbs.		2		
Ridomil Gold Bravo 76.4 W (chlorothalonil +mefenoxam)	4 / M5	3 lbs.	12 lbs	14	Early blight Late blight Gray leaf spot Target Spot	Limit is 4 appl./ crop, see label
Amistar 80 DF (azoxystrobin)	11	2 oz	12 oz	0	Early blight Late blight Sclerotinia Powdery mildew Target spot Buckeye rot	Limit is 6 appl/crop. Must alternate or tank mix with a fungicide from a different FRAC group, see label.
Quadris (azoxystrobin)	11	6.2 fl.oz.	37.2 fl.oz.	0		
Cabrio 2.09 F (pyraclostro-bin)	11	16 fl oz	96 fl oz	0	Early blight Late blight Sclerotinia Powdery mildew Target spot Buckeye rot	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.

CHEMICAL	FUNGICIDE GROUP[1]	MAXIMUM RATE / ACRE		MIN. DAYS TO HARVEST	PERTINENT DISEASES OR PATHOGENS	REMARKS[2]
		APPLIC.	SEASON			
Flint (trifloxystro-bin)	11	4 oz	16 oz	3	Early blight Late blight Gray leaf spot	Limit is 5 appl/crop. Must alternate or tank mix with a fungicide from a different FRAC group, see label.
Evito (fluoxastrobin)	11	5.7 fl oz	22.8 fl oz	3	Early blight Late blight Southern blight Target spot	Limit is 4 appl/crop. Must alternate or tank mix with a fungicide from a different FRAC group, see label.
Reason 500SC (fenamidone)	11	8.2 oz	24.6 lb	14	Early blight Late blight Septoria leaf spot	See label for details
Ridomil Gold EC (mefenoxam)	4	2 pts. / trtd. acre	3 pts / trtd. acre	28	Pythium diseases	See label for details
Ultra Flourish (mefenoxam)	4	2 qts	3 qts		Pythium and Phytophthora rots	See label for details
Ridomil MZ 68 WP (mefenoxam + mancozeb)	4 / M3	2.5 lbs.	7.5 lbs.	5	Late blight	Limit is 3 appl./ crop, see label
Ridomil Gold Copper 64.8 W (mefenoxam + copper hydroxide)	4 / M1	2 lbs.		14	Late blight	Limit is 3 appl. / crop. Tank mix with maneb or manco-zeb fungicide, see label
JMS Stylet-Oil (paraffinic oil)		3 qts.			Potato Virus Y Tobacco Etch Virus CMV	See label for restrictions and use (e.g. use of 400 psi spray pressure)
Aliette 80 WDG (fosetyl-al)	33	5 lbs.	20 lbs.	14	Phytophthora root rot	See label for warn-ings concerning the use of copper compounds.
Bravo Ultrex (chlorothalonil)	M5	2.6 lbs.	18.3 lbs	0	Early blight Late blight Gray leaf spot Target spot Botrytis Rhizoctonia fruit rot Leaf mold	Use higher rates at fruit set, see label
Bravo Weather Stik (chlorothalonil)	M5	2.75 pts.	20 pts	0		
Botran 75 W (dichloran)	14	1 lb.	4 lbs.	10	Botrytis	Greenhouse use only. Limit is 4 applications. Seed-lings or newly set transplants may be injured, see label
Nova 40 W (myclobutanil)	3	4 ozs.	1.25 lbs.	0	Powdery mildew	Note that a 30 day plant back restriction exists, see label

