PRO 108

1996 PROCEEDINGS of the Florida Tomato Institute

compiled by C.S. Vavrina

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Table of Contents

APPENDICES

Florida Tomatoes in a Global Market

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Abstract

Florida growers of fresh tomatoes have seen their share of the market significantly decline over the last 4 years as Mexico has increased their shipments to North American markets. Mexico has increased shipments with the aid of improved technology and a competitive devaluation of their currency which has led to a stronger comparative advantage for their producers. The futures market for the Mexican peso indicates that traders believe Mexico will continue a policy of competitive devaluation of the peso through next season and continue to reap the rewards resulting from a currency devaluation. Florida producers need to aggressively pursue all possible advantages to maintain their market share. This includes seeking favorable trade policy and advances in technology.

Introduction

Florida and Mexico have long competed in the U.S. winter market for fresh tomatoes. The battle began in the 1960's after the imposition of the Cuban embargo. The battle was brought to a peak in the late 1970's when Florida filed an anti-dumping petition against Mexico with the U.S. Department of Commerce. The 1980's was a period in which Mexico controlled the volume of shipments into the U.S. with voluntary export restraints that limited the amount of tomatoes exported to the U.S.

Post NAFTA Competition

The negotiation of the North American Free Trade Agreement (NAFTA) brought on a new era of competition between Florida and Mexico. Florida's share of the winter fresh vegetable industry peaked in 1992 when Mexico experienced production problems following heavy rains in the peak of their growing season (table 1). The following 2 years was a period of negotiation between the U.S., Canada and Mexico toward NAFTA, which was implemented in January, 1994. The basic principles of NAFTA are that tariff and non-tariff barriers to trade are to be eliminated over the transition period of 10 years following its implementation. Tariffs on tomatoes were significant, ranging from 3.3 to 4.5 cents per kilogram, but considered to be small enough that many analysts did not feel it would change the comparative advantage in the fresh tomato industry. Other advantages provided Mexican growers by NAFTA included opening the investment sector in Mexico and the liberalization of the transportation sector.

Table 1. Shipments and market shares for Florida and Mexico in the U.S. tomato market, December to April market window, 1989/90 to 1994/95.

Season	Shipments			Market shares	
	Florida	Mexico	Total	Florida	Mexico
	(--------1,000,000 lbs.------)			(------- % ------)	
1989/90	681	560	1,276	53.4	43.9
1990/91	838	561	1,422	58.9	39.5
1991/92	1,004	200	1,246	80.6	16.1
1992/93	829	610	1,462	56.7	41.7
1993/94	782	617	1,423	55.0	43.4
1994/95	511	866	1,393	36.7	62.2

Source: USDA, Agricultural Marketing Service, Fruit and Vegetable Division, Market News Branch.

The effect of NAFTA from the lowering of tariffs has been only slight. The 10 year transition period for fresh tomatoes has resulted in a 30% decline in the tariff rate on tomatoes in the 1996 calendar year. 'Snap back' provisions were included in NAFTA implementing legislation that results in tariffs increasing to pre-NAFTA rates when shipments exceed pre-negotiated Tariff Rate Quotas (TRQ). Snap backs for tomatoes have been used each season since NAFTA went into force because Mexican shipments exceeded the TRQs.

A second important provision of NAFTA is the opening of the transportation sector that could eventually lead to direct shipment of produce from Mexican growing areas to buyers in the U.S. and Canada markets. Currently, produce must be off loaded at the U.S. border for shipment to North American markets. Off loading requirements add significant cost to the marketing of Mexican produce in U.S. and Canadian markets. The first phase of this liberalization was to occur in 1996 with direct transportation being allowed in the bordering states of the 2 countries. Concerns about safety of Mexican trucks led to President Clinton delaying the implementation of this section of NAFTA. The 2 countries are negotiating differences and it is expected that borders between the NAFTA partners will eventually become transparent, possibly as soon as the year 2000 when borders were to become transparent in the original agreement.

The most significant impact of NAFTA has been in the investment of new technology in Mexico. Provisions in NAFTA and new policies implemented within Mexico have made it easier to invest in Mexican agriculture. This has led to an increase in investment in Mexican agriculture that has resulted in greater gains in technology and efficiency than in the U.S. The U.S. has long been a leader in development and use of new technology, giving U.S. producers a comparative advantage in supplying North American markets even though the cost of labor was as much as 10 times higher than in Mexico. Prior to NAFTA, Florida growers held as much as a 60% advantage in productivity because of production practices and superior varieties developed for use in Florida. Investment in Mexico has led to the adoption of new production practices and development of new varieties that approach the productivity in Florida.

The most damaging factor in changing the competitive structure in the winter fresh tomato industry is the competitive peso devaluation which began in December, 1994. Exchange rates have significantly altered the competitive nature of the winter fresh tomato industry. Exchange rates in 1975 were fixed at 12.5 pesos to the dollar. Several devaluations since have caused the value of the peso to plummet. The peso fell to a value of 2,970 pesos to the dollar by 1990. A devaluation normally leads to an improvement in competitive advantage as exports become cheaper in international markets. However, inflation leads to higher costs of production and normally offsets any advantage afforded by devaluation of the currency. Inflation in Mexico reached 172 percent in 1987, offsetting much of the advantage Mexican growers received from the devalued peso in the early 1980's. In addition, policy makers in Mexico controlled the volume of exports in the 1980's by imposing minimum export standards on fresh tomatoes to keep returns to Mexican growers reasonable. These policies led to a decade of greater content between Mexico and Florida growers and a decline in the intensity of competition between the 2 areas.

Mexico's controlled rate of slippage in the exchange rate coupled with lower rates of inflation introduced stability in the exchange rate from 1990 to 1994. Exchange rates stabilized at about 3.4 new pesos per dollar over this period (Mexico converted their old currency to the new peso by converting 1,000 old pesos into 1 new peso) and inflation moderated to single digit rates prior to December, 1994. The peso became overvalued during this period leading to Florida growers gaining comparative advantage in the winter fresh tomato industry.

The signing of NAFTA was followed by a new policy agenda for Mexican policy makers. The new administration of Mexican President Zedillo began pursuing a policy of export led growth primed by competitive devaluations of the peso. The overvalued peso was devalued beginning in December, 1994, from 3.44 new pesos per U.S. dollar to 6.70 new pesos per U.S. dollar in March, 1995. The rapid devaluation broke the confidence of many investors in the Mexican economy and led to a flight of capital out of Mexico. The United States led a program of financing for the Mexican government to provide stability and to stop the free fall of the peso.

As the bottom fell out on the peso, the comparative advantage controlled by Mexican growers increased dramatically. While most economists argue that devaluations do not change comparative advantage because inflation also is fueled and offsets any artificial advantage created by the devaluation, the dynamics of inflation are slower to ignite and producers of exportable items are afforded a short term comparative advantage that otherwise would not exist. The pain that comes with this kind of policy is that imports become expensive to Mexican consumers because inflation on consumer purchases outstrips income gains to the working class. The standard of living for most Mexican consumers was sacrificed to expand exports benefitting exporters, including tomato exporters.

The resulting pain spread to losses suffered by U.S. growers competing with Mexican growers in the U.S. market. Florida growers have been battered by the increased imports of Mexican tomatoes. Imports from Mexico have increased because technology has improved in Mexico, but more importantly because devaluation made their exports more profitable in U.S. markets and more expensive to Mexican consumers. Prior to December, 1994, some analysts had estimated that the Mexican domestic market consumed as much as 30 percent of the tomatoes produced in Sinaloa, the remaining being exported to the U.S. and Canada. When consumers in Mexico could not afford Mexican grown tomatoes following the rapid devaluation of the peso, those tomatoes were exported to the U.S., and even though prices were depressed in U.S. markets, U.S. prices were still generally better than Mexican growers could get in Mexico because of the dynamics of the devaluation.

The result has been that Mexico has gained a comparative advantage in supplying North American markets and has become the leading supplier in this market. Provisions within NAFTA to protect domestic growers from surges in imports have failed to protect Florida growers. Snap back provisions only increase tariffs to pre-NAFTA levels when imports exceed TRQ's. These increases in tariffs are small compared to the gains in comparative advantage Mexican growers procured following implementation of NAFTA. Gains in productivity have decreased costs to Mexican growers significantly. Even more important to Mexico, artificial gains in comparative advantage realized because of competitive devaluation policies followed by the Zedillo administration have given Mexican growers cost savings much larger than the safeguards provided by NAFTA snap back policies. The devaluation in the 1994/95 season reduced costs to Mexican growers by as much as 43% (VanSickle).

As a result, imports of Mexican tomatoes into U.S. markets set records over the last 2 seasons. Imports of Mexican tomatoes were 68% higher in 1995 than in 1991 and 224% higher than in 1992 when Mexico experienced their own production problems. Market shares for Mexican growers increased dramatically at the expense of Florida and other U.S. growers.

Table 2. Imports of fresh tomatoes from Mexico, U.S. production and Mexican imports as a percent of U.S. production.

Year	U.S. production	Mexican imports	Mexico imports as % U.S. production
	(--- 1,000,000 lbs.	----)	
1991	3,388.7	779.5	23.0
1992	3,903.3	403.7	10.3
1993	3,559.9	882.9	24.8
1994	3,663.6	829.0	22.6
1995	3,284.0	1,307.4	39.8

Source: U.S. International Trade Commission. "Fresh Tomatoes and Bell Peppers." p. I-11.

According to data collected by the U.S. International Trade Commission (ITC), U.S. tomato growers realized red ink in record numbers. More than 75% of the U.S. growers responding to the survey taken by the U.S. ITC reported losses in 1996. Losses as a percent of sales topped 40% for U.S. tomato growers.

The 201 petition filed with the U.S. International Trade Commission was countered by Mexican growers and shippers with claims that Florida's problems stem from bad weather in 1995 and 1996, and from Mexico's shift to a higher quality tomato that has grabbed market share because buyers now prefer their tomato. While weather did have an impact on Florida production in 1995 and again in 1996, the impact of weather was small compared to the impact caused by the devaluation of the peso. A study conducted by VanSickle, Jordan and Spreen indicated that the devaluation of the peso caused significant increases in shipments from Mexico to U.S. markets because consumers in Mexico could not afford the production normally sold in Mexico and that product was diverted to U.S. markets, and because the dynamics of the devaluation provided artificial cost advantages that Mexican growers and shippers were able to capitalize on in those seasons.

The argument that Mexican tomatoes are preferred by the retail trade was also shallow. U.S. tomatoes have long been preferred because they held the characteristic of longer shelf life with fewer losses due to perishability. The new tomato now being grown by Mexican growers is an extended shelf life (ESL) hybrid introduced following the implementation of NAFTA in 1994. This ESL tomato is an improvement over the vine ripe tomatoes Mexico used to ship to U.S. markets, but data does not demonstrate a superiority in quality over U.S. tomatoes.

Implications

The recent decision of the U.S. International Trade Commission that U.S. growers were not damaged by increased imports of Mexican tomatoes was wrong. First, imports of Mexican tomatoes increased from 23% of domestic production in 1994 to nearly 40% of domestic production in 1995. Imports in 1996 have increased another 42% (through July 20) in 1996 over 1995. Second, there has been serious injury to the domestic industry. Losses totaling as much as 40% of sales, as measured by the U.S. International Trade Commission, are evidence of an industry struggling to survive. Finally, the injury realized by domestic growers is primarily due to increased imports. Consumption of fresh tomatoes has grown only moderately since 1990. With consumption steady and imports increasing more than 40% per year, that leaves no room but for the share supplied by U.S. domestic growers to do anything but shrink.

What might we expect in the future? The decision by the U.S. International Trade Commission does not provide any level of comfort that fair trade will be the norm in the international market for fresh produce. Roberto Salinas-Leon (Executive Director of the Center for Free Enterprise Research in Mexico City) contends that Mexico is pursuing a dangerous obsession with its competitive exchange rate policy to drive export led growth (Wall Street Journal, May 24, 1996, p. A11). If Mexico would strive to stabilize exchange rates and remove artificial advantages provided by competitive exchange rate devaluations, then Florida growers could expect a recovery in their competitive struggle with Mexico and be able to approach a more level trade playing field. Inflation in Mexico would offset the artificial advantages provided by currency devaluations. However, the financial markets do not believe the trend in devaluing the peso will end. A futures contract is traded for the Mexican peso on the floor of the Chicago Mercantile Exchange. Closing prices on July 23, 1996, indicate that traders expect the peso to continue its devaluation into next year, forecasting an 11.1% decline in the value of the peso from September, 1996 to March, 1997. This would indicate that imports will continue to be driven by devaluation in the peso again next season. Unless the U.S. Department of Commerce finds an affirmative determination in the anti dumping investigation (i.e., that Mexican shippers are dumping tomatoes in U.S. markets), imports of Mexican tomatoes will continue to grow.

Investment in Mexico will also continue as long as their growers continue to expand production. This continued investment will make Mexico more competitive in international markets. One of the greatest advantages U.S. growers held prior to NAFTA was superiority in technology, productivity and quality. Those advantages have eroded along with the comparative advantage Florida growers once held. Florida growers must continue to invest in research and development if they are to remain competitive with the world's producers of fresh tomatoes. We can compete if we make the right decisions and make the right investments. We can commiserate with our friends and foes about our dilemma or we can pursue strategies that will allow us to survive. Mexico may have important resource advantages because of its cheap labor and other government subsidized resources, but Florida growers have more resource advantages than European greenhouse growers and they also have been expanding market share in the U.S. We must carefully identify our resource advantages and aggressively pursue a strategy that allows us to capitalize on those strengths.

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Premium-Quality Tomato Program for Florida

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Florida tomato growers continue to face increased competition from other growing areas, resulting in decreased demand in many of our traditional markets. In addition to more shipments from Mexican producing areas, demand for "value-added" tomatoes is also on the rise. The sudden drop in prices in late spring 1996 has been attributed, in part, to lower prices and the increased availability of greenhouse-grown tomatoes from Canada, Europe and the Mediterranean (The Packer, 1996). With tomatoes being a high-selling vegetable item with, perhaps, the most consumer complaints, it appears that the time has arrived for Florida shippers to market tomatoes with name recognition. They have the most demand as a "salad-topper", with 61% of consumers purchasing tomatoes to go along with fresh-cut salads (Fresh Trends, 1996).

In order for a branded product, a value-added product, to succeed in the marketplace, it must have not only high quality, but consistent quality throughout the growing season. This marketing strategy has served well for many commodities, most notably, Vidalia onions, which demand a significantly higher price in the marketplace over onions grown in other producing areas. Tree-ripened fruits are also increasing in popularity, for example peaches, nectarines and plums. For many years California has had grade standards for major horticultural crops which are more strict than U.S.D.A. grade standards. Therefore, high quality standards and strict quality control strategies must be an integral component of any premium-quality program. A premium-quality program for Florida tomatoes would accommodate all tomatoes; those not meeting the stricter standards to be labeled as premium grade would be labeled as food-service grade for the institutional sector.

Quality Limitations under Current Handling Practices

Florida tomatoes are harvested primarily at the green color stage to permit harvest flexibility, reduce the number of harvests and to provide a product with a relatively long shipping life. Although marketing is facilitated by this handling scheme, the ability of Florida shippers to ship tomatoes which will have consistently high quality at the consumer level can be seriously compromised for three reasons.

Harvest maturity. First of all, normal ripening of tomatoes harvested at green color stage is contingent upon the completion of physiological maturity, and physiological maturity cannot be reliably detected when tomatoes are harvested at the green stage. Those tomatoes which are harvested at the mature green stage (M-3 or M-4 stages) will ripen with high quality when handled under recommended conditions (Table 1). Tomatoes harvested at M-2 stage will ripen with moderate quality, while those harvested at M-1 stage will never ripen normally. Random samples of green-harvested tomatoes from packinghouses have determined the percent of immature tomatoes (M-1) to range from 20% to 80%, depending upon growing area and time of harvest.

Table 1. Definitions of maturity stages for green tomatoes.

Maturity Stage	Internal Appearance
M-1	Seeds are immature (white), cut when tomato is sliced; no gel in the locule.
M-2	Seeds are mature (tan); gel formation in at least two locules.
M-3	All locules have gel; seeds pushed aside when tomato is sliced; internal color is green.
M-4	Appearance of red color in gel and pericarp tissue.

Adapted from U.S.D.A, 1976.