CHEMICAL	FUNGICIDE GROUP[1]	MAXIMUM RATE / ACRE		MIN. DAYS TO HARVEST	PERTINENT DISEASES OR PATHOGENS	REMARKS[2]
		APPLIC.	SEASON			
Sulfur (many brands)	M2			1	Powdery mildew	Follow label closely, it may cause phytotoxicity.
Actigard (acibenzolar-S-methyl)	P	0.75 oz.	4.75 oz	14	Bacterial spot Bacterial speck Tomato spotted wilt – a viral disease (use in combination of UV-reflective mulch and vector thrips specific insecticides.	Do not use highest labeled rate in early sprays to avoid a delayed onset of harvest. See label for details.
ManKocide 61.1 DF (mancozeb + copper hydroxide)	M3 / M1	5 lbs.	112 lbs.	5	Bacterial spot Bacterial speck Late blight Early blight Gray leaf spot	See label
Gavel 75DF (mancozeb + zoaximide)	M3 / 22	2.0 lbs	16 lbs	5	Buckeye rot Early blight Gray leaf spot Late blight Leaf mold	See label
Previcur Flex (propamocarb hydrochloride)	28	1.5 pints (see Label)	7.5 pints	5	Late blight	Only in a tank mixture with chlorotalonil, maneb or mancozeb, see label
Curzate 60DF (cymoxanil)	27	5 oz	30 oz per 12 month	3	Late Blight	Do not use alone, see label for details
Revus Top (mandipropamid + difenconazole)	40 / 3	7 fl oz	28 oz	1	Anthracnose Black mold Early blight Gray leafspot Late blight Leaf mold Powdery mildew Septoria leafspot Target spot	4 apps. per season; no more than 2 sequential apps. Do not use on varieties with mature tomatoes of less than 2 inches; see label
Tanos (famoxadone + cymoxanil)	11 / 27	8 oz	72 oz	3	Late blight Target spot Bacterial spot (suppression)	Do not alternate or tank mix with other FRAC group 11 fungicides. See label for details
Acrobat 50 WP (dimethomorph)	15	6.4 oz	32 oz	4	Late blight	See label for details
Forum (dimethomorph)	15	6 oz	30 oz	4	Late blight	Only 2 sequential appl. See label for details
K-phite 7LP Fosphite Fungi-Phite Helena Prophyte Phostrol Topaz (mono-and di-potassium salts of phosphorous acid)	33	See label		0	Phythophthora spp. Pythium spp. Fusarium spp. Rhizoctonia Late Blight Powdery Mildew	Do not apply with copper-based fungicides. See label for restrictions and details

CHEMICAL	FUNGICIDE GROUP[1]	MAXIMUM RATE / ACRE		MIN. DAYS TO HARVEST	PERTINENT DISEASES OR PATHOGENS	REMARKS[2]
		APPLIC.	SEASON			
K-phite 7LP **Fosphite** **Fungi-Phite** **Helena Prophyte** **Phostrol** **Topaz** **(mono-and di-potassium salts of phosphorous acid)**	33	See label		0	Phythophthora spp. Pythium spp. Fusarium spp. Rhizoctonia Late Blight Powdery Mildew	Do not apply with copper-based fungicides. See label for restrictions and details
Manex 4 F (maneb)	M3	2.4 qts.	16.8 qts.	5	Early blight Late blight Gray leaf spot Bacterial spot[3]	See label for details
Scala SC (pyrimethanil)	9	7 fl oz 0.27 lbs	35 fl oz 1.4 lbs	1	Early blight Botrytis	Use only in a tank mix with another effective fungicide (non FRAC code 9), see label
Endura (boscalid)	7	12.5 oz	25	0	Target spot (Corynespora cassiicola) Early Blight (Alternaria solani)	Alternate with non-FRAC code 7 fungicides, see label
Terraclor 75 WP (PCNB)	14	See Label	See Label	Soil treatment at planting	Southern blight (Sclerotium rolfsii)	See label for application type and restrictions
Fix (Copper + mancozeb or maneb)	M1 / M3			5	Bacterial spot Bacterial speck	Mancozeb or maneb enhances bactericidal effect of fix copper compounds. See label for details.
Kocide 101 or Champion 77 WPs (copper hydroxide)	M1	4 lbs.		2	Anthracnose Bacterial speck Bacterial Spot Early blight Grey leaf mold Grey leaf spot Late blight Septoria leaf spot	Mancozeb or maneb enhances bactericidal effect of fix copper compounds. See label for details.
Kocide 4.5 LF (copper hydroxide)	M1	2.66 pts		1		
Kocide 2000 53.8 DF (copper hydroxide)	M1	3 lbs.		1		
Champ 57.6 DP (copper hydroxide)	M1	1.3 lbs		1		
Basicop 53 WP	M1	4 lbs.		1		
Kocide 61.4 DF (copper hydroxide)	M1	4 lbs				
Cuprofix Disperss 36.9 DF (copper hydroxide)	M1	6 lbs				



CHEMICAL	FUNGICIDE GROUP[1]	MAXIMUM RATE / ACRE		MIN. DAYS TO HARVEST	PERTINENT DISEASES OR PATHOGENS	REMARKS[2]
		APPLIC.	SEASON			
Nu Cop 50WP (copper hydroxide)	M1	4 lb			Anthracnose Bacterial speck Bacterial Spot Early blight Grey leaf mold Grey leaf spot Late blight Septoria leaf spot	Mancozeb or maneb enhances bactericidal effect of fix copper compounds. See label for details.
Bonide Liquid Copper (copper salts)	M1	6 tsp/ gal		0		
Allpro Exotherm Termil (20 % chlorothalonil)	M5	1 can / 1000 sq. ft.		7	Botrytis Leaf mold Late blight Early blight Gray leaf spot Target spot	Greenhouse use only. Allow can to remain overnight and then ventilate. Do not use when greenhouse temperature is above 75 F. See label for details.
Terramaster 4EC (etridiazole)	F3	7 fl oz	27.4 fl oz	3	Pythium and Phytophthora root rots	Greenhouse use only. See label for details
Ranman (cyazofamid)	21	2.1-2.75 oz	16 oz	0	Late Blight	Limit is 6 appl./ crop, see label
Agri-mycin 17 (streptomycin sulfate)	25	200 ppm			Bacterial spot	See label for details
Ag Streptomycin (streptomycin sulfate)	25	200 ppm			Bacterial speck Bacterial spot	See label for details
AgriPhage (bacteriophage)						
Oxidate (hydrogen dioxide)		1:100 dilution			Anthracnose Bacterial speck Bacterial spot Botrytis Early blight Late blight Powdery mildew Rhizoctonia fruit rot	See label for details
Amicarb 100 Kaligreen Milstop (Potassium bicarbonate)		See label			Powdery mildew	See label for details
Serenade ASO Serenade Max Sonata (Bacillus sp.)	Biological material	See label	See label	0	Bacterial spot Early Blight Late Blight Powdery mildew Target spot Botrytis	Mix with copper compounds, see label

[1]FRAC code (fungicide group): Numbers (1-37) and letters (M, U, 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. M = Multi site inhibitors, fungicide resistance risk is low; U = Recent molecules with unknown mode of action; P = host plant defense inducers. Source: 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.

[3]Tank mix of mancozeb or maneb enhances bactericidal effect of copper compounds.

SELECTED INSECTICIDES

APPROVED FOR USE ON INSECTS ATTACKING TOMATOES

Susan Webb, UF/IFAS Entomology and Nematology Department, Gainesville, sewe@ufl.edu

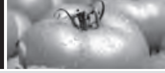
TRADE NAME (COMMON NAME)	RATE (PRODUCT/ACRE)	REI (HOURS)	DAYS TO HARVEST	INSECTS	MOA CODE[1]	NOTES
Acramite-50WS (bifenazate)	0.75-1.0 lb	12	3	twospotted spider mite	2	One application per season.
Actara (thiamethoxam)	2.0-5.5 oz	12	0	aphids, flea beetles, leafhoppers, stinkbugs, whiteflies	4A	Maximum of 11 oz/acres per season. Do not use following a soil application of a Group 4A insecticide.
Admire 2F (imidacloprid)	16-24 fl oz	12	21	aphids, Colorado potato beetle, flea beetles, leaf-hoppers, thrips (foliar feed-ing thrips only), whiteflies	4A	Most effective if applied to soil at transplanting. Limited to 24 oz/acre. Admire Pro limited to 10.5 fl oz/acre.
Admire Pro	7-10.5 fl oz					
Admire 2F (imidacloprid)	1.4 fl oz/1000 plants	12	0 (soil)	aphids, whiteflies	4A	Greenhouse Use: 1 application to ma-ture plants, see label for cautions.
Admire Pro	0.6 fl oz/1000 plants					
Admire 2F (imidacloprid)	0.1 fl oz/1000 plants	12	21	aphids, whiteflies	4A	Planthouse: 1 application. See label.
Admire Pro	0.44 fl oz/10,000 plants					
Agree WG (Bacillus thuringi-ensis subspecies aizawai)	0.5-2.0 lb	4	0	armyworms, hornworms, loopers, tomato fruitworm	11B1	Apply when larvae are small for best control. Can be used in greenhouse. OMRI-listed[2].
*Agri-Mek 0.15EC (abamectin)	8-16 fl oz	12	7	broad mite, Colorado potato beetle, Liriomyza leafminers, spider mite, Thrips palmi, tomato pin-worms, tomato russet mite	6	Do not make more than 2 sequential applications. Do not apply more than 48 fl oz per acre per season.
*Ambush 25W (permethrin)	3.2-12.8 oz	12	up to day of harvest	beet armyworm, cabbage looper, Colorado potato beetle, granulate cutworms, hornworms, southern army-worm, tomato fruitworm, tomato pinworm, vegetable leafminer	3	Do not use on cherry tomatoes. Do not apply more than 1.2 lb ai/acre per season (76.8 oz). Not recommended for control of vegetable leafminer in Florida.
*Asana XL (0.66EC) (esfenval-erate)	2.9-9.6 fl oz	12	1	beet armyworm (aids in control), cabbage looper, Colorado potato beetle, cutworms, flea beetles, grasshoppers, hornworms, potato aphid, southern armyworm, tomato fruit-worm, tomato pinworm, whiteflies, yellowstriped armyworm	3	Not recommended for control of vegetable leafminer in Florida. Do not apply more than 0.5 lb ai per acre per season, or 10 applications at highest rate.