From our observations, the term "star breaker" is quite loosely used as a harvest indicator for tomatoes which are at the onset of ripening. Star breaker tomatoes refer to several short lines radiating from the blossom end of a green tomato, supposedly preceding breaker stage. In fact, star breakers which we have sliced on the day of harvest had maturity stages ranging from M-1 to M-4 (Maul and Sargent, unpublished data). Breaker stage is defined by the U.S.D.A. grade standards as the point at which there is a distinct change in the tomato color from green to tannish-yellow, pink or red on not more than 10% of the surface (U.S.D.A., 1976). Therefore, star-breaker cannot reliably predict internal maturity; if there is a distinct change in color at the blossom end, the tomato is at breaker stage.

Time of gassing. A second reason for lower quality is related to timing of the gassing treatment. Highest quality at table-ripe stage is achieved when green tomatoes are gassed soon after harvest. Chomchalow (1991) found that storage of ungassed tomatoes at 55F (12.5C) for more than seven days caused non-unifotm ripening on individual tomatoes and checker-boarding within lots, and reduced postharvest life when compared to tomatoes which were gassed immediately after harvest followed by storage at 55F.

Temperature management. Thirdly, temperature management influences tomato ripening. Green and ripening tomatoes are quite sensitive to temperatures below 55F. Storage below this threshold temperature at any point during handling and shipping can result in chilling injury, which is characterized by uneven ripening, poor color and flavor development, and increased susceptibility to decay as the tomatoes ripen. Storage at temperatures above 68 to 74F (20-23C) inhibits normal ripening and promotes decay.

There is also confusion in the marketplace regarding use of the term "vine-ripe" tomatoes. The current lack of a legal definition for vine-ripe tomatoes allows virtually any tomato showing red color to be labeled as vine-ripe at retail level, regardless of the ripeness stage at harvest. Although this term infers that the tomatoes were picked red ripe from the vine, a practical definition for vine-ripe tomatoes should refer only to those tomatoes which were harvested at breaker stage or later as defined by the U.S.D.A. grade standards, and thus, requiring no gassing.

Initiation of a Premium-Quality Program for Florida Tomatoes

A coordinated research/extension/educational program should be implemented immediately to develop delivery systems for a premium-quality Florida tomato for our industry to remain competitive. This program would investigate the current systems for handling Florida tomatoes and to determine the changes and modifications necessary to implement a program for growers and shippers to consistently ship premium-quality tomatoes. The multi disciplinary and inter-institutional project would combine the talents of Florida scientists at university, state and federal levels, as well as county extension faculty and industry leaders. The focus of this effort would be on all steps of tomato production and distribution, beginning with determination of premium grade standards, selection of high quality varieties followed by application of innovative handling practices to ensure quality maintenance until retail level.

Grade standards would be defined for both premium and food service markets, based on quality parameters associated with taste panel scores. Feasibility for commercializing tomatoes with the new standards will be determined using demand and cost analyses.

Premium-Quality Handling Scenarios

This program would be feasible for tomatoes harvested at either green or breaker ripeness stages.

The objective for handling tomatoes harvested at green stage would be twofold: minimizing harvest of M-1 tomatoes and rapid initiation of ripening. Determination of the optimal harvest date for tomatoes harvested at green stage (Stage 1) requires sampling of the field block to determine internal maturity. The main goal of sampling is to collect tomatoes representative of the entire block to account for maturity differences. Differences in maturity within a particular block could be due to time of planting, variations in soil type, field drainage patterns and weather conditions. To provide maximum uniformity in harvest maturity, the block should not be picked unless 90% of the sample shows maturity stages M-2 or higher.

<u>Sampling scheme to determine optimal harvest.</u> Random samples should be taken throughout the block. One method is to assign different workers to collect samples from either the first or second hand. Following a grid pattern, tomatoes from each hand should be picked approximately 70 feet apart (25 paces). This would yield a sample of about 16 tomatoes per hand per acre. More samples should be taken per acre for fields with less uniform growing conditions. The samples for each hand are returned to a central site for slicing and determination of percent tomatoes above M-2.

<u>Quality screening by gassing.</u> Following harvest tomatoes would be run over a packing line designed for low impacts, being washed, sorted and bulk-packed for gassing. Following a predetermined gassing period, the tomatoes would be rerun over the packing line, color sorted and packed into the final shipping container. Recent developments in

electronic color sorters and packing line speed control show great potential for reducing costs through automation of labor-intensive tasks.

Studies are currently underway to determine the number of days necessary for gassing while achieving high quality at table-ripe stage. Preliminary results from Spring 1996 indicated that tomatoes requiring more than five days gassing to reach breaker stage had 15% less Vitamin C and a noticeable shift from normal red-orange to a more yellow-orange color upon reaching table-ripe stage (Maul, unpublished results). Using ethylene to screen premium tomatoes would permit classification of other tomatoes to food service grade.

Tomatoes harvested at breaker-to-turning stages would be packed the day of harvest. At this point the objective for both vine-ripe harvested and gassed/screened tomatoes would be to retard the ripening process as much as possible to maximize postharvest life without causing negative effects on final quality. Techniques with potential to extend postharvest life include rapid cooling (precooling), controlled/modified atmosphere storage and/or shipping, and appropriately designed shipping containers.

Research Priorities

The following research projects will need to be initiated in order to determine key components for implementation of a premium quality program for Florida tomatoes:

1) Screening for Optimal Maturity of Green-Harvested Tomatoes
2) Effects of Rapid Cooling Techniques on Tomato Quality
3) Use of Controlled Atmosphere Storage to Delay Ripening
4) Determination of Grade Standards for Premium and Food-Service Tomatoes
5) Feasibility Study for Premium Tomatoes
6) Flavor Components and Quality of Promising Tomato Cultivars
7) Packaging Systems for Premium Tomatoes

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Tomato Response to Ethylene at High Temperatures: Are Pressure Ripening Systems Worth Considering?

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Conditions for optimum ripening of tomatoes. Tomato ripening is a complex process that requires precise control of temperature, humidity, ethylene concentration and duration of treatment, air circulation, and ventilation in order to achieve optimum results. Perhaps the most critical of the above factors is temperature because of its influence on how tomatoes ripen and respond to ethylene. Tomatoes will generally ripen at temperatures between 55 and 77F. Lower temperatures induce chilling injury in green fruit, one symptom of which is impaired or abnormal color development; higher temperatures (especially greater than 85F) inhibit red color development. Optimum development of red color occurs at 68 to 70F, while lower or higher temperatures within the 55 to 77F range result in slower color development or more orange fruit, respectively. Initial fruit maturity also has a great effect on how tomatoes respond to ripening treatment: immature fruit (ie., those requiring more than 3 days of ethylene treatment to reach breaker stage) are likely to never achieve full red color. Recommended conditions for ripening Florida tomatoes are:

Temperature: 68F
Relative humidity: 90-95%
Ethylene concentration: 100-150 ppm
Treatment duration: 24-72 hours, depending on maturity*
Air circulation: 20-40 cfm per ton of product
Ventilation: 0.5 hour, twice each day (shot system) or,
one air change per 6 hours (trickle system)

*treating tomatoes with ethylene before packing allows immature fruit and fruit with decay to be sorted out

Tomato temperatures during commercial handling. Air temperatures above 77F are common during most of the Florida tomato season, and temperatures above 85F are regularly experienced early and late in the season. The tomatoes themselves may warm to substantially above the air temperature while they are being accumulated in the field and outside the packinghouse, especially if they are exposed to the sun. Because of the necessity for heating the packinghouse dump tank water in order to avoid infiltration of bacterial pathogens into the tomatoes, and since the tomatoes are packed under ambient conditions, the result is that tomatoes are often loaded into ripening rooms with pulp temperatures well above the optimum ripening range. This means that cooling the tomatoes in the ripening rooms down to the optimum 68 to 70F range is a critical first step in the ripening process.

Ten years ago, when Mark Sherman and Mike Talbot reported on temperature and air distribution in tomato ripening rooms, they pointed out that ripening rooms are not generally designed for efficient cooling of the fruit (Sherman and Talbot, 1986). Although they recommended some modifications to improve air distribution, for the most part these modifications have not been adopted by the industry. Furthermore, when Sherman and Jim Hicks compared the 25-lb MUM tomato carton to the then-standard 30-lb carton in handling and shipping tests conducted in 1982, they noted that the fruit packed in the MUM container were slower to warm and cool than those packed in the 30-lb container (Sherman et al., 1982). This was presumably due to the tight stacking pattern of the MUM carton compared to the air stacking pattern used with the 30-lb carton. Since those carton comparisons were conducted during cool, January conditions (initial tomato pulp temperature was 56F), they suggested that it would be important to determine if the tight stacking pattern of the MUM carton would cause problems when rapid removal of field heat during hot weather is more critical. This has apparently never been done. All of the foregoing information suggests that there is a good possibility that, at certain times, Florida tomatoes are remaining above the critical 85F temperature at which color development is inhibited for some time while they are in the ripening rooms, and certainly above 68F, the optimum temperature for color development.

Pressure ripening. Pressure ripening applies the principles of forced-air cooling to the management of temperatures in ripening rooms. Pressure ripening systems have been widely adopted in the banana industry, where the demands of retail handlers require delivery of precisely controlled, uniform ripeness stages. Standard banana ripening procedure has traditionally involved tearing down pallets that are shipped in a tight stacking pattern and re-stacking the cartons in the ripening room in an air stacking or pigeonhole pattern. This is done to facilitate heat removal during ripening and allow rapid temperature changes for following relatively complex ripening schedules. Pressure ripening systems work by isolating one side of a pallet row from the other and using the refrigeration system fans to create a pressure differential that draws the room air through the cartons of fruit. This makes re-stacking unnecessary, and allows fruit pulp temperatures to be brought to the desired temperature in about 4 to 6 hours (compared to 18 to 24 hours in conventional rooms). Pressure ripening systems greatly increase the temperature uniformity of fruit throughout the room, which leads to more uniform ripening.

Research on tomato temperature and ripening. The research establishing the response of tomatoes to temperature during ripening in terms of color development in all cases involved holding the fruit at different constant temperatures and measuring fruit color. Unfortunately, in the real world of tomato handling, the fruit are rarely, if ever, at a constant temperature from initiation to completion of ripening. Also, it had never been determined how tomatoes respond to ethylene treatment while at higher than optimum temperatures for color development. Therefore, Mike Masarirambi, a Ph.D. student in the Horticultural Sciences Department at UF, has been exposing tomatoes to ethylene for from 1 to 3 days at 68, 77, 86, 95 and 104F before transferring them to air without ethylene at 68F to continue and complete ripening. Also, along with Mike Talbot of the Agricultural & Biological Engineering Department, we have monitored tomato pulp temperatures in a standard ripening room compared to tomatoes that we pressure ripened using a small, forced-air cooling unit, and then followed their color development during subsequent holding at 68F.

As we reported at last year's Florida State Horticultural Society meeting (Masarirambi et al., 1995), tomatoes exposed to ethylene at temperatures of 86F or higher for 24 hour before being transferred to 68F showed little difference in color development compared to those exposed to ethylene while at 68 or 77F. However, increasing the time at 95 or 104F to 48 or 72 hours inhibited subsequent red color development at 68F. A surprising result was that fruit that were at 86F for 48 or 72 hours while being exposed to ethylene actually developed red color faster upon transfer to 68F, reaching the full red stage faster than fruit held continuously at 68F despite still being green at the end of their high temperature/ethylene treatment. This suggests that the tomatoes could sense the ethylene at 86F even though they were unable to respond to it in terms of red color development.

In our commercial ripening room test, we cooled the tomatoes on the forced-air unit from 84F to 68F in about 2.5 hours with a 67F air temperature. The tomatoes handled in the standard manner actually increased in temperature by 2-3 degrees initially, and took from 18 to 24 hours to cool, depending on location in the room, never reaching less than 72F in 62 hours in a 68F room. This means that the standard ripening room could not keep the tomatoes' heat of respiration from initially warming the fruit and from later keeping them equilibrated at 4 degrees above the air temperature. When the same tomatoes were transported to the laboratory and allowed to ripen at 68F, the tomatoes from the pallets at the front and rear of the ripening room turned red faster than tomatoes from a middle pallet. The pressure-ripened tomatoes developed red color more uniformly than the room-ripened tomatoes, but at a rate in between the extremes of the tomatoes in the standard ripening room.

Summary. Our results to date are focused on the effect of treating tomatoes with ethylene at high temperatures on color development. In this respect, since it seems unlikely that tomatoes in a ripening room would ever remain above 85F for more than 24 hours, it is questionable whether color development is being negatively affected when warm tomatoes are placed in ripening rooms at 68F for ethylene treatment. In fact, based on the results of our laboratory experiments, it could be argued that fruit that remain around 86F for some portion of the ethylene treatment might ripen faster than fruit that are nearer to 68F during the entire exposure time. We are still analyzing data related to the effect of treatment with ethylene at high temperatures on other quality aspects, namely firmness, soluble solids content and acid content. However, there is no question that there is much room for improvement in temperature uniformity within ripening rooms, which would, in turn, improve color uniformity. This is one area where there is a definite potential for benefit from pressure ripening systems. As we develop more information, the potential for using stepwise temperature regimes to custom deliver tomatoes at desired ripeness stages in less time may become feasible using pressure ripening techniques.

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Maintaining Clean Packinghouse Water Systems

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Introduction: Clean packinghouse water systems are essential in the operation of tomato packinghouses. Clean, defined as an absence of living fungi and bacteria, isn't the same as clear. In modern packinghouses, the water can be kept clean even though it is clear only at beginning of the work day. Currently, clean packinghouse water systems are achieved through proper use of products that produce hypochlorous acid and hypochlorite ion in water. This practice has the general name of water chlorination.

Chemistry of water chlorination: The addition of chlorine gas, dry chlorine products, or commercial bleach to water, produces active chlorine in the form of hypochlorous acid and hypochlorite ion according to the following equations:

$Cl_2 + H_2O \rightarrow HOCl + H^+ + Cl^-$;

$Ca(OCl)_2 + H_2O = Ca^{++} + 2OCl^- + H_2O$; or

$NaOCl + H_2O \rightarrow Na^+ + OCl^- + H_2O$ (White, 1992).

Hypochlorous acid and hypochlorite ion are in equilibrium in the solution ($HOCl \rightarrow OCl^- + H^+$). Both the acid and the ion are considered free chlorine although the acid is much more reactive with most other chemicals and 20 to 300 times more toxic to bacteria and fungi (White, 1992). The ratio of acid to ion is controlled principally by the pH of the solution with salt concentration, water temperature, and chlorine concentration having a minor influence. At pH 7.5, the ratio of acid to ion in a chlorine solution is roughly 1:1, whereas at pH 6.0 and 9.0 the ratios are 97:3 and 3:97, respectively. Interestingly, the elemental chlorine concentration in chlorinated water is extremely low until the solution pH decreases below about 4.0. Solutions with 500 ppm free chlorine contain <1 ppb (µg/L) elemental chlorine at pH 6.0, 26 ppb at pH 5.0, and 0.26 ppm at pH 4.0 (White, 1992). Since the solubility of chlorine gas in water ranges from 14,600 ppm for cold water to 5,700 ppm in water at 30°C (Handbook of Chemistry and Physics), elemental chlorine should not bubble out of water (= off-gas) even at pH levels below 4.0.

Importance of the ratio of hypochlorous acid to hypochlorite ion in the sanitation of packinghouse water systems. The HOCl form of active chlorine more lethal to microbes than OCl^-, apparently because the acid penetrates into cells, whereas the charge on the ion prevents it from doing so (White, 1992). Chlorine solutions with 99% of the free chlorine in the form of hypochlorite ion require about 250 times longer to kill microbes than those containing mostly hypochlorous acid (Pryor, 1949). Since one of the main purposes of chlorinating water in tomato packinghouses is to prevent postharvest pathogens from moving into wounds or other infection courts on fruit, how rapidly microbes suspended in the water.are killed is extremely important. At pH levels in the range of 7.0 to 8.5, hypochlorite ions serve as a reservoir of unreacted chlorine, which will help to sanitize dump tanks, flumes, washers as well as tomatoes (White, 1992). The ion is converted to the acid within seconds as the latter reacts with microbes, organic matter, etc. Therefore, microbes exposed to chlorine solutions for more than a few seconds will absorb hypochlorous acid molecules that were originally hypochlorite ions. If pH levels exceed 9.0, however, the quantity of HOCl in chlorine concentrations normally used in packinghouses is very small. The equilibrium conversion of ion to acid will not supply enough hypochlorous acid to reliably kill bacteria and fungi before they can contaminate tomatoes floating in the water. Therefore, the pH of chlorinated water systems in packinghouses should be maintained in the range of 6.0 to 7.5 with pH levels of 8 to 8.5 being acceptable if the water is heated (see below).