TRADE NAME (COMMON NAME)	RATE (PRODUCT/ACRE)	REI (HOURS)	DAYS TO HARVEST	INSECTS	MOA CODE[1]	NOTES
Assail 70WP (acetamiprid)	0.6-1.7 oz	12	7	aphids, Colorado potato beetle, thrips, whiteflies	4A	Do not apply to crop that has been already treated with imidacloprid or thiamethoxam at planting. Begin applications for whiteflies when first adults are noticed. Do not apply more than 4 times per season or apply more often than every 7 days.
Assail 30 SG	1.5-4.0 oz					
Avaunt (indoxacarb)	2.5-3.5 oz	12	3	beet armyworm, hornworms, loopers, southern armyworm, tomato fruitworm, tomato pinworm, suppression of leafminers	22	Do not apply more than 14 ounces of product per acre per crop. Minimum spray interval is 5 days.
Aza-Direct (azadirachtin)	1-2 pts, up to 3.5 pts, if needed	4	0	aphids, beetles, caterpillars, leafhoppers, leafminers, mites, stink bugs, thrips, weevils, whiteflies	18B	Antifeedant, repellant, insect growth regulator. OMRI-listed[2].
Azatin XL (azadirachtin)	5-21 fl oz	4	0	aphids, beetles, caterpillars, leafhoppers, leafminers, thrips, weevils, whiteflies	18B	Antifeedant, repellant, insect growth regulator.
*Baythroid XL (beta-cyfluthrin)	1.6-2.8 fl oz	12	0	beet armyworm(1), cabbage looper, Colorado potato beetle, dipterous leafminers(2), European corn borer, flea beetles, hornworms, potato aphid, southern armyworm(1), stink bugs, tomato fruitworm, tomato pinworm, variegated cutworm , western flower thrips, whitefly adults(2)	3	(1) lst and 2nd instars only (2) Suppression Do not apply more than 0.132 lb (Baythroid XL) ai per acre per season.
Beleaf 50 SG (flonicamid)	2.0-2.8 oz	12	0	aphids, plant bugs	9C	Do not apply more than 8.4 oz/acre per season. Begin applications before pests reach damaging levels.
Biobit HP (Bacillus thuringiensis subspecies kurstaki)	0.5-2.0 lb	4	0	caterpillars (will not control large armyworms)	11B2	Treat when larvae are young. Good coverage is essential. Can be used in the greenhouse. OMRI-listed[2].
BotaniGard 22 WP, ES (Beauveria bassiana)	WP: 0.5-2 lb/100 gal ES: 0.5-2 qts 100/gal	4	0	aphids, thrips, whiteflies	--	May be used in greenhouses. Contact dealer for recommendations if an adjuvant must be used. Not compatible in tank mix with fungicides.
*Brigade 2EC (bifenthrin)	2.1-5.2 fl oz	12	1	aphids, armyworms, corn earworm, cutworms, flea beetles, grasshoppers, mites, stink bug spp., tarnished plant bug, thrips, whiteflies	3	Make no more than 4 applications per season. Do not make applications less than 10 days apart.
CheckMate TPW, TPW-F (pheromone)	TPW: 200 dispenser TPW-F: 1.2-6.0 fl oz	0	0	tomato pinworm	--	For mating disruption - See label.