Chlorine demand. Most of the products of the reactions of hypochlorous acid or hypochlorite ion with various chemicals and microbes are non toxic to microbes. The products of these reactions are often called disinfection by-products or DFBs (White, 1992). The chemicals, microbes, organic matter, etc, that react with free chlorine are collectively called "chlorine demand." When water is chlorinated, HOCl and OCl^- concentrations decrease rapidly until the chlorine demand is satisfied, at which time their concentrations stabilize. All unreacted chlorine in water is called "free available chlorine." The unloading of unwashed tomatoes into a packinghouse tank/flume system creates a chlorine demand in that system. Certain water supplies that are typically used in packinghouses such as surface waters, sulfur or iron containing water, etc., contain a chlorine demand. The chlorine demand in packinghouse water systems competes with microbes for reaction with free available chlorine, which means that microbial survival is enhanced when chlorine demand is present.

Chlorine solutions with a lower pH (with mostly HOCl) are less stable, free chlorine is lost to demand reactions more rapidly, than those with mostly OCl^-. For example, HOCl reacts roughly 10,000 times more rapidly with nitrogenous compounds than OCl^- (Morris, 1978). Use of high pH levels to achieve better stability, however, is usually not recommended because such solutions may not be active enough to achieve the desired effect on fungi and bacteria.

Disagreeable and/or corrosive gasses associated with water chlorination. Disagreeable odors associated with water chlorination in tomato packinghouses are usually DFBs and not chlorine gas. Significant concentrations of elemental chlorine can form in the water if the pH is below about 4.0 as described above. However, the hypochlorous acid and hypochlorite forms, which predominate at pH levels above 4.0, are not gasses and will not volatilize from the water (White, 1992). The most common volatile associated with water chlorination in tomato packinghouses would likely be trichloramine (sometimes called nitrogen trichloride), which is the only species of active chlorine in swimming pools to cause tears in swimmers (White, 1992). Trichloramine is formed when the concentration of free chlorine is much higher than that of ammonium ions or certain amino groups in water (= situation in packinghouse dump tanks, flumes, and washers). Trichloramine is a highly unstable, corrosive gas that is not as soluble in water as chlorine (White, 1992). Significant concentrations of this gas are likely to develop in the air over dump tanks, flumes, and washers due Henry's Law, which states that the partial pressure of a gas at equilibrium in the atmosphere over a solution of that gas is proportional to the concentration of the gas dissolved in the solution. The practical meaning of Henry's law is that if a gas is dissolved in water, some of the gas will be in the air above the solution. If air is mixed with the solution, such as occurs when water is broken into droplets, more gas with exit the water in a process calling "air stripping". Air stripping will likely occur in packinghouse water systems where tomatoes are spray washed or where they splash into the water.

Considerations about the type of chlorine product to use in packinghouses. Three different types of chlorine products can be used in packinghouse water systems. Liquid or elemental chlorine is the least expensive formulation (White, 1992). It is supplied as a pressurized liquid, which is injected into moving water with special equipment. The injection equipment delivers precise amounts of chlorine into the water and has safety features to prevent overdosing, which prevents the off-gassing of Cl_2 from the water. When elemental chlorine hydrolyzes in the water, hydrogen ions are released, which combine with the hydroxyl(OH^-), carbonate ($CO_3^=$), or bicarbonate ions (HCO_3^-) found in most natural water supplies to form H_2O, HCO_3^-, and/or $H_2O + CO_2$. These natural buffering reactions prevent the accumulation of hydrogen ions. As chlorine gas is injected to replace the free chlorine lost to demand reactions, the natural buffers become depleted and hydrogen ion accumulates, which decreases the pH below desired levels. Consequently, alkaline buffering agents such as sodium bicarbonate must be added to waters chlorinated with chlorine gas.

Calcium hypochlorite ($Ca(OCl)_2$) is usually supplied as a granule or dry powder with about 60 to 70% free available chlorine per unit weight. The dry formulations are extremely stable and lose strength slowly over time. However, containers of calcium hypochlorite should not be allowed to heat up or to be stored near readily oxidized materials as rapid decomposition (= explosion) can occur (White, 1992). The dry formulations are added to water systems by gravity feed or manually (measuring cup, etc.). Alternatively, a highly concentrated liquid hypochlorite solution is created in "nurse tanks" where water and calcium hypochlorite are mixed. The liquid is metered into the packinghouse water system. In general the calcium hypochlorite systems cannot control the amount of free chlorine entering dump tanks, flumes or washers as reliably as gas metering equipment. The free chlorine in calcium hypochlorite is not completely released until the powder or granules dissolve. Since calcium hypochlorite is only partially soluble in water, a desired release of free chlorine in water may lag considerably behind addition of the dry product depending on the mixing rate of water with the dry product. The lime ($Ca(OH)_2$) in commercial calcium hypochlorite increases the pH of the solution and produces a precipitate when calcium reacts with carbonate ion to form the slightly soluble calcium carbonate.

Commercial strength, liquid bleach contains 9 to 15.5% NaOCl with a pH of 11.2 or slightly higher (White, 1992). These solutions are the most expensive formulation on a unit of chlorine basis, but they are the easiest to use because they can be added to water in precise amounts, they provide instant chlorine, the injection equipment does not have to have the safety features required for gas injectors, storage of the liquid in the packinghouse does not require a special facility, and training is not required to use this material. The liquid bleach concentrates contain excess hydroxide ion to stabilize the concentration of free chlorine in the solution. However, these solutions can lose substantial amounts of active chlorine within 30 days, particularly at higher storage temperatures.

The use of liquid as well as the dry hypochlorite materials to chlorinate packinghouse water systems leads to an increase in the pH of the solution because: i) as hypochlorite ions combine with H^+ and then react with microbes, hydroxyl ions are left behind and ii) excess hydroxyl ions are included in the formulations. The excess hydroxyl ions must be neutralized with acid to maintain the solution pH at the proper levels.

Two acids have been recommended for adjusting the pH levels when hypochlorite salts are being used. Muriatic acid or HCl is the most common one. It is very concentrated and must be blended carefully into chlorinated water to avoid the development of an area of low pH, which could lead to chlorine gas production. A milder acid, citric acid, has also been recommended. It normally can be purchased as a dry powder that can be added as such or the powder can be dissolved in water to produce a solution that can be metered into the water system. Care must be exercised with the citric acid system because chlorine reacts with citrate ion (Echols, et al., 1973). The amount of citric acid required to eliminate the alkalinity supplied with a typical bleach solution or dry chlorine product is not large enough to noticeably affect the free chlorine content of the final solution (Bartz, unpublished). However, if the water contains high natural alkalinity or if a citrate buffer is used, then much larger amounts of citrate are required, which could provide a substantial chlorine demand.

Suggested chlorine concentrations for packinghouse water systems. How much free chlorine is required to adequately sanitize packinghouse water systems is not entirely clear. Available research data, from which recommendations could be drawn, have not always specified pH, water temperature, free chlorine concentrations, pathogen populations, and chlorine demand in the test system (Bartz and Eckert, 1982). Many well designed experiments on the toxicity of chlorine to microbes have utilized bacteria harvested from pure cultures in log growth phase (Carlson, 1991). The cultures were washed to remove slimes and spent culture media and then suspended such that cells were isolated from each other. Chlorine products were mixed with the suspended spores. The contact interval was usually terminated by quenching the unreacted chlorine with sodium thiosulfate. Survival of the treated cells or spores was then determined. These experimental protocols produce results that can be duplicated in different laboratories, but unfortunately, the protocols usually do not reflect natural situations. For example, in natural systems, such as tomato packinghouses, microbes would be in aggregates, attached to the fruit surface and likely covered with slimes. Chlorine demand would provide competing reactions for HOCl. Each of these factors would increase the amount of HOCl needed to kill the cells. Brown and Wardowski (1984) reported that 100 ppm free chlorine at pH 7 would kill 10^6 spores of *Penicillium digitatum* or *G. candidum* suspended in 1 ml of water within 10 sec. With naturally contaminated oranges, however, twice as much chlorine applied for 15 seconds failed to kill *P. digitatum* on the fruit surfaces, whereas ten times as much chlorine failed to kill naturally occurring *G. candidum*. Less than 1 ppm free chlorine as HOCl is rapidly lethal to suspended, single cells of bacteria responsible for postharvest decays such as *Erwinia carotovora* subsp. *carotovora* (cause of bacterial soft rot) (Robbs, et al.1995). Suspended, single spores of *G. candidum*, cause of sour rots of tomatoes, citrus, and several other commodities, are killed by 20 to 25 ppm free chlorine as HOCl within 2 min (Robbs, et al, 1995), whereas 40 to 80 ppm is required to kill spores of *Botrytis cinerea* (cause of gray mold rot) and *Rhizopus stolonifer* (cause of Rhizopus rot) (Ferreira, 1994). Concentrations of free chlorine up to 120 ppm at pH 7.0 did not reliably prevent wounds on tomatoes floating in the water from becoming inoculated with freshly released spores of *R. stolonifer* (Bartz, et al., 1992). In two separate tests conducted in a packinghouse, however, 50 ppm free chlorine at pH 7.0 in solutions at 38°C provided as much control of postharvest decays as 80 ppm (first test) or 100 ppm (second test) at the same water temperature and pH (Bartz et al., 1992). The decay incidence over a 14-day storage interval following the treatments averaged below the 5% allowed by grade standards. The better efficiency of chlorine in the packinghouse tests as compared with laboratory tests with *R. stolonifer* may have been associated with the amount of inoculum entering the water, as well as wound size. Rhizopus rot was not observed among the fruit entering the packinghouse nor commonly observed among fruit retrieved from the packinghouse; therefore, populations of this difficult to kill fungus were likely very low. By contrast, the tomatoes in the laboratory tests were exposed to 1.6×10^4 spores/ml. The wounds on the tomatoes used in the laboratory tests were the size of stem punctures, whereas in the packinghouse, fruit with such wounds were culled.

Temperature has a profound impact on the ability of chlorine products to kill microbes. Warm chlorine solutions have greatly increased antimicrobial activity as compared with cool solutions. For example, chlorinated water is nearly twice as active against spores of *R. stolonifer* and *B. cinerea* at 40 as compared with 24 C, whereas the latter is more than twice as active as chlorinated water at 5 C (Ferreira, 1994). In tests with wounded tomato fruit, chlorine solutions at pH 8.0 and 40 C provided the same level of protection against *R. stolonifer* and as those at pH 7.0 and 25 C (Bartz, et al.,1992). Thus, the use of warm solutions of chlorine in packinghouse provides more flexibility with regard to managing the pH of the water system.

Previous recommendations for chlorinating dump tank water in Florida tomato packinghouses were for 100 to 150 ppm free chlorine (Hicks and Segall, 1974). California packinghouses were reported to use 70 to 100 ppm with 300 to 350 ppm in sprays on the fruit as they exit the tank (Ogawa, et al., 1980). Neither recommendation is supported by published data, however. If the addition of chlorine products is balanced against the loss of chlorine to demand reactions and the crop is relatively clean, then maintenance of 50 to 80 ppm at a pH of 7 to 7.5 and a temperature of 38 C such as used by Bartz, et al. (1992) would appear to be adequate for protecting tomatoes.

A factor in the successful chlorination of dump tanks, flumes, and washers is location of the targeted microbes. Microbes located in aggregates are difficult to treat successfully with chlorinated water, whereas those embedded in wounds on tomato surfaces cannot be successfully treated. If decaying fruits or vegetables are dumped into packinghouse water systems along with healthy ones, then the system will, at least temporarily, be contaminated because chlorine will react with the surfaces of decayed tissues instead of killing the decay pathogens in the tissues. Washer brushes in particular can become coated with rotted tissues that contain large populations of pathogens (Brown, 1995). Chlorine will not kill microbes in decayed tissues until those tissues have been dispersed.

Monitoring chlorine concentrations and making adjustments. When tomato packinghouses are handling fruit, chlorine products must be added continuously or intermittently to the water to maintain adequate free chlorine concentrations. Various approaches ranging from completely automated to completely manual have been used. Automated chlorination systems that include continuous measurement of both free chlorine (measurement of oxidation-reduction potential or DPD measurement automatically made every 2 minutes) and pH are attractive because of their rapid response to changes in chlorine demand and solution pH. With such systems, large free chlorine reserves (excess free chlorine required to insure that adequate amounts are present at all times) aren't necessary. Large free chlorine reserves are undesirable for several reasons including increased expense, increased equipment corrosion, and likely increased production of DFBs. Continuous chlorine product addition based on periodic measurements is somewhat less attractive than fully automated systems because the measurements may not be frequent enough to detect undesirable changes in the free chlorine concentration in the water. Since neither insufficient nor excessive free chlorine concentrations can be corrected quickly, the periodic measurements must be made frequently by workers that understand the type of kit being used. Completely manual systems are undesirable because they rely not only on frequent measurements of both free chlorine and pH but also on frequent additions of chlorine product and the appropriate buffer to the water, which means workers must understand how to achieve the proper mixing of chlorine and buffer in the water.

Factors that can lead to excessive postharvest decays despite the use of proper water chlorination procedures in the packinghouse. A. Field inoculation/wet weather. Tomatoes harvested during or immediately after rainy weather are especially vulnerable for postharvest decays. These tomatoes are more likely to have surface cracks and to have become wounded during harvest operations. Tomato plants that have been wet for several hours or more are likely to develop large surface populations of decay pathogens. These pathogens can be transferred to wounds or other potential infection courts during the harvest. Fruit that have been inoculated in the field or during harvest cannot be successfully cleaned by washing or treating with chlorinated water. The only postharvest handling practice known to slow the development of decay after fruit have been inoculated is prompt cooling (slows pathogen development) along with use of lower humidity in storage (tends to dry damaged tissues and eliminate free moisture). Wet weather also tends to produce the highest chlorine demand in fruit unloads. The combination of increased organic debris in the unloads, high populations of postharvest pathogens and other microbes, and perhaps soil splashed on fruit call for precise control of free available chlorine concentrations in the water and perhaps use of higher free chlorine concentrations.

B. Infiltration of fruit with tank water. The handling or washing of any freshly harvested fruit or vegetable with water has the potential for causing a portion of the water to enter wounds or natural openings on the surface of the product. This is called infiltration (Bartz and Showalter, 1981) With tomatoes, areas of concern are wounds and the stem scar. If the tomato surfaces and water are sterile or nearly so, then infiltration has no adverse consequences on the postharvest life of these fruit. Tomato surfaces are seldom sterile, however, and many fruit have internal populations of viable bacteria (Samish, 1962). Pathogenic microorganisms frequently live on the surfaces of healthy plants and cause no harm until the microbes enter wounded tissues or natural openings (Leben, 1965). The infiltration of unwashed tomatoes with clean tap water has produced extensive postharvest decays that began at or beneath the stem scar. The addition of chlorine to the water reduced decay incidence but the levels remained unacceptable (Bartz, 1988) Thus, we have recommended that hydrohandling procedures be designed to prevent tomatoes from becoming infiltrated with tank or wash water. This includes not allowing fruit to cool while in the water, not allowing tomatoes to be forced more than 6 inches below the water's surface, and not allowing tomatoes to remain in the water more than 2 min. Also, since the presence of surfactants in the water greatly increases the chance that fruit will become infiltrated, we have discouraged the use of detergents or other surfactants in packinghouse water systems.

Recontamination of fruit in the packing line. After tomatoes exit the tank and flume system, they are usually spray rinsed and brush washed with fresh water to remove residual tank water. California growers heavily chlorinate the rinse water (Ogawa, et al., 1980). We have no current recommendations about chlorinating the rinse water; however, some chlorine probably should be in the water for three reasons. First, if any partially decayed fruit or leaves enter the rinse/brush area, the brushes and subsequent packing line equipment can become contaminated with decay organisms. Fruit moving through contaminated equipment will become contaminated and are likely to decay. Free chlorine in the rinse water will help to sanitize the washer area. Secondly, sponge dewatering rollers are ideal places for the development of biofilms (sticky to slimy accumulations of microorganisms that grow on inert surfaces) because the rolls are likely to remain continuously wet. The sour rot pathogen, *G. candidum*, is known to grow on tomato processing equipment (Timmer, 1962) and would likely be a part of biofilm formation on sponge rollers. If the rollers are continuously in contact with water containing free chlorine, then biofilm formation is unlikely. Thirdly, free chlorine residues on fruit exiting the dewatering rolls will help to keep the equipment clean and free of potentially harmful microorganisms. On the other hand, chlorination of the rinse water will not eliminate the need for regular cleaning and disinfecting of the packing line belts, sizers, waxers, etc.