TRADE NAME (COMMON NAME)	RATE (PRODUCT/ACRE)	REI (HOURS)	DAYS TO HARVEST	INSECTS	MOA CODE[1]	NOTES
Confirm 2F (tebufenozide)	6-16 fl oz	4	7	armyworms, black cutworm, hornworms, loopers	18A	Product is a slow-acting IGR that will not kill larvae immediately. Do not apply more than 1.0 lb ai per acre per season.
Coragen (rynaxypyr)	3.5-7.5 fl oz	4	1	beet armyworm, Colorado potato beetle, fall armyworm, hornworms, leafminer larvae loopers, southern armyworm, tomato fruitworm, tomato pinworm	28	Can be applied by drip chemigation - See label. Do not use more than 15.4 fl oz product/acre per crop.
Courier 40SC (buprofezin)	9-13.6 fl oz	12	1	whitefly nymphs	16	See label for plantback restrictions. Apply when a threshold is reached of 5 nymphs per 10 leaflets from the middle of the plant. Product is a slow-acting IGR that will not kill nymphs immediately. No more than 2 applications per season. Allow at least 28 days between applications.
Crymax WDG (Bacillus thuringiensis subspecies kurstaki)	0.5-2.0 lb	4	0	armyworms, loopers, tomato fruitworm, tomato hornworm, tomato pinworm	11B2	Use high rate for armyworms. Treat when larvae are young.
*Danitol 2.4 EC (fenpropathrin)	10.67 fl oz	24	3 days, or 7 if mixed with Monitor 4	beet armyworm, cabbage looper, fruitworms, potato aphid, silverleaf whitefly, stink bugs, thrips, tobacco hornworm, tomato pinworm, twospotted spider mites, yellowstriped armyworm	3	Use alone for control of fruitworms, stink bugs, tobacco hornworm, twospotted spider mites, and yellowstriped armyworms. Tank-mix with Monitor 4 for all others, especially whitefly. Do not apply more than 0.8 lb ai per acre per season. Do not tank mix with copper.
Deliver (Bacillus thuringiensis subspecies kurstaki)	0.25-1.5 lb	4	0	armyworms, cutworms, loopers, tomato fruitworm, tomato pinworm	11B2	Use higher rates for armyworms. OMRI-listed[2].
*Diazinon AG500; 4E; *50 W (diazinon)	AG500, 4E: 1-4 qts 50W: 2-8 lb	48	preplant	cutworms, mole crickets, wireworms	1B	Incorporate into soil - see label.
Dimethoate 4 EC, 2.67 EC (dimethoate)	4EC: 0.5-1.0 pt 2.67: 0.75-1.5 pt	48	7	aphids, leafhoppers, leafminers	1B	Will not control organophosphate-resistant leafminers.
DiPel DF (Bacillus thuringiensis supspecies kurstaki)	0.5-2.0 lb	4	0	caterpillars	11B2	Treat when larvae are young. Good coverage is essential. OMRI-listed[2].
Entrust (spinosad)	0.5-2.5 oz	4	1	armyworms, Colorado potato beetle, flower thrips, hornworms, Liriomyza leafminers, loopers, other caterpillars, tomato fruitworm, tomato pinworm	5	Do not apply more than 9 oz per acre per crop. OMRI-listed[2].
Esteem Ant Bait (pyriproxyfen)	1.5-2.0 lb	12	1	red imported fire ant	7C	Apply when ants are actively foraging.

TRADE NAME (COMMON NAME)	RATE (PRODUCT/ACRE)	REI (HOURS)	DAYS TO HARVEST	INSECTS	MOA CODE[1]	NOTES
Extinguish ((S)-methoprene)	1.0-1.5 lb	4	0	fire ants	7A	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.
Fulfill (pymetrozine)	2.75 oz	12	0 - if 2 applications 14 - if 3 or 4 applications	green peach aphid, potato aphid, suppression of whiteflies	9B	Do not make more than four applications. (FL-040006) 24(c) label for growing transplants also (FL-03004).
Intrepid 2F (methoxyfenozide)	4-16 fl oz	4	1	beet armyworm, cabbage looper, fall armyworm, hornworms, southern armyworm, tomato fruitworm, true armyworm, yellowstriped armyworm	18A	Do not apply more than 64 fl oz acre per season. Product is a slow-acting IGR that will not kill larvae immediately.
Javelin WG (Bacillus thuringiensis subspecies kurstaki)	0.12-1.5 lb	4	0	most caterpillars, but not Spodoptera species (armyworms)	11B2	Treat when larvae are young. Thorough coverage is essential. OMRI-listed[2].
Knack IGR (pyriproxyfen)	8-10 fl oz	12	14 7 - SLN No FL-200002	immature whiteflies	7C	Apply when a threshold is reached of 5 nymphs per 10 leaflets from the middle of the plant. Product is a slow-acting IGR that will not kill nymphs immediately. Make no more than two applications per season. Treat whole fields.
Kryocide (cryolite)	8-16 lb	12	14	armyworm, blister beetle, cabbage looper, Colorado potato beetle larvae, flea beetles, hornworms, tomato fruitworm, tomato pinworm	9A	Minimum of 7 days between applications. Do not apply more than 64 lbs per acre per season.
*Lannate LV, *SP (methomyl)	LV: 1.5-3.0 pt SP: 0.5-1.0 lb	48	1	aphids, armyworm, beet armyworm, fall armyworm, hornworms, loopers, southern armyworm, tomato fruitworm, tomato pinworm, variegated cutworm	1A	Do not apply more than 21 pt LV/acre/crop (15 for tomatillos) or 7 lb SP/acre/crop (5 lb for tomatillos).
Lepinox WDG (Bacillus thuringiensis subspecies kurstaki)	1.0-2.0 lb	12	0	for most caterpillars, including beet armyworm (see label)	11B2	Treat when larvae are small. Thorough coverage is essential.
Malathion 5 Malathion 8 F (malathion)	1.0-2.5 .0 pt 1.5-2 pt	12	1	aphids, Drosophila, mites	1B	Can be used in greenhouse (8F).
*Monitor 4EC (methamidophos) [24(c) labels] FL-800046 FL-900003	1.5-2 pts	96	7	aphids, fruitworms, leafminers, tomato pinworm(1), whiteflies(2)	1B	(1) Suppression only (2) Use as tank mix with a pyrethroid for whitefly control. Do not apply more than 8 pts per acre per crop season, nor within 7 days of harvest.
M-Pede 49% EC (Soap, insecticidal)	1-2% V/V	12	0	aphids, leafhoppers, mites, plant bugs, thrips, whiteflies	--	OMRI-listed[2].

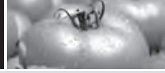
TRADE NAME (COMMON NAME)	RATE (PRODUCT/ACRE)	REI (HOURS)	DAYS TO HARVEST	INSECTS	MOA CODE[1]	NOTES
*Mustang Max *Mustang Max EC (zeta-cypermethrin)	2.24-4.0 oz	12	1	beet armyworm, cabbage looper, Colorado potato beetle, cutworms, fall armyworm, flea beetles, grasshoppers, green and brown stink bugs, hornworms, leafminers, leafhoppers, Lygus bugs, plant bugs, southern armyworm, tobacco budworm, tomato fruitworm, tomato pinworm, true armyworm, yellowstriped armyworm. Aids in control of aphids, thrips and whiteflies.	3	Not recommended for vegetable leafminer in Florida. Do not make applications less than 7 days apart. Do not apply more than 0.15 lb ai per acre per season.
Neemix 4.5 (azadirachtin)	4-16 fl oz	12	0	aphids, armyworms, hornworms, psyllids, Colorado potato beetle, cutworms, leafminers, loopers, tomato fruitworm (corn earworm), tomato pinworm, whiteflies	18B	IGR, feeding repellant. OMRI-listed[2].
NoMate MEC TPW (pheromone)		0	0	tomato pinworm	--	For mating disruption - See label.
Oberon 2SC (spiromesifen)	7.0-8.5 fl oz	12	7	broad mite, twospotted spider mite, whiteflies (eggs and nymphs)	23	Maximum amount per crop: 25.5 fl oz/acre. No more than 3 applications.
Platinum Platnum 75 SG (thiamethoxam)	5-11 fl oz 1.66-3.67 oz	12	30	aphids, Colorado potato beetles, flea beetles, leafhoppers, thrips, tomato pinworm, whiteflies	4A	Soil application. See label for rotational restrictions. Do not use with other growth insecticides.
*Pounce 25 W (permethrin)	3.2-12.8 oz	12	0	beet armyworm, cabbage looper, Colorado potato beetle, dipterous leafminers, granulate cutworm, hornworms, southern armyworm, tomato fruitworm, tomato pinworm	3	Do not apply to cherry or grape tomatoes (fruit less than 1 inch in diameter). Do not apply more than 1.2 lb ai per acre per season.
*Proaxis Insecticide (gamma-cyhalothrin)	1.92-3.84 fl oz	24	5	aphids(1), beet armyworm(2), blister beetles, cabbage looper, Colorado potato beetle, cucumber beetles (adults), cutworms, hornworms, fall armyworm(2), flea beetles, grasshoppers, leafhoppers, plant bugs, southern armyworm(2), spider mites(1), stink bugs, thrips(1), tobacco budworm, tomato fruitworm, tomato pinworm, vegetable weevil (adult), whiteflies(1), yellowstriped armyworm(2)	3	(1) Suppression only. (2) First and second instars only. Do not apply more than 2.88 pints per acre per season.