Worker sanitation. Since fresh market tomatoes are consumed raw, every effort must be made to keep them free of potentially harmful microorganisms. Wei, et al. (1995) and others have shown that various bacteria responsible for disease in people can survive and even multiply in tomato tissue. Interestingly, a clean blemish-free fruit provides the consumer with the best guarantee that no harmful microorganisms are present. Proper water chlorination will help to clean and disinfect tomatoes as they are washed. Preventing cleaned tomatoes from becoming contaminated is the final step in producing a wholesome product. This step is accomplished through rigid enforcement of proper worker hygiene, keeping the packinghouse free of rodents, birds or other animals, and not allowing workers that are ill or have recently been ill to work with tomatoes.

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QUALITY DIFFERENCES BETWEEN MUTANT, TRANSGENIC AND COMMERCIAL CULTIVARS

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Abstract. Various tomato cultivars were compared for levels of flavor compounds and other postharvest characteristics over several seasons. Cultivars studied included some ultrafirm lines and *rin* hybrids, from university breeding programs or commercial sources, as well as some transgenic fruit with low levels of polygalacturonase, an enzyme thought to be involved with softening. Generally, the ultrafirm lines, *rin* hybrids and transgenic fruit showed some advantages in terms of shelf-life and also in firmness for the ultrafirm and hybrid types. There were no consistent differences in soluble solids and titratable acidity, but one ultrafirm line and all *rin* hybrids were low in some key flavor volatiles. This was confirmed by sensory analysis where *rin* hybrids were rated lower than high flavor normal cultivars, even when harvested at a later stage of maturity (breaker versus mature green).

Introduction

One goal of genetic manipulation of tomatoes (*Lycopersicon esculentum* Mill.) is to slow softening or delay ripening in order to harvest fruit at a more mature state without incurring undue losses during shipping and handling. In theory, advanced harvest maturity should indirectly improve the flavor of tomatoes (El Shaal et al., 1979; Kader et al., 1978; Kader er al., 1977; Picha, 1986). Three approaches have been taken in this respect: to use naturally occurring mutant tomatoes that exhibit inhibited ripening characteristics in crosses with normal tomatoes (Tigchelaar et al., 1978); to down regulate enzymes that are involved with softening or ripening; or to select for very firm fruit in a conventional breeding program. One advantage to harvesting after color break is the elimination of immature green fruit, which are thought to ripen with poor quality. Nevertheless, new genetically altered cultivars, that can be harvested after color break, need to be evaluated for flavor enhancement and shelf life compared with standard commercial tomato cultivars.

The problem in evaluating new cultivars for flavor improvement, however, is that tomato flavor perception and analysis are not well defined. This is partly because the importance of taste and aroma in tomato flavor has not been clearly established. The sweet taste of tomato is attributed to the sugars glucose and fructose (Petro Turza, 1987) and the sour taste to primarily the acid citrate with a small contribution from another acid, malate (Stevens et al., 1977). It has been established in sensory tests that increasing sugar levels in tomatoes improved flavor quality, but that there was an optimal level of acids (Malundo et al., 1995) beyond which flavor quality was reduced. Few sensory observations about identified flavor chemicals have been made, thus their flavor activity is poorly understood (Acree, 1993). Nevertheless, over 400 aroma active compounds have been identified in tomato fruit (Buttery and Ling, 1993a, Buttery and Ling, 1993b, Buttery et al., 1989; Petro-Turza, 1987). Of these, at least 17 have been identified as important to tomato flavor based on odor threshold studies (level of a compound at which it can be detected by smell) (Buttery et al., 1971, Buttery et al., 1989).

There is a need for instrumental measurement of tomato flavor (soluble solids, titratable acidity, sugar/acid, volatile levels) to be integrated with sensory studies. Sensory analysis requires much expertise and resources, often not available to breeders, seed companies, and molecular biologists. Objective or instrumental analysis would be more useful if the relationship of levels of important flavor active compounds to sensory perception were established.

This research describes a series of experiments conducted over several years in which both instrumental and sensory analyses were conducted on ripened tomato fruit. Volatile profiles, titratable acidity (TA), soluble solids (SS), total sugars, firmness, handling, and shelf life data were obtained for various *rin* tomato inbreds and their F_1 hybrids, tomato inbreds selected for high levels of firmness (ultrafirms), and a transgenic fruit with down regulated polygalacturonase (PG) activity. Sensory studies were conducted comparing *rin* and/or *alc* (Kopeliovitch et al., 1981) commercial hybrids with a normal hybrid ('Solar Set') that has been shown to have relatively high levels of many important flavor volatiles (Baldwin et al., 1991a; Baldwin et al., 1991b).

Methods

Red ripe fruit samples were analyzed for color (both whole fruit and homogenate) by measuring 'a*' values using a Minolta Chromameter (Baldwin et al., 1991a), SS by refractometer (Jones and Scott, 1984), TA by titration with NaOH (Jones and Scott, 1984), and individual sugars (glucose and fructose) combined and converted to sucrose equivalents (SE) by HPLC (Baldwin et al., 1991a; Koehler and Kays, 1991). Volatiles, present in high levels or that have been determined to be important based on odor threshold studies, were analyzed in tomato homogenate headspace by gas chromatography (Baldwin et al., 1992). Thirteen flavor compounds were analyzed including aldehydes, ketones, alcohols and a sulfur containing compound.

Firmness (mm deformation) was determined on 15 fruit per cultivar. Shelf life was the mean number of days past the red ripe stage until the fruit became unacceptable or until three out of the original 15 fruit per cultivar were left.

Sensory analysis was conducted with a group of 100 consumers, identified as regular purchasers of fresh tomato, or 30 experienced panelists at the Gulf Coast Research Center. The consumers evaluated coded tomato samples using a 3-point scale (tastes great, acceptable, unacceptable), and panelists at the research center used a 9 point hedonic scale.

Fruit were harvested at mature green, breaker, turning, or red stages of maturity and ripened at 21C. Fruit were determined to be red ripe when 'a*' values at the blossom end did not change over 2-3 days.

Spring 1990. 'Solar Set', Fla. 7060 (the better flavored parent of 'Solar Set'), *rin* inbred, and a heterozygous *rin* hybrid with Fla. 7060 as one parent. Fruit were harvested (10 fruit /cultivar from each of 3 plots) at the red ripe stage of maturity (or with full color in the case of the *rin* inbreds) and analyzed for flavor volatiles.

Spring and fall 1993. In the spring, the following cultivars were grown: 'Solar Set', 'Sunny', 'Florasette', 'Sunbeam', and 'Solimar'; two experimental *rin* hybrids; two ultrafirm inbreds; and an antisense PG inbred. At least 60 fruit from each cultivar were harvested from each of three replicate plots at three maturity stages (mature green, turning and red ripe) and run across a grading line. The mature-green fruit were treated with ethylene for three days. At the red ripe stage, the harvested fruit from each cultivar/maturity stage were sampled for SS, TA, and flavor volatiles (green harvest only) and assessed for damage after transport to USDA, Winter Haven. Fifteen other fruit were tested for firmness and 15 for shelf-life as described above.

In the fall the same cultivars were tested except that 'Solimar' was omitted and the untransformed isoline of the antisense PG inbred was included.

Spring 1994. 'Solar Set', the *rin* hybrid 'Daniella', and the *alc* hybrid 'Lenor' were harvested at the turning stage of maturity (6 fruit/cultivar/sample) and ripened to red ripe for taste panel comparisons and sugar/acid analysis. Instrumental measurements were done on homogenized samples from the same fruit used in the sensory panel.

Data for the different volatile compounds, SS, and TA were analyzed by analysis of variance using the general linear model (GLM) procedure (SAS Institute, Cary, NC) and means compared for least significant difference (LSD, $P < 0.05$). Data for firmness, shelf life, handling, and all instrumental analysis of fruit from the sensory study were analyzed by analysis of variance (GLM) and means were compared using Duncan's multiple range test ($P < 0.05$).

Results

The two *rin* inbreds (R1 and R2) exhibited very low volatile levels with the exception of methanol (Fig. 1). All volatiles measured were significantly lower compared to either 'Solar Set' (SS in Fig. 1) or its parent, Fla. 7060 (P), with the exception of *cis*-3-hexenol. The *rin* hybrid (F_1) had volatile levels that were similar to Fla. 7060 for hexanal, *cis*-3-hexenal (Fig. 1A), β-ionone (Fig. 1B), 2+3-methylbutanol, and 2-isobutylthiazole (Fig. 1C), while all other volatiles measured were significantly lower. The 7060 X (7060 X BR200 F_4) hybrid had significantly lower levels of hexanal (Fig. 1A), geranylacetone, acetone, 6-methyl-5-hepten-2-one, 1-penten-3-one (Fig. 1B), and 2-isobutylthiazole (Fig. 1C) compared with 'Solar Set'.

The experimental *rin* hybrids from a commercial seed company were compared to five normal cultivars, the ultrafirm inbreds, an antisense PG inbred, and an untransformed fruit from the same line for flavor components, firmness, shelf life, and handling tolerance. When measuring 'a*' values to determine ripeness, it became apparent that the *rin* hybrids did not consistently achieve full red color. This was evidenced by maximum 'a*' values ranging from 19-27 for the two hybrids compared to 25-30 for normal cultivars.

Although there were differences between cultivars within each harvest maturity stage for soluble solids and titratable acidity, these differences were not consistent when the fruit were harvested at different maturities or from one season to the next for spring and fall 1993. Statistical analysis showed that neither cultivar nor harvest maturity effects were significant. The fall season data for SS and TA showed the effect of heavy rains prior to harvest. The differences between cultivars and harvest maturities were minimized. A similar situation occurred for flavor volatile compoundswhere differences between cultivars were muted. This phenomenon could be attributed to a dilution effect or the result of anaerobic stress on root systems.

For volatile flavor compounds in ripened green-harvested fruit, it was evident that the *rin* hybrids were low in many important volatiles compared with most other cultivars. When volatile levels were compared across all 10 cultivars, the two *rin* hybrids fell in the bottom third for 6 out of the 13 volatiles measured. The *rin* hybrids had moderate to high levels of alcohol volatile compounds, which are sometimes associated with off-flavor, and *cis*-3-hexenal. The *rin* hybrids were significantly lower in hexanal, geranylacetone, and 6-methyl-5-hepten-2-one compared to at least 5 of the other cultivars and lower in *trans*-2-hexenal, and 2-isobutylthiazole compared with at least two other cultivars. One of the ultrafirm tomatoes was also low in hexanal, geranylacetone, and β-ionone. The transgenic tomato showed high levels of *cis*-3-hexenal, but otherwise no major differences for other flavor volatiles compared to most normal cultivars.

Firmness of red ripe fruit tended to decrease with increasing harvest maturity in both the spring and fall trials of 1993 (Fig. 2A and B). In the spring, the *rin* hybrids (#6 and 7) and the ultrafirm inbreds (#8 and 9) were generally significantly firmer than the normal hybrids when harvested at the turning or red stage but not when harvested mature-green. The #7 *rin* hybrid was also firmer than most other cultivars for the mature-green spring harvest (Fig. 2A). In the fall, the same trend occurred but the differences were not always significant. The *rin* hybrid #7 and the ultrafirm inbred #9 were significantly firmer than the normal hybrids for the mature-green fall harvest.

Shelf life decreased with increasing harvest maturity (Fig. 2C). The *rin* hybrid #7 had significantly longer shelf life than the other cultivars at all three harvest maturities. The ultrafirm inbreds (#8 and 9) and the antisense PG inbred (#10) had greater shelf life than the normal hybrids and *rin* hybrid #6 at the red ripe harvest. The #7 *rin* hybrid, the ultrafirm inbreds, and the antisense PG inbred also had generally less handling damage only in the red harvested fruit (Fig. 2D).

Among a panel of 100 consumers, twice as many panelists thought that 'Solar Set' tomatoes 'tasted great' compared with the *rin* hybrid 'Daniella' and the mutant *alc* hybrid 'Lenor' when all fruit were harvested at the breaker stage of maturity and sampled when red ripe (Fig. 3A). Instrumental analysis of the sampled fruit showed that there were no differences in SE, TA, or SS, indicating that sugars and acids were not responsible for the consumer preference for 'Solar Set' over the two mutant hybrids (Fig. 3B). This result supports the notion that volatile flavor compounds are important factors determining acceptability of tomato flavor. Color analysis based on chromameter 'a*' values of fruit homogenate reflect the slightly pale color of the *rin* and *alc* fruit compared with 'Solar Set' which exhibited higher 'a*' values. Color differences may have been due to the mutant genes or to other differences in the genetic background of the three cultivars. In another study, panelists rated 'Solar Set' (which has FL 7060 as the high flavored parent), harvested mature green, higher than a *rin* hybrid (*rin* inbred x 7060 backcrossed to 7060), harvested at breaker stage (ratings of 6.3 and 4.4, respectively, on a 9-point scale where higher scores indicate better flavor).

In conclusion, the *rin* inbreds and mutant hybrids analyzed in this study differed from normal tomatoes in the levels of some important flavor volatiles and red color while no meaningful differences were found for sugar levels (SE), SS or TA. The commercial mutant hybrids 'Daniella' and 'Lenor' were shown to have inferior flavor quality in a consumer taste panel compared with the normal cultivar, 'Solar Set' when harvested at the same stage of maturity (breaker). Similarly 'Solar Set (harvested green), was rated higher than a *rin* hybrid with a similar background (harvested breaker). The difference in flavor could not be attributed to sugar and acid levels. When using non- or slow-ripening mutants in crosses with normal inbreds, some decrease in flavor and color quality may occur in order to gain an increase in fruit firmness and shelf-life. It remains to be demonstrated if this decrease can be overcome with further breeding. It is evident from these studies that mutant hybrids, ultrafirms, and transgenic fruit can be harvested at later stages of maturity with less losses due to handling and increased shelf life compared with normal cultivars. More studies need to be conducted to determine if there is an advantage in flavor quality with these new cultivars that can be harvested with color.

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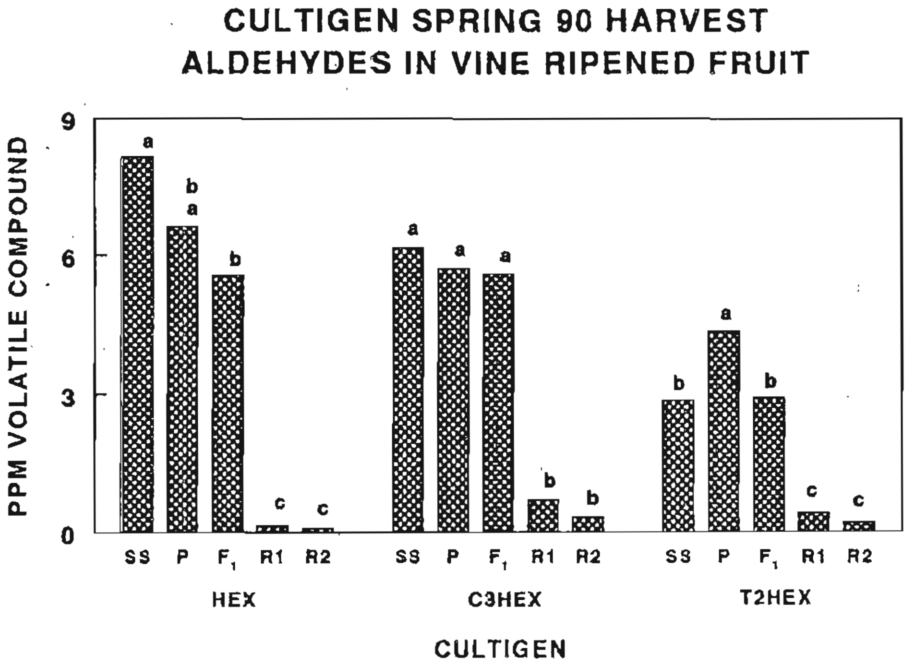
Figure Legends

Fig. 1. Ten Tomato fruit from 5 cultigens at each of 3 plots were harvested at the ripe stage of maturity (with full color) and analyzed for headspace volatile compounds: A.) hexanal (HEX), *cis*-3-hexenal (C3HEX), *trans*-2-hexenal (T2HEX); B.) geranylacetone (GER), acetone (ACET), 6-methyl-5-hepten-2-one (METH), 1-penten-3-one (PENT), β-ionone (BIO); and C.) methanol (MEOH), 2+3-methylbutanol (MBUT), *cis*-3-hexenol (C3XOL), 2-isobutylthiazole (ISO). Data are means of 10 replicate samples, each a composite of 3 fruit. Cultigens include 'Solar Set' (SS), Fla. 7060 (P), *rin* inbred #1 (R1) and *rin* inbred #2 (R2). Letters indicate mean separation by LSD at $P < 0.05$.