TRADE NAME (COMMON NAME)	RATE (PRODUCT/ACRE)	REI (HOURS)	DAYS TO HARVEST	INSECTS	MOA CODE[1]	NOTES
*Proclaim (emamectin benzoate)	2.4-4.8 oz	12	7	beet armyworm, cabbage looper, fall armyworm, hornworms, southern armyworm, tobacco budworm, tomato fruitworm, tomato pinworm, yellowstriped armyworm	6	No more than 28.8 oz/acre per season.
Prokil Cryolite 96 (cryolite)	10-16 lb	12	14	blister beetle, cabbage looper, Colorado potato beetle larvae, flea beetles, hornworms	9A	Minimum of 7 days between applications. Do not apply more than 64 lbs per acre per season. Not for cherry tomatoes.
Provado 1.6F (imidacloprid)	3.8-6.2 fl oz	12	0	aphids, Colorado potato beetle, leafhoppers, whiteflies	4A	Do not apply to crop that has been already treated with imidacloprid or thiamethoxam at planting. Maximum per crop per season 19 fl oz per acre.
Pyrellin EC (pyrethrin + rotenone)	1-2 pt	12	12 hours	aphids, Colorado potato beetle, cucumber beetles, flea beetles, flea hoppers, leafhoppers, leafminers, loopers, mites, plant bugs, stink bugs, thrips, vegetable weevil, whiteflies	3, 21	
Radiant SC (spinetoram)	5-10 fl oz.	4	1	armyworms, Colorado potato beetle, flower thrips, hornworms, Liriomyza leafminers, loopers, Thrips palmi, tomato fruitworm, tomato pinworm	5	Maximum of 34 fl oz per acre per season.
Sevin 80S; XLR; 4F (carbaryl)	80S: 0.63-2.5 XLR; 4F: 0.5-2.0 A	12	3	Colorado potato beetle, cutworms, fall armyworm, flea beetles, lace bugs, leafhoppers, plant bugs, stink bugs(1), thrips(1), tomato fruitworm, tomato hornworm, tomato pinworm, sowbugs	1A	(1) suppression Do not apply more than seven times. Do not apply a total of more than 10 lb or 8 qt per acre per crop.
10% Sevin Granules (carbaryl)	20 lb	12	3	ants, centipedes, crickets, cutworms, earwigs, grasshoppers, millipedes, sowbugs, springrails	1A	Maximum of 4 applications, not more often than once every 7 days.
SpinTor 2SC (spinosad)	1.5-8.0 fl oz	4	1	armyworms, Colorado potato beetle, flower thrips, hornworms, Liriomyza leafminers, loopers, Thrips palmi, tomato fruitworm, tomato pinworm	5	Do not apply to seedlings grown for transplant within a greenhouse or shadehouse. Leafminer and thrips control may be improved by adding an adjuvant. Do not apply more than three times in any 21 day period. Do not apply more than 29 oz per acre per crop.
Sulfur (many brands)	See label	24	see label	tomato russet mite, twospotted spider mite	--	May burn fruit and foliage when temperature is high. Do not apply within 2 weeks of an oil spray or EC formulation.
*Telone C-35 (dichloropropene + chloropicrin)	See label	5 days (See label)	preplant	garden centipedes (symphylans), wireworms	--	See supplemental label for restrictions in certain Florida counties.

TRADE NAME (COMMON NAME)	RATE (PRODUCT/ACRE)	REI (HOURS)	DAYS TO HARVEST	INSECTS	MOA CODE[1]	NOTES
*Telone II (dichloropropene)						
Thionex EC Thionex 50W (endosulfan)	0.66-1.33 qt 1,0-2.9 lb	24	2	aphids, blister beetle, cabbage looper, Colorado potato beetle, flea beetles, hornworms, stink bugs, tomato fruitworm, tomato russet mite, whiteflies, yellowstriped armyworm	2	Do not exceed a maximum of 3.0 lb active ingredient per acre per year or apply more than 6 times. Can be used in greenhouse.
Trigard (cyromazine)	2.66 oz	12	0	Colorado potato beetle (suppression of), leafminers	17	No more than 6 applications per crop. Does not control CPB adults. Most effective against 1st & 2nd instar larvae.
Trilogy (extract of neem oil)	0.5-2.0% V/V	4	0	aphids, mites, suppression of thrips and whiteflies	18B	Apply morning or evening to reduce potential for leaf burn. Toxic to bees exposed to direct treatment. Do not exceed 2 gal/acre per application. OMRI-listed[2].
Ultra Fine Oil, JMS Stylet-Oil, and others (oil, insecticidal) Saf-T-Side	3-6 qts/100 gal water (JMS) 1-2 gal/100 gal	4	0	aphids, beetle larvae, leafhoppers, leafminers, mites, thrips, whiteflies, aphid-transmitted viruses (JMS)	--	Do not exceed four applications per season. Organic Stylet-Oil and Saf-T-Side are OMRI-listed[2].
Venom Insecticide (dinotefuran)	foliar: 1-4 oz soil: 5-6 oz	12	foliar: 1 soil: 21	Colorado potato beetle, flea beetles, leafhoppers, leafminers, thrips, whiteflies	4A	Use only one application method (soil or foliar). Limited to three applications per season. Do not use on grape or cherry tomatoes. Toxic to honeybees.
*Vydate L (oxamyl)	foliar: 2-4 pt	48	3	aphids, Colorado potato beetle, leafminers (except Liriomyza trifolii), whiteflies (suppression only)	1A	Do not apply more than 32 pts per acre per season.
*Warrior II (lambda-cyhalothrin)	0.96-1.92 fl oz	24	5	aphids(1), beet armyworm(2), cabbage looper, Colorado potato beetle, cutworms, fall armyworm(2), flea beetles, grasshoppers, hornworms, leafhoppers, leafminers(1), plant bugs, southern armyworm(2), stink bugs, thrips(3), tomato fruitworm, tomato pinworm, whiteflies(1), yellowstriped armyworm(2)	3	(1) suppression only (2) for control of 1st and 2nd instars only. Do not apply more than 0.36 lb ai per acre per season. (3)Does not control western flower thrips.
Xentari DF (Bacillus thuringiensis subspecies aizawai)	0.5-2 lb	4	0	caterpillars	11B1	Treat when larvae are young. Thorough coverage is essential. May be used in the greenhouse. Can be used in organic production. OMRI-listed[2].