Fig. 2. Fifteen tomato fruit were harvested from cultigens #1-11 at each of 3 plots and stage of maturity (green harvest, GH; turning harvest, TH; and red harvest, RH) and analyzed for firmness, A.) spring harvest, B.) fall harvest, C.) shelf life, and D.) handling characteristics. Data are means of 15 fruit for (A-C) and of 3 composite samples of 30 fruit each (D). Letters indicate mean separation by Duncan's multiple range at $P < 0.05$.

Fig. 3. Six fruit per cultigen were harvested at the breaker stage of maturity, ripened at 21C, A.) Rated by 100 consumers for : tastes great (TG), acceptable (A), or unacceptable (UA); and B.) analyzed for red color of fruit homogenate (COL 'a*'), sucrose equivalents (SE), soluble solids (SS), and titratable acidity (TA) for the same fruit (LNR='Lenor', DAN='Daniella', and SLS='Solar Set'). Letters indicate means separation by Duncan's multiple range at $p < 0.05$.

A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ALDEHYDES IN VINE RIPENED FRUIT
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3
6
9
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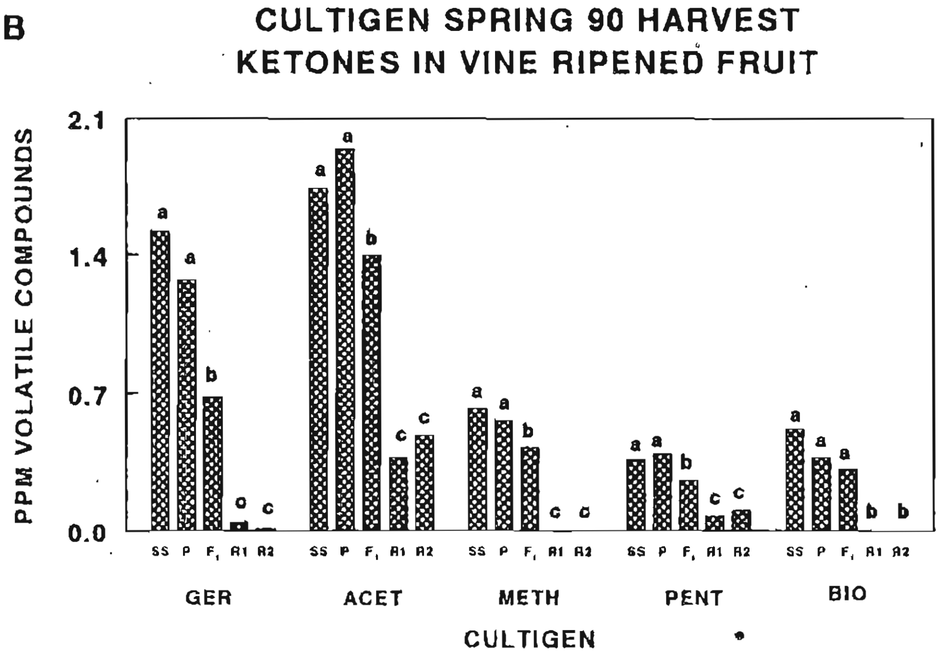
HEX
C3HEX
T2HEX
CULTIGEN

B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PPM VOLATILE COMPOUNDS
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GER
ACET
METH
PENT
BIO
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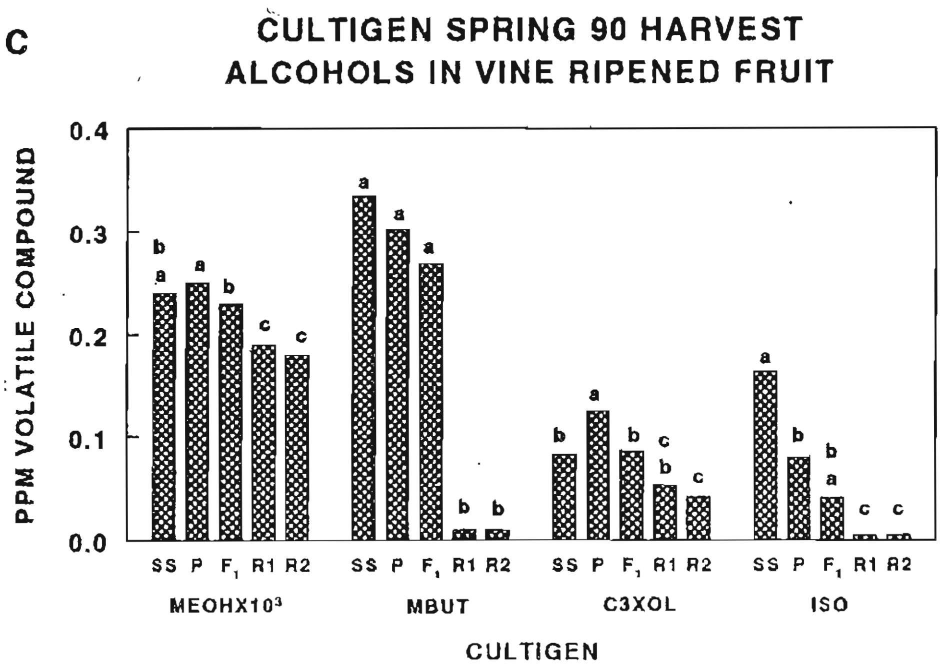
C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PPM VOLATILE COMPOUND
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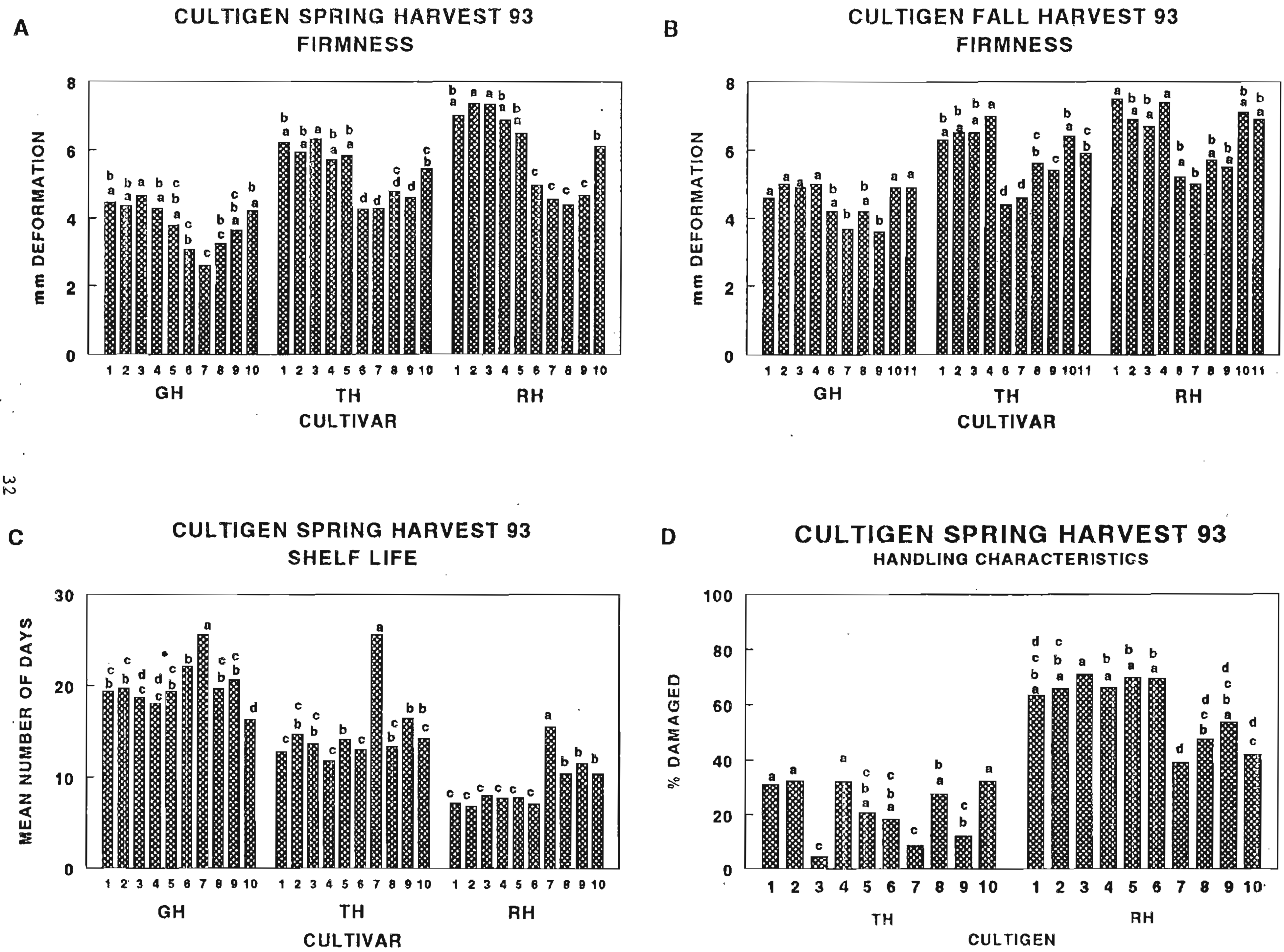
A
CULTIGEN SPRING HARVEST 93
FIRMNESS
mm DEFORMATION
GH
TH
RH
CULTIVAR
B
CULTIGEN FALL HARVEST 93
FIRMNESS
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GH
TH
RH
CULTIVAR
C
CULTIGEN SPRING HARVEST 93
SHELF LIFE
MEAN NUMBER OF DAYS
GH
TH
RH
CULTIVAR
D
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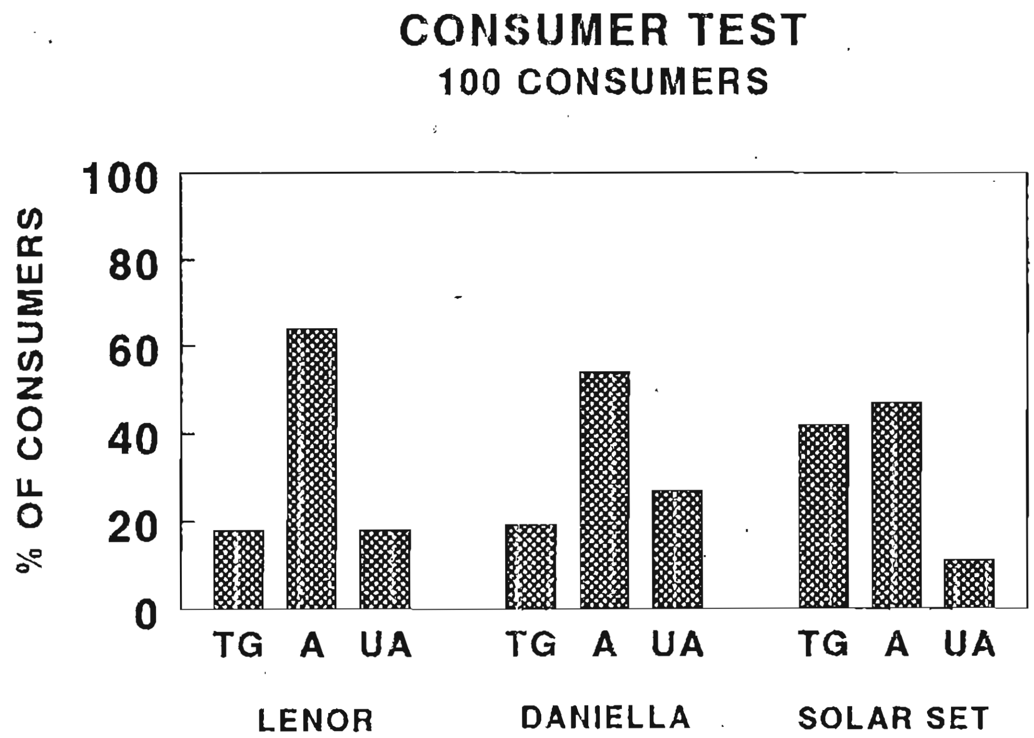
HANDLING CHARACTERISTICS
% DAMAGED
TH
RH
CULTIGEN

A


CONSUMER TEST
100 CONSUMERS
% OF CONSUMERS
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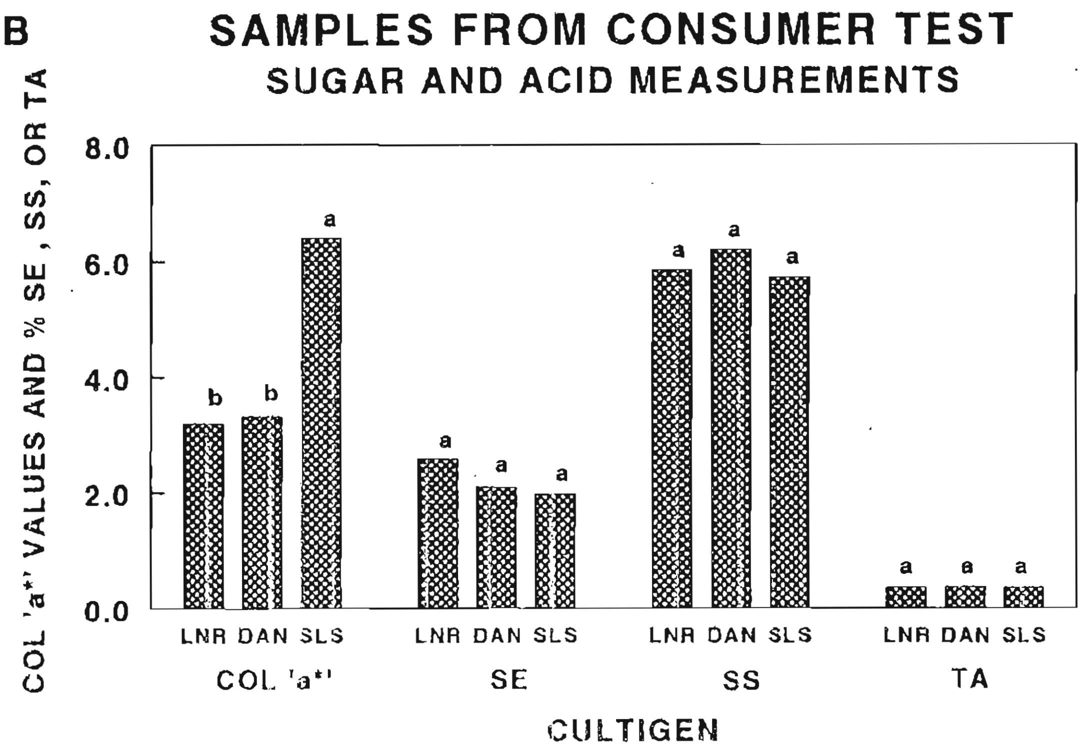
20
40
60
80
100
TG A UA
TG A UA
TG A UA
LENOR
DANIELLA
SOLAR SET

B


SAMPLES FROM CONSUMER TEST
SUGAR AND ACID MEASUREMENTS
COL 'a*' VALUES AND % SE , SS, OR TA
0.0
2.0
4.0
6.0
8.0
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a a a
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LNR DAN SLS
LNR DAN SLS
LNR DAN SLS
LNR DAN SLS
COL 'a*'
SE
SS
TA
CULTIGEN

Nitrogen and Potassium Fertigation and Cultivar Effects on Tomato Yield and Graywall in Dade County

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Introduction

Graywall and other, possibly related, ripening disorders are responsible for widespread losses in marketable yields and for reduced quality of Florida tomatoes. Cullage due to graywall has been estimated to be above 50% for some commercial plantings in Florida. Losses of 10 to 20% are common in commercial fields.

Scientists and growers believe that high nitrogen (N) and low potassium (K) fertilizer application rates are associated with graywall incidence, abnormal ripening, and subsequent reduced yields. It is also believed that certain environmental conditions combined with improper fertigation rates enhance the occurrence of graywall. This problem is particularly important for Dade County tomato growers, who have shown considerable interest in finding solutions to this malady.

Current fertilizer recommendations for fertigated tomatoes in Dade County are "best guesses" based on data from sandy soils in other parts of Florida and dry fertilizer application rates for Dade County tomatoes grown without plastic mulch. Tomato fertigation recommendations have not been calibrated for the rocky soil types found in Dade County.

The objectives of this study were to evaluate the effects of N and K fertigation on tomato fruit yield and graywall incidence.

Materials and Methods

This study was conducted in a Dade County grower's field on Rockdale soil during the fall/winter season of 1995-1996.
A random pre-plant soil sample was taken and analyzed at the University of Florida, IFAS, Analytical Research Laboratory (ARL) to determine pre-plant fertilizer needs and to develop a base line for available nutrients. The results indicated that the soil concentration of P was high to very high, suggesting that there would not be a yield response to the addition of P. As a result, no P was applied to the experimental plots.

Prior to applying the fertilizer treatments, soil samples were collected from the top 2 in. from 4 randomly selected locations within each fertilizer plot and analyzed for N and K concentrations at the ARL. Fertilizer treatment main plots were 50 ft. long and were arranged following a 4 x 4 factorial design with 4 N rates and 4 K rates resulting in 16 treatments (Table 1). There were 4 replications of each treatment resulting in a total of 64 fertilizer plots. Ammonium nitrate and potassium chloride were selected as the sources of N and K, respectively. The total fertilizer rates were 0, 75, 150, and 225 lbs N/A and 0, 50, 100, and 150 lbs K_2O/A. Twenty percent of the total fertilizer was applied pre-plant by hand as dry fertilizer and incorporated into the bed. The remainder was injected through the drip tube in a graduated system (Table 2). Beds were laid out with 2 drip tubes, one for irrigation purposes and the other for applying the liquid fertilizer treatments. Fertigation was applied to each fertilizer plot on a weekly basis using a CO_2 gas injection system. During early growth stages, the first three weeks after transplanting, a total of 7 lbs of N or K_2O /A/week was injected through the drip system. After the 4th week, this amount increased up to 14 lbs/A/week. (Table 2).

Two commercially-grown cultivars, "Agriset 761" and "Sunny", were selected for use in this experiment. The two were transplanted by hand on November 22, 1995, in single rows within each fertilizer treatment following a split plot design. Each cultivar was planted in a plot 25 ft. long with a between plant spacing of 20 in..

All of the spray and cultural practices, except fertilization and irrigation, were managed by the grower. An irrigation pump was placed in the experiment that was independent from the grower's system. Four irrometers (tensiometers) were randomly placed in the field to be used as a reference for soil moisture content and to determine irrigation needs. Irrigation amounts depended on the stage of plant growth, averaging 1200 gallons/A/day for the season.

During the growth phase of the crop, 4 leaf petiole samples were collected from each variety in each plot and analyzed for NO_3-N and K^+ sap concentrations using portable Cardy ion meters. A second companion set of leaf samples was collected ,dried and analyzed in the ARL for N and K concentrations.

Fruit were harvested 3 times during the season in combination with the grower's harvest schedule. The harvest dates were March 5, March 25, and April 10, 1996. Fruit were graded for graywall and for yield using USDA guidelines.

Results

The pre-fertilization soil samples were analyzed and found to be in the medium to high range for K, indicating that no K response was expected. There was no fruit yield or quality response observed that could be related to the level of K_2O fertilization (Table 3).

Yields of extra large and total marketable fruit increased with an increase in N fertilization and appeared to peak around 150 lbs of N/A. Graywall incidence and total culled fruit also increased with increased N fertilizer rate. Among the harvests, graywall incidence was significantly affected by the N fertilizer treatments only in the 1st of the 3 harvests (data not shown). The grower reported a similar finding (Personal communication). There was no significant interaction between N and K relating to the incidence of graywall. "Agriset 761" and "Sunny" had similar total yields, but "Agriset 761" had a significantly larger incidence of graywall than "Sunny" over the season (Table 3).

In the 1st sampling date, no difference was observed between "Agriset 761" and "Sunny" for leaf sap NO_3-N and or K^+. In the 2nd sampling date, no difference in sap NO_3-N was observed between the 2 cultivars, however sap K^+ was significantly higher in "Agriset 761". In the 3rd sampling date, "Agriset 761" had significantly more sap NO_3-N than "Sunny".

Results for the dry tissue leaf analysis were not available at the time of the writing of this report.

Discussion

This study had some notable findings: (1) the lack of yield response to K_2O fertilization rates, (2) the incidence of graywall was related to high N and not to low K_2O fertilization rates, and (3) the yield response to the N fertilization rates supports the current State of Florida Extension recommendations for tomato N fertilization.

A threshold N rate for the onset of graywall remains to be determined. A second year of investigation is needed to determine this threshold and to confirm the N and K_2O fertilization rate effects on yield and leaf sap NO_3-N and K^+ concentrations. Further studies are also needed to collect additional information on the relationship of graywall incidence with weather conditions.

Table 1. Total dry and liquid fertilizer rates (lbs/A) for the season, Homestead, winter 95-96.

	Treatment															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Nitrogen (N)	0	0	0	0	75	150	225	75	75	75	150	150	150	225	225	225
Potassium (K_2O)	0	50	100	150	0	0	0	50	100	150	50	100	150	50	100	150

Table 2. Total and weekly N and K_2O fertilizer rates (lbs/A) for each fertilizer treatment.

	Total		Week																							
			1 - 3		4		5		6		7		8		9		10		11		12		13		14	
Trt	N	K	N	K	N	K	N	K	N	K	N	K	N	K	N	K	N	K	N	K	N	K	N	K	N	K
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	30	0	7	0	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	80	0	7	0	14	0	14	0	14	0	14	0	3	0	0	0	0	0	0	0	0	0	0	0	0
4	0	130	0	7	0	14	0	14	0	14	0	14	0	14	0	14	0	14	0	11	0	0	0	0	0	0
5	55	0	7	0	14	0	14	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	130	0	7	0	14	0	14	0	14	0	14	0	14	0	14	0	14	0	11	0	0	0	0	0	0	0
7	205	0	7	0	14	0	14	0	18	0	18	0	18	0	20	0	18	0	18	0	18	0	14	0	14	0
8	55	30	7	7	14	9	14	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	55	80	7	7	14	14	14	14	6	14	0	14	0	3	0	0	0	0	0	0	0	0	0	0	0	0
10	55	130	7	7	14	14	14	14	6	14	0	14	0	14	0	14	0	14	0	11	0	0	0	0	0	0
11	130	30	7	7	14	9	14	0	14	0	14	0	14	0	14	0	14	0	11	0	0	0	0	0	0	0
12	130	80	7	7	14	14	14	14	14	14	14	14	14	3	14	0	14	0	11	0	0	0	0	0	0	0
13	130	130	7	7	14	14	14	14	14	14	14	14	14	14	14	14	14	14	11	11	0	0	0	0	0	0
14	205	30	7	7	14	9	14	0	18	0	18	0	18	0	20	0	18	0	18	0	18	0	14	0	14	0
15	205	80	7	7	14	14	14	14	18	14	18	14	18	3	20	0	18	0	18	0	18	0	14	0	14	0
16	205	130	7	7	14	14	14	14	18	14	18	14	18	14	20	14	18	14	18	11	18	0	14	0	14	0

K = K_2O

Table 3. Effects of N, K and cultivar on total tomato yield and graywall incidence (25 lbs boxes/A) over the season, Homestead, winter 95-96.

N	K_2O	Cultivar	Tot. mkt. lrg.	Tot. mkt.	Graywall	Cull
0			503	939	7	242
75			1077	1783	31	566
150			1197	1901	38	575
225			1193	1904	34	578
Significant			**	**	*	**
	0		867	1453	25	451
	50		1042	1743	33	525
	100		1024	1666	27	501
	150		1037	1666	24	485
	Significant		ns	ns	ns	ns
		Agriset 761	1084	1651	39	458
		Sunny	901	1613	16	522
		Significant	**	ns	**	ns

*= sig. 5% level; **= sig. 1% level; ns= not significant

Table 4. Effect of fertilizer rate and cultivar on tomato leaf petiole sap NO_3-N and K^+ concentrations (ppm), Homestead, winter 95-96.

			Sampling date							
			12/29/1995		1/16/1996		1/31/1996		2/19/1996	
N	K_2O	Cultivar	NO_3-N	K^+	NO_3-N	K^+	NO_3-N	K^+	NO_3-N	K^+
0			878	3384	508	3303	205	3119	129	3331
75			1041	3366	1083	2987	708	3006	274	3194
150			933	3250	1100	3066	697	2962	500	3184
225			922	3141	1124	2944	720	2956	469	3028
Significant			ns	ns	**	ns	*	ns	**	*
	0		966	3228	952	2943	584	2525	370	2906
	50		971	3363	1012	3084	614	3181	379	3181
	100		928	3278	883	3141	575	3234	311	3328
	150		910	3272	968	3131	557	3103	312	3322
	Significant		ns	ns	ns	ns	ns	ns	ns	ns
		Agriset 761	978	3236	1012	3302	629	3023	352	3302
		Sunny	909	3334	895	2848	536	2998	334	3067
		Significant	ns	ns	ns	**	*	ns	ns	ns

*= sig. 5% level; **= sig. 1% level; ns= not significant.

Heirloom & Unusual Tomatoes for Speciality Markets

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Consumers have broadened their tastes in produce over the past several years, and now are more sophisticated, wanting a wider variety of colors, sizes, and shapes. Heirloom and unusually colored tomatoes provide a rich diversity of eye-appealing color and shape and different flavors to buyers. Produce markets and supermarket chains in urban areas in the Northeast, Midwest, and especially on the West Coast have been incorporating specialty tomatoes in their produce line for years and have made them part of their mainstream offerings.

Many of these varieties can be grown successfully in Florida and could be marketed to fill a niche that exists. These unusual tomatoes could give growers added income or even substitute as a crop that is not currently available to consumers within Florida. Consideration should be given to varieties that have shown some degree of disease resistance and offer relatively high levels of productivity. Trials should be made prior to committing large amounts of acreage since growing techniques may have to be altered to accommodate the indeterminate growth habit of most of these varieties.

The following varieties have been grown successfully in small plots on an informal basis in Florida:

TOMATO VARIETIES FOR SPECIALTY MARKETS:

Arkansas Traveler--Indeterminate variety, old Southern heirloom tomato known for its ability to produce well in hot weather. Dark pink tomatoes are 6 to 8 ozs. and highly flavorful.

Black Plum--Small, elongated-oval fruits are deep mahogany colored, and sweet with a fruity flavor. "Black" tomatoes are the newest popular color choice with gardeners today. Indeterminate, tall plants produce a steady, large crop of these teardrop-shaped cherry-type fruit.

Brandywine--Indeterminate variety, legendary for its exceptional flavor. Dark pink fruit is 1 to 1 1/2 lbs. with few seeds and finely textured pink flesh. Tall vines with potato-leaved foliage. Amish heirloom that is widely considered by home gardeners to be the best-tasting tomato available.

Cherokee Purple--Very productive, indeterminate plants with 10 to 12 oz. dusky rose/purple fruit that have brick red interior flesh. Delicious taste that is sweet yet rich. Heirloom variety from Tennessee.

Green Grape--Compact determinate that yields 3/4 to 1 inch fruit that is yellow-green when ripe and very sweet and juicy. Amber yellow on the outside and bright green on the inside. Eye-catching color and great flavor that is typical of tomatoes that ripen green.

Green Zebra--Unique and delicious salad tomato. 3 oz. amber-green tomatoes with darker green stripes. The chartreuse flesh is a taste treat--sweet but with an acidic zip. Indeterminate plants yield heavily.

Lemon Boy VFN Hybrid--Indeterminate variety with disease resistance produces lemon yellow, large fruit that weigh an average 7 ozs. Very attractive fruit tastes good and is produced well on vigorous vines. This one has better flavor and texture than other yellow tomatoes currently being marketed.

Sun Gold Hybrid--The most popular colored cherry tomato variety on the market. Everyone loves this tomato. Very sweet, bright orange fruit are not just sugary, but also fruity. Tall plants are extremely productive. Very vigorous with resistance to fusarium wilt and tobacco mosaic virus.

Yellow Pear--Heirloom and still popular variety is famous for big production of tiny, pear-shaped yellow fruit, 1 1/2 inches long. Very sweet with clear yellow color. A favorite at produce markets and farm stands. Very tall indeterminate vines.

Yellow Stuffer--Unique tomato that looks just like a yellow bell pepper and is hollow. Tall, vigorous vines bear profusely and fruit can be marketed as a stuffer for cold salads or baked stuffings.

Types of Varieties Which May Provide Alternatives to Conventional Tomato Growing in Florida

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There has been a disturbing number of tomato growers in Florida that have gone out of business over the last several years. The primary reason for this is over-production and low returns during much of the growing season. At times there are simply too many tomatoes grown in Florida, but often competition from Mexico has glutted the market. Higher production costs in Florida compared to Mexico has put Florida growers at a disadvantage. This has been exacerbated by NAFTA, the peso devaluation, and the widespread use of extended-shelf-life (ESL) tomato varieties in Mexico. The ESL varieties have allowed for more efficient shipping of tomatoes harvested at the breaker stage into the United States and Canada. The purpose of this report is to identify two types of tomato varieties which could be grown in Florida that might help to sustain the Florida tomato industry.

One possibility would be to grow varieties without staking to reduce production costs. This would entail using varieties specifically designed for ground culture which are called compact-growth-habit (CGH) tomatoes. A breeding project to develop CGH varieties has been ongoing for several years at North Carolina State University by Dr. Randy Gardner (Kemble *et al.*, 1994a). This project combines a gene called brachytic (*br*) which shortens internodes by 50% (Burton *et al.*, 1955) and prostrate growth habit which causes wide branch angles and a spreading growth habit. The CGH plants can be grown in double rows per bed (Kemble *et al.*, 1994b) like peppers without vining into the aisles. Planting density is increased over staked tomatoes to make up for some of the loss in the vertical space utilization. Fruit set is concentrated reducing harvests to one or two per crop. Ultimately, jointless pedicel varieties would allow for once-over mechanical harvest, thus removing not only the staking and tying costs, but reducing harvest costs as well.

In North Carolina, the effects of transplant cell size on plant size, earliness, and overall production was studied and a cell volume of 37.1 cm^3 (Todd planter flat 150) was the most economical (Kemble *et al.*, 1994b). However, the aspects of ground culture need to be studied in Florida. CGH tomato varieties which set fruit well tend to have less leaf cover than optimal at the crown of the plant. Thus, there is a possibility that sunscald or fruit cracking (radial, concentric, and/or cuticle) could be increased. These disorders are less severe when leaf cover is adequate and most severe when protected fruit are suddenly exposed to the environment by opening up vines at harvest or a rapid defoliation by a foliar disease epidemic. The somewhat exposed fruit of CGH tomatoes would be acclimated to the sun and rain and less subject to cracking. Nevertheless, CGH varieties need to be assessed over several growing seasons and locations in Florida to determine their suitability. Fertilization of these varieties should also be studied as too much nitrogen could result in overly vegetative plants which would grow off the plant beds and into the aisles. This was observed in Homestead last year (Scott and Bryan, unpublished). It has also been difficult to obtain large fruit on the periphery of the plants, thus harvesting a third time would not be feasible even if the prices were good. One would have to rely on sequential plantings.

The previous scheme would reduce production costs and labor requirements while packing tomatoes similar to present practices. Another approach would be to grow premium tomatoes for an upscale market to circumvent competition from Mexico. Such an approach is presently being used by Israel and Holland who are shipping tomatoes by air into the US and selling them at a higher price by touting improved eating (consumer) quality. There are flavor problems with Florida tomatoes because immature as well as mature-green fruit are harvested, and the fruit are sometimes refrigerated or otherwise not allowed to ripen properly. Furthermore, flavor has not been a major consideration in choosing varieties to grow and some of the varieties grown in Florida do not taste particularly good. The ESL tomatoes grown in Mexico are picked at the breaker stage and thus avoid the immaturity problem. However, they possess the ripening inhibitor (*rin*) gene to increase shelf-life and flavor problems have been reported with *rin* hybrids (Kopeliovitch *et al.,* 1982). It is my experience in working with *rin* for many years that there is generally an unpleasant metallic after-taste in *rin* hybrids. Our taste panel results generally show that *rin* hybrids are not as good as their somewhat isogeneic normal tomato counterparts. It is my opinion that it is not possible to obtain good flavored tomatoes consistently from *rin* hybrid varieties. If off flavors in *rin* hybrids are not as evident for one harvest they are likely to be evident at another one. Thus, it is not possible for Mexico to provide a high quality product, the best they can do is provide a tomato with fair eating quality. However, changes would be needed for Florida to provide a premium product. First, a variety should be chosen which will yield and ship well, but also have good flavor. The fruit would have to be picked at the breaker stage to eliminate immature fruit. Since these are not ESL varieties, they need to be handled carefully and run over shorter, padded packing lines and shipped in smaller boxes.