THE PESTICIDE INFORMATION PRESENTED IN THIS TABLE WAS CURRENT WITH FEDERAL AND STATE REGULATIONS AT THE TIME OF REVISION. THE USER IS RESPONSIBLE FOR DETERMINING THE INTENDED USE IS CONSISTENT WITH THE LABEL OF THE PRODUCT BEING USED. USE PESTICIDES SAFELY. READ AND FOLLOW LABEL INSTRUCTIONS.



[1]MOA CODE LEGEND

Mode of Action codes for vegetable pest insecticides from the Insecticide Resistance Action Committee (IRAC) Mode of Action Classification v.5.2 September 2006.

1A. Acetylcholine esterase inhibitors, Carbamates

1B. Acetylcholine esterase inhibitors, Organophosphates

2A. GABA-gated chloride channel antagonists

3. Sodium channel modulators

4A. Nicotinic Acetylcholine receptor agonists/antagonists, Neonicotinoids

5. Nicotinic Acetylcholine receptor agonists (not group 4)

6. Chloride channel activators

7A. Juvenile hormone mimics, Juvenile hormone analogues

7C. Juvenile hormone mimics, Pyriproxifen

9A. Compounds of unknown or non-selective mode of action (selective feeding blockers), Cryolite

9B. Compounds of unknown or non-selective mode of action (selective feeding blockers), Pymetrozine

9C. Compounds of unknown or non-selective mode of action (flonicamid)

11B1. Microbial disruptors of insect midgut membranes, B.t. var aizawai

11B2. Microbial disruptors of insect midgut membranes, B.t. var kurstaki

12B. Inhibitors of oxidative phosphorylation, disruptors of ATP formation, Organotin miticide

15. Inhibitors of chitin biosynthesis, type 0, Lepidopteran

16. Inhibitors of chitin biosynthesis, type 1, Homopteran

17. Molting disrupter, Dipteran

18A. Ecdysone agonist/disruptor (methoxyfenozide, tebufenozide)

18B. Ecdysone agonist/disruptor (azadirachtin)

20. Site II electron transport inhibitors

21. Site I electron transport inhibitors

22. Voltage-dependent sodium channel blocker

23. Inhibitors of lipid biosynthesis

25. Neuronal inhibitors

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

*** Restricted Use Only**

NEMATICIDES REGISTERED

FOR USE ON FLORIDA TOMATO

Joseph W. Noling, Extension Nematology, UF/IFAS, Citrus Research & Education Center, Lake Alfred, jnoling@ufl.edu

PRODUCT	ROW APPLICATION (6' ROW SPACING - 36" BED)[4]				
	BROADCAST (RATE)	RECOMMENDED CHISEL SPACING	CHISELS (PER ROW)	RATE/ACRE	RATE/1000 FT/CHISEL
FUMIGANT NEMATICIDES					
METHYL BROMIDE[1,3] 67-33	225-375 LB	12"	3	112-187 LB	5.1-8.6 LB
METHYL BROMIDE[1,3] 50-50	300-480 LB	12"	3	150-240 LB	6.8-11.0 LB
CHLOROPICRIN[1]	300-500 LB	12"	3	150-250 LB	6.9-11.5 LB
TELONE II[2]	9-12 GAL	12"	3	4.5-9.0 GAL	26-53 FL OZ
TELONE C-17	10.8-17.1 GAL	12"	3	5.4-8.5 GAL	31.8-50.2 FL OZ
TELONE C-35	13-20.5 GAL	12"	3	6.5-13 GAL	22-45.4 FL OZ
METHAM SODIUM	50-75 GAL	5"	6	25-37.5 GAL	56-111 FL OZ
NON FUMIGANT NEMATICIDES					
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.					

[1] If treated area is tarped with impermeable mulch, dosage may be reduced by 50%.

[2] The manufacturer of Telone II, Telone C 17, and Telone C-35 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 for tomato, pepper, eggplant and strawberry has been awarded for calendar years 2005 through 2008. Specific, certified uses and labeling requirements for CUE acquired methyl bromide must be satisfied prior to grower purchase and use in these crops. 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.

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 July 7, 2008 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. Additional products may become available or approved for use.

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