They would need to be labeled and aggressively marketed as a premium product to obtain the greater prices needed for the increased handling costs.

In addition to flavor, fruit appearance (purchase quality) is important to the consumer. This includes firmness and fruit color. Thus a premium variety should have good ripening characteristics so the fruit look appealing. There are several genes in tomato which intensify the red color of tomatoes. One of these genes is called the crimson or old-gold (*og*) gene. This recessive gene causes a 50% reduction in Beta-carotene with a concomitant increase in lycopene (Thompson *et al.,* 1965). Crimson varieties have fruit with a very attractive intense red color, but they have reduced pro-vitamin A content due to the reduced Beta-carotene. Recently several oncological studies have reported on the cancer preventing properties of lycopene (DiMascio et al., 1989; Levy et al., 1995; Giovannucci et al., 1995). People with high lycopene in their bloodstream have reduced frequencies of several cancers including prostrate cancer in men (Giovannucci et al. 1995). Since crimson tomatoes have 40-50% more lycopene, they theoretically could be marketed for their health aspects as well as their appearance.

There are numerous *og* inbreds in the University of Florida tomato breeding program which have very good flavor and horticultural adaptation to Florida. It would be possible in a short time to have acceptable *og* varieties available to growers. Advantages over Mexico would be flavor, color, and high lycopene levels for cancer prevention. Theoretically, growers could grow some of their acreage for the premium market while making up for their increased labor by growing CGH tomatoes of the rest of their acreage. Otherwise, growers can always continue doing business as usual and take their chances on the market.

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Prospects for Using Bacteriophages for Control of Bacterial Spot and Bacterial Wilt on Tomato

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Bacterial diseases of tomato have caused serious problems for the Florida tomato industry for years. Bacterial spot, incited by *Xanthomonas campestris* pv. *vesicatoria*, is considered one of the major disease problems, and occurs when high moisture and high temperatures exist. The disease is extremely difficult to control by conventional means. Bactericides such as copper and antibiotics have been partially effective. However, when conditions are optimal for disease development, chemical control may be inadequate. The presence of antibiotic and copper resistant strains further contributes to poor disease control. Bacterial wilt, incited by *Burkholderia* (*Pseduomonas*) *solanacearum*, has also been a problem to Florida tomato growers. This disease can be extremely devastating, wreaking havoc when incidence is high.

Bacteriophages, which are virus particles that infect bacteria, have been proposed in the past to be used for controlling bacterial plant pathogens. Although researchers have used bacteriophages (Moore, 1926; Okabe and Goto, 1963), their use has been limited due to the development of mutant bacteria resistant to the phages employed (Katznelson, 1937; Okabe and Goto, 1963). Although the mutation rate for a bacterial cell becoming resistant to one phage is quite low, disease control using a single phage is not expected to be great because of the development of phage resistant bacterial strains; however, the probability for developing resistance to two or more phages at the same time is highly unlikely. Theoretically, the use of several different phages would eliminate the possibility for development of phage resistant populations.

In 1989, Dr. L. E. Jackson, research scientist, AgriPhi, Inc., received a patent (U.S. Patent 4,828,999) for using a mixture of h-(host-range) mutants with or without wild-type phages to control plant pathogenic bacteria. H-mutants, which are capable of attacking an extended range of hosts, are spontaneously derived from the wild-type parent phages, and are so named because they lyse both the parent wild-type bacteria and the phage-resistant mutants originating from the parent bacterium. If the control application is a mixture of phages including h-mutants, phage-resistant mutants that arise in a natural bacterial-pathogen population will be destroyed by h-mutants in the multiphage composition.

We are in the process of testing bacteriophages for control of bacterial wilt and bacterial spot of tomato. Dr. Jackson, an expert on bacteriophages, has made a collection of the bacteriophages from a group of strains of *Burkholderia* (*Pseudomonas*) *solanacearum* and *X. c.* pv. *vesicatoria*, representing diverse geographic locations and/or genetic backgrounds. For the past 10 months, bacteriophages have been tested at the GCREC for efficacy against two bacterial diseases (i.e. bacterial wilt and bacterial spot).

In control tests, the phage mixtures were tested for control of the bacterial wilt pathogen, *B. solanacearum*. Three-week old tomato plants were pretreated with a mixture of phages specific for this pathogen. The plants were pretreated 5, 3 and 0 days before inoculation with a mixture of four different strains of *B. solanacearum*. The phage mixture had a final titer of 3.3 x 10^8 plaque-forming units (pfu)/ml, and the bacterial suspension was 10^7 cfu/ml. After 3 weeks, each plant was rated for disease severity (Table 1). The ratings were: 1=healthy; 2=slight wilting; 3=general wilting; and 4=dead. More than 90% of plants pretreated with the phage mixture remained healthy, whereas all plants without phage treatment expressed wilting symptoms.

In a separate study for the control of bacterial spot of tomato, three-week old plants were treated in the greenhouse with 50 ml of a mixture of three h-mutant phages for race 3 (T3) of *X. c. vesicatoria*. Treatment consisted of pouring the phage mixture onto the soil around the base of each tomato plant. The titer of the phage mixture was 10^8 pfu/ml. Four h later both phage-treated as well as plants not treated with phage were sprayed with 10^8 colony-forming units per ml of a T3 strain suspended in 0.01 M $MgSO_4$. All plants were enclosed in clear polyethylene bags, placed in a growth chamber at 28°C for 36 h. Then, they were unbagged and returned to the greenhouse. Seven days after inoculation with the pathogen, disease incidence was higher on those plants that did not receive the phage mixture than those that did. Two weeks after inoculation the plants were rated for bacterial spot severity as shown in the table below. As can be seen (Table 2), 90% and 33% of the plants without and with the phage treatment, respectively, had more than 6% defoliation. More significantly, 60% of phage-untreated plants and none of the phage-treated plants had greater than 12% defoliation. On the eleventh day after inoculation, terminal leaflets were aseptically removed from all leaves of a phage-treated plant and analyzed for the presence of phage. Phages were found in all leaflets assayed.

Bacteriophages are appealing for several reasons. Phages are **naturally occurring**. Phages are **highly specific** for the targeted bacterium and in this case the plant pathogenic bacterium; thus, they are **not toxic** to those bacteria which are beneficial to the environment (eg. nitrogen-fixing bacteria). Furthermore, phages are **nontoxic to workers**. There is considerable flexibility in using bacteriophages; the h-mutant mixture can be modified as needed to control specific bacterial populations.

Considerable work must be done to determine the practicality and efficacy of this new technology before it can be utilized commercially. However, the future for bacteriophages appears promising for controlling the bacterial spot pathogen in the greenhouse and in the field.

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Table 1. The effect of applying bacteriophages specific to *Burkholderia solanacearum* at various time periods prior to application of the bacterial pathogen on bacterial wilt severity on 'Walter' tomato.

Phage Treatment (Days)	Disease Severity[a] 1	2	3	4
0[b]	10[c]	0	0	0
3	8	0	0	2
5	10	0	0	0
None	0	2	2	6

[a]Disease severity values where 1=healthy; 2=slight wilting; 3=moderate wilting; and 4=dead.

[b]Value represents number of days before inoculation that phage treatment was applied.

[c]Value represents number of plants.

Table 2. The effect of applying bacteriophages specific to *Xanthomonas campestris* pv. *vesicatoria* to the soil prior to application of the bacterial spot pathogen on bacterial spot severity on 'Walter' tomato.

Treatment	Disease Severity (% defoliation) 0-3	3-6	6-12	12-25	25-50
With phage	2[a]	4	3	0	0
Without phage	0	1	3	2	4

[a]Value represents number of plants.

Biology and Management of Flower Thrips and Tomato Spotted Wilt Virus

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The western flower thrips is native to the western United States. Populations have become established throughout much of the world, and western flower thrips feeding and egg-laying result in damage to agronomic, vegetable, fruit, and ornamental crops. Densities are great in the southern United States, and females lay eggs in the small tomato fruit (Salguero Navas et al., 1991b). Eggs are deposited individually, with each site resulting in a small indentation. A light-colored halo sometimes surrounds the indentation. When egg-laying is great on tomato fruit, cullout and downgrading can occur at harvest.

There are at least six species of thrips that transmit tomato spotted wilt virus (German et al., 1992). Most of the vector species are present in Florida, including western flower thrips, tobacco thrips, common blossom thrips, and onion thrips. Melon thrips are native to the Pacific Basin, with populations recently established in South Florida. This species is a vector of watermelon silver mottle virus and peanut bud necrosis virus that are strains of tomato spotted wilt virus not present in Florida.

Tomato spotted wilt virus belongs to the family Bunyaviridae. Particles are spherical with a diameter of 80 - 110 nm (Best, 1968; German et al., 1992). Virus particles consist of a nucleocapsid represented by at least four structural proteins, surrounded by a lipid envelope with distinctive surface projections consisting of two membrane glycoproteins. The genome consists of three linear, single-stranded RNA molecules. Like its thrips vector species, tomato spotted wilt virus has an extensive host range, and is a pest of many agronomic, vegetable, and ornamental crops (Cho et al., 1987). Disease symptoms in tomato are necrosis, chlorosis, ring patterns, mottling, silvering, stunting, and local lesions.

Since becoming established in the mid-1980's, western flower thrips and tomato spotted wilt virus have become important economic problems in tomatoes in Florida. Research has been conducted since that time to understand thrips biology and disease epidemiology and to develop management strategies for tomatoes in Florida.

Thrips Host Range and Population Biology

Flower thrips are opportunists that are polyphagous and especially exploitive of leguminous and composite plant species (Mound and Toulon, 1995). We have found that at least 61 wild plant hosts for western flower thrips inhabit wooded areas, hedgerows, and crop fields in North Florida. The predominant plant host during the winter and throughout the spring is wild radish (Table 2). Other examples of good winter and spring hosts are sand blackberry, common vetch, Japanese honeysuckle, hedgeprivet, and flowering dogwood. Populations of western flower thrips develop through four to five generations during the winter and early spring with abundant hosts and favorable temperatures leading to great population buildup (Toapanta et al., 1996).

Western flower thrips and tobacco thrips are both leaf and flower-feeding species, but western flower thrips typically prefers flowers and tobacco thrips leaves. At least 43 species of wild hosts have been determined to serve as hosts for tobacco thrips in North Florida (Chellemi et al., 1994). Wheat is a good host and four to five generations develop on wheat during the winter and spring in northern and central Florida (Toapanta et al., 1996).

Flowers on wild hosts are short-lived, and adult flower thrips migrate into tomato fields which serve as islands for aggregating populations (Salguero Navas et al., 1991a).

Western flower thrips are very common in tomatoes in North Florida from late April until middle June. Other common species inhabiting tomato flowers in the spring are eastern flower thrips (*F. tritici*) and Florida flower thrips (*F. bispinosa*). The above thrips species are present in tomato flowers during the fall in North Florida, but populations are much less abundant (Salguero Navas et al., 1991a). Adult tobacco thrips may occur in tomato, but tomato is not a suitable host for reproduction (C. P. Tipping and J. E. Funderburk, unpublished). This thrips species however will migrate into tomato fields, especially during periods of hot, dry weather (J. E. Funderburk, personal observation).

The species composition and temporal patterns of abundance of thrips in tomatoes is different in central and southern Florida (S. E. Webb, J. Tsai, and J. E. Funderburk, unpublished). Florida flower thrips is the most abundant species. Western flower thrips are much less abundant, and cosmetic damage is not an economic problem in central and southern Florida tomato production regions. Common blossom thrips is a known vector of tomato spotted wilt virus inhabiting tomatoes in central and southern Florida, but not northern Florida. Tomatoes are not a reproductive host for melon thrips, but small populations of adults may sometimes be present (Tsai et al., 1995).

Tomato Spotted Wilt Virus Host Range and Disease Progress in Fields

Tomato spotted wilt virus epidemics occur in tomato in most production regions of the continental United States. During 1995 and 1996, epidemics were reported in California, Arkansas, North Carolina, Virginia, and Maryland (J. E. Funderburk, personal communications), and in previous years in Texas, Louisiana, Alabama, Georgia, and North Florida. The disease occurs in tomato in central and southern Florida production regions, but has not become a major economic problem.

Because the disease has only recently spread into the southeastern United States, factors contributing to epidemics are only now beginning to be understood. Disease losses occur in spring tomatoes in North Florida, but incidence greater than 10% is atypical in most production fields (Puche et al., 1995). Insecticides sprayed for control of vector populations are effective in preventing polycyclic, but not monocyclic spread of the disease (Chellemi and Funderburk, unpublished).

Large economic losses in ornamental, fruit, agronomic, and vegetable crops in many areas worldwide are due in large part to an extremely wide host range involving more than 500 plant species (German et al., 1992). Weeds have been shown to be a contributing factor in the development of tomato spotted wilt virus epidemics in Hawaii (Cho et al., 1986). Although wild hosts are important sources of thrips entering tomato fields in the spring in North Florida, incidence of tomato spotted wilt virus in susceptible weeds such as Florida beggarweed (*Desmodium tortuosum*), sicklepod (*Senna obtusifolia*), coffee sena (*Cassia occidentalis*), common cocklebur (*Xanthium strumarium*), pitted morningglory (*Ipomoea lacunosa*), and smallflower morningglory (*Jacquemontia tamnifolia*) is very low (Johnson et al., 1996).

Crops however contribute significantly to epidemiology of tomato spotted wilt virus in South Georgia (Johnson et al., 1996). Peanut is an excellent host, and epidemics frequently occur in the fall tomatoes grown near peanut fields in North Florida (J. E. Funderburk, personal observation). The primary vector in these situations is tobacco thrips. This thrips does not develop on tomato, but is able to transmit the virus by probing the leaves (D. O. Chellemi, J. E. Funderburk, and J. W. Scott, unpublished).

Natural Enemies of Thrips

Thrips are attacked by a wide variety of natural enemies. Numerous generalist predators are important, especially bigeyed bugs (*Geocoris* species), minute pirate bugs (*Orius* species), and even thrips themselves (e.g., Gonzalez et al., 1995). Numerous fungal and viral entomopathogens infect thrips, and naturally occurring mycopathogens are biocontrol agents that are produced and used commercially in certain situations (Brownbridge, 1995). Fungi isolated from thrips are *Entomopthora*, *Verticillium*, *Paecilomyces*, *Beauveria*, and *Metarhizium*. Parasites include wasps and an entomophilic nematode, *Thripinema nicklewoodii* (Greene and Parrella, 1995).

Field studies of thrips natural enemies recently were begun in our laboratories. Fungal pathogens have been noted with last year epizootics occurring in August and September (C. Tipping, J. E. Funderburk, and D. G. Boucias, unpublished). The pathogens were isolated and pathogenicity tests are in progress. An entomophilic nematode, *Thripinema* new species, was discovered, and is being described (C. Tipping, J. E. Funderburk, and G. Smart, unpublished). Both western flower thrips and tobacco thrips were parasitized. Parasitization rates greater than 50% occurred on populations of tobacco thrips inhabiting crops with the nematode found in about 80% of crop flowers and terminals where infection of adult and immature thrips occurred.

Current Management and Control Tactics

Economic thresholds are available for managing flower thrips in tomatoes (Salguero Navas et al., 1991b; 1994), and a therapeutic system of management has been successfully implemented in tomato integrated pest management programs (Salguero Navas et al., 1994; Pernezny et al., 1996). The economic threshold for the western flower thrips is one third of the flowers infested (= 0.33 thrips per flower). Flowers are sampled from the upper half of tomato plants and at least 15 flowers are sampled to ensure adequate precision in scouting programs. Populations of thrips may be greater in field margins near wild host sources. Populations of Florida flower thrips greater than five per flower may cause flower abortion and poor fruit set. Western flower thrips and Florida flower thrips appear very similar, and are difficult to separate under field conditions.

Methamidophos is efficacious and the most widely used insecticide for thrips control in North Florida. Pyrethroids and carbamates with efficacy are sometimes applied. Application of these insecticides is inherently destabilizing to target and nontarget pest populations and their frequent use for thrips control is a problem for integrated pest management programs in North Florida and other areas where western flower thrips frequently exceed the economic threshold. A biorational insecticide, Spinosad (DowElanco, Indianapolis, IN 46268), has proved efficacious in preliminary trials, and may soon be labeled for tomatoes and other vegetable crops (J. E. Funderburk and S. M. Olson, unpublished). The product is not detrimental to populations of important natural enemies of thrips and other pests such as minute pirate bugs, and as such compatible for integrated pest management programs of tomato and other vegetable crops.

Insecticides are effective in reducing polyclic spread of tomato spotted wilt virus and control of immature thrips with insecticide is recommended in tomato fields with a high incidence of tomato spotted wilt virus. Insecticides are not effective in preventing monocyclic development of disease and in fact alter vector behavior sometimes increasing disease incidence (D. O. Chellemi and J. E. Funderburk, unpublished). Monocycles of disease are prevented by employing methods that reduce the influx of viruliferous thrips into tomato fields. Producers in North Florida typically avoid planting fall tomatoes near peanut and other crops that are good hosts for tomato spotted wilt virus and that support reproduction of tobacco thrips or western flower thrips. Properly timed insecticide application in a field serving as a source for viruliferous thrips reduces spread of tomato spotted wilt virus into nearby crops.

Resistant Cultivars

Tomato cultivars with resistance to tomato spotted wilt virus are not grown commercially in Florida. A South African tomato cultivar 'Stephens' contains resistance to tomato spotted wilt virus. This cultivar was developed from a cross between *Lycopersicon esculentum* and *L. peruvianum*. The source of resistance is the single dominant 'SW-5' gene. Tomato spotted wilt virus has a history of overcoming resistance developed in tomato cultivars, and stability of resistance will clearly be a problem with tomato spotted wilt virus (e.g., Cho et al., 1990). The extensive host range of the virus and its vectors has contributed to the development of viral isolates which differ in virulence, plant and vector specificity.

In Florida, there are two principle pathosystems in which widespread epidemics occur. In spring tomato production fields, western flower thrips is the principal vector, whereas in peanut production fields tobacco thrips is the primary vector and the primary driving force behind fall epidemics. Using a novel screening technique refective of events which occur during the epidemic process, the SW-5 gene was determined to be a suitable source of resistance to tomato spotted wilt virus isolates in Florida (D. O. Chellemi, J. E. Funderburk, and J. W. Scott, unpublished). Crosses were made of the SW-5 gene with Florida tomato breeding lines, and backcross populations were resistant to Florida isolates of tomato spotted wilt virus in assays using the novel screening technique. Accessions of *L. chilense* with reported resistance to tomato spotted wilt virus are being evaluated for inclusion in the breeding program. Multiple sources of resistance are being sought in attempts to sustain resistance to tomato spotted wilt virus in released tomato cultivars.

Thrips and Tomato Spotted Wilt Virus in Florida

Western flower thrips and tomato spotted wilt virus are serious problems in North Florida. Producers are relying heavily on multiple applications of broad-spectrum synthetic insecticides that prevent cosmetic damage from western flower thrips and polycyclic spread of tomato spotted wilt virus. This is costly and destabilizing to target and nontarget pest populations and does not prevent losses from monocyclic development of tomato spotted wilt virus. Our goal is to develop a more integrated approach for managing thrips that relies on cultural tactics to reduce immigration of thrips onto tomatoes (especially viruliferous thrips) and effective use of natural enemies. Research previously described is in progress to develop biorational pesticides, biological controls, and resistant cultivars. In addition, benefits of silver-reflective mulches and other cultural methods are being evaluated as tactics for use in management programs.

Tomato spotted wilt has not developed into a major economic problem for tomato producers in central and southern Florida production areas. This is surprising considering the virus has been introduced throughout the southern United States, and epidemics have occurred in tomatoes throughout this region. Additional knowledge of vector biology and disease epidemiology in central and southern Florida is needed to better understand the potential for epidemics in tomatoes and to effectively manage the pests if they develop into economic problems.

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Table 1. Confirmed vectors of tomato spotted wilt virus found in Florida.

Common Name	Scientific Name
Tobacco thrips	*Frankliniella fusca* (Hinds)
Western flower thrips	*F. occidentalis* (Pergande)
Common blossom thrips	*F. schultzei* (Trybom)
Onion thrips	*Thrips tabaci* Lindeman
Melon thrips	*T. palmi* Karny

Table 2. The predominant wild plant hosts for flower thrips around tomato fields in North Florida (Chellemi et al., 1994).

Common Name	Scientific Name
Wild radish	*Raphanus raphanistrum* L.
Sand blackberry	*Rubus cuneifolius* Pursh
Common vetch	*Vicia sativa* L.
Japanese honeysuckle	*Lonicera japonica* Thunb.
Hedgeprivet	*Ligustrum sinense* Lour.
Flowering dogwood	*Cornus florida* L.

New Insecticides to Control Tomato Pests in Florida

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The new generation of insecticides presently emerging from the regulatory morass is distinctive from the previous generation in many aspects. *Chemical Composition*: chemistry of the new insecticides is divers and not easily categorized. *Mode of Action*: divers modes of action reflect divers chemistries, but often target physiological mechanisms unique to insects. *Selectivity*: most new compounds are active against one or a few groups of insects in contrast to the broad-spectrum activity of older compounds. *Mammalian Toxicity*: as a consequence of modes of action more or less unique to insects, toxicity to vertebrates is generally low. *Efficacy*: many new products are extremely efficacious at low rates of active ingredient. *Price*: high development and registration costs for products with new modes of action are paralleled by high prices and complex pricing structures tailored to individual markets.

Types of new insecticides. Gone are the days when most insecticides could be classified as one of 4 chemical types (organo-phosphates, carbamates, chlorinated hydrocarbons, and pyrethroids) with basically 2 modes of action affecting nerve function: (inhibition of acetylcholinesterase and disruption of sodium channel activity). As mentioned above, chemical composition and modes of action are divers and defy any simple classification scheme, although the following three general categories are all inclusive.

Biopesticides. This is a relatively broad term as defined by EPA, encompassing pesticidal materials composed of, or derived from living organisms. The registration process for biopesticides is based on a tiered scheme depending on results of early tests, so may be considerably reduced from that required for synthetic insecticides. In particular, biopesticides are generally exempt from establishing residue tolerances. Biopesticides include entomopathogenic microorganisms (fungi, bacteria, viruses), fermentation products, plant extracts (botanicals) and hormones. Development is accelerating in this area, in part due to the facilitated registration process, especially in regard to fermentation products and Bts. Technological advances in genetic engineering are another contributing factor to development in this area, although at the expense of facilitated registration, at least for live organisms. On the other hand, genetically engineered formulations of Bacillus thruingensis (Bt) have shown some improved efficacy, and are already commonplace in the market.

Insect growth regulators (IGRs). Again, this is a broad category of agents active in altering insect growth and development, including insect hormone analogues and agonists, and inhibitors of chitin synthesis. This is another active area of development and a proliferation of IGRs available to the grower within the next few years may be expected.

Everything else. All synthetic insecticides not considered insect growth regulators go into this category. Many are in chemical classes by themselves with names such as pyrrole (Alert®), nitroguanadine (Admire), and trizine (Trigard®)

New insecticide list. The following list is not exhaustive, but includes many of the new insecticides recently registered or scheduled for registration on tomatoes in Florida. Most of the products listed in Table 1 have been field-tested on tomato by us a SWFREC in Immokalee or GCREC in Bradenton. Results obtained from tests conducted during the period 1993 through 1996 are included here. Results of earlier tests can be found in the Proceedings from previous years. Protocols for individual tests may vary, especially in regard to plot size, but in general, Florida cultural practices are followed, and sprays closely simulate commercial applications. No one test is ever definitive, but results reported in the following tables should aid the grower to evaluate efficacy of these products in comparison to more familiar standards.

Table 1. Names, type, activity, registration status and reference to tables giving results of field testing done from 1993 through 1995 for some newly registered or soon (hopefully) to be registered insecticides for Florida tomatoes.

Trade Name	Common Name	Manufact/ Distrib	Class	Function Affected	Tomato Pest Controlled	Registration Label Status	Tables
	Spinosad	Dow Elanco	Fermentation	Nervous	Armyworms Pinworms, Leafminer, Thrips	Mid-late 1997	9,10
Proclaim	Emamectin benzoate	Merck	Fermentation	Nervous	Armyworms Pinworms	EUP by 1998	3,6,7
Alert	Chlor-fenapyr	Cyanamid	Pyrrol	Oxidate Phosphory-lation	Armyworms Pinworms Mites, Thrips	EUP 1996	2,3,4,6,7
Fulfill	Pymetrozine	Ciba	Azmethine	Feeding	Aphids Whiteflies	EUP 1997	11,12
Confirm	Tebufen-ozide	Rohm & Haas	IGR	Molting	Armyworms		2,3
Knack	Pyri-poxyfen	Valent	IGR	Metamor-phosis	Whitefly	1998 (?)	12,13
Trigard	Cyromazine	Ciba	IGR	Molting	Leafminer	Registered	
Applaud	Buprofezin	NorAM	IGR	Molting	Whitefly	EUP 1997(?)	11
Neemix, Align	Azadir-achtin	Grace, biosys	Botanical	Molting, Feeding egg laying	Armyworms Whiteflies	Registered	11,13
Spod-X	Nuclear Polyhed-rosis virus	biosys	Microbial	Cell Rep-lication	Beet Armyworms	Registered	
Various	<u>Bacillus thuringiensis</u>	Various	Microbial	Digestion	Armyworms	Registered	2,3,4,5, 6,7,8

Table 2. Armyworm and pinworm control on fresh market tomatoes in West-Central Florida, fall 1993.

Treatment/ formulation	Rate amt (AI)/acre	Fruit yield/10 plants: Undamaged		Armyworm damaged		Pinworm damaged	
		No.	Wt(lb)	No.	Wt(lb)	No.	Wt(lb)
ABG 6315 AS***	1.0 qt*	324	88.4	2	0.4	1	0.2
ABG 6348 WDG***	1.0 lb*	308	85.3	2	0.5	1	0.2
Alert 2SC	0.20 lb	311	79.1	2	0.8	<1	0.1
Alert 2SC	0.10 lb	292	75.9	1	0.4	<1	0.1
Alert 2SC	0.05 lb	291	75.6	3	0.7	1	0.2
Agri-Mek 0.15EC	0.01 lb	310	80.7	12	2.4	<1	0.1
Karate 1EC	0.03 lb	343	89.4	2	0.5	2	0.4
Kryocide 96%	8.0 lb*	338	88.9	3	0.9	1	0.1
Lannate 2.4L	0.9 lb	282	72.5	5	1.2	1	0.3
Proclaim 0.16EC	0.0075 lb	337	81.6	<1	0.1	<1	0.1
RH-2485 2F	0.06 lb**	261	70.5	<1	0.1	1	0.3
Confrim 2F	0.12 lb**	325	82.1	1	0.2	2	0.6
Xentari WP	1.0 lb*	260	72.3	1	0.1	1	0.3
Check (water)	---	312	74.2	15	3.2	3	0.7
LSD P = 0.05		79	22.1	7	1.5	1	0.4

*Amount of product per acre.
**Latron B-1956 added at 0.06% v/v.
***Experimental Bt from Abbott.

Table 3. Leafminer, armyworm and tomato pinworm control on fresh market tomatoes in West-Central Florida, spring 1992.

Treatment	Rate lb (AI)/acre	No. leafmines/ min. search small	No. leafmines/ min. search large	No. tomato pinworm leafrolls/ 4 min. search	Fruit / 10 plants Undamaged No.	Fruit / 10 plants Undamaged Wt (lb)	Fruit / 10 plants Damaged Armyworm No.	Fruit / 10 plants Damaged Armyworm Wt (lb)
ABG 6314 WP****	1.0*	6.8b-e**	71.0c-e	26.8b-d	339.0b-d	98.8b	7.0e	1.7cd
ABG-6092 WP****	0.68*	7.3b-e	74.8c-e	19.3de	392.3a-d	108.4b	9.5de	1.8cd
Alert 3SC	0.2***	5.5c-e	126.8a	0.0f	442.3a-c	120.2b	1.0e	0.4d
Alert 3SC	0.1***	2.5de	119.3ab	0.0f	341.8b-d	91.8b	0.8e	0.1d
Alert 3SC	0.1	4.3de	126.3a	0.0f	491.3a	124.9ab	0.5e	0.1d
Alert 3SC	0.05***	4.3de	116.3ab	1.0f	408.8a-d	117.1b	1.0e	0.2d
Agree 50WP	1.0*	4.8de	61.0e-g	38.5ab	425.8a-d	116.5b	43.3b	9.8b
CGA-269941 50WP	1.0*	8.5b-d	67.5d-f	25.0cd	421.3a-d	105.0b	33.3b-d	6.5bc
CGA-269941 50WP	0.5*	11.8ab	73.8c-e	33.3bc	356.3b-d	98.8b	40.0bc	9.1b
Javelin WG	1.5*	8.0b-d	81.8cd	16.5ed	379.8a-d	103.3b	16.8c-e	3.9cd
Kryocide 96%	8.0lb*	7.8b-e	82.3cd	26.8b-d	378.8a-d	106.7b	16.3c-e	3.4cd
Lannate 1.8 L	0.45	8.3b-d	106.5b	20.5de	417.0a-d	113.5b	0.8e	0.1d
Proclaim 0.16EC	0.01	16.3a	49.5g	0.8f	415.0a-d	114.9b	0.5e	0.1d
Proclaim 0.16EC	0.0075	15.8a	53.0fg	2.5f	426.3a-d	116.3b	1.0e	0.2d
RH-2485 2F	0.12***	8.5b-d	75.0c-e	12.3ef	311.0c-d	85.7b	0.3e	0.1d
RH-2485 2F	0.06***	7.3b-e	79.5cd	17.8de	349.3b-d	106.3b	0.8e	0.2d
Confirm 2F	0.25***	6.5b-e	72.3c-e	18.5de	445.0ab	174.6a	0.5e	0.1d
Confirm 2F	0.12***	10.8bc	74.5c-e	27.5b-d	429.5a-d	131.5ab	2.5e	0.5d
Confirm 2F	0.06***	8.3b-d	87.0c	17.8de	423.0a-d	127.5ab	8.0e	2.0cd
Check (water)	-	8.3b-d	74.8c-e	45.8a	300.0d	89.5b	69.8a	16.1a

*Amount of product.
**Means within columns followed by the same letter are not significantly different at the P<0.05 level, Duncan's multiple range test.
***Combined with B-1956 at 0.07% v/v.
****Experimental Bt from Abbott.

Table 4. Armyworm and leafminer control on fresh market tomatoes in West-Central Florida, fall 1994.

Treatment/ formulation	Rate amt lb(AI)/acre	Total no. fruit	Fruit yield/10 plants: Undamaged No.	Fruit yield/10 plants: Undamaged Wt (lb)	Fruit yield/10 plants: Armyworm damaged No.	Fruit yield/10 plants: Armyworm damaged %	No. leafmines/ 1 min search	No. armyworm larvae/ 2 min search
ABG 6347 WDG**	1.0*	329	186	55.7	143	44	92	12
ABG 6385A DF**	1.0*	302	165	49.1	137	45	50	6
Alert 2SC	0.20	370	358	109.5	12	3	114	0
Alert 2SC	0.10	355	340	103.1	16	4	86	0
Alert 2SC	0.075	362	346	111.5	19	6	86	0
Alert 2SC	0.05	378	345	98.9	33	9	95	1
Asana XL 0.66EC	0.05	296	259	75.5	38	12	84	0
Asana XL 0.66EC	0.015	327	273	76.6	54	16	64	0
Decis 0.2EC	0.013	335	301	87.4	34	10	77	0
Decis 0.2EC	0.0065	314	267	81.1	47	15	77	0
Dipel 2X WP	1.0*	308	154	54.5	154	50	82	4
Lannate 2.4L	0.9	318	293	87.5	25	8	74	0
Check (water)	---	289	64	20.2	225	79	43	44
LSD _P_ = 0.05		55	58	21.4	54	16	34	12

*Amount of product per acre.
**Experimental Bt from Abbott.

Table 5. Control of southern armyworm with Bt in staked tomato in Southwest Florida, fall 1994.

		Larvae per 12 Plants							Yield (box/ac)
Treatment/ Formulation	Rate/ac	27OCT	03NOV	09NOV	17NOV	22NOV	29NOV	MEAN	
Florbac HPW	1 lb	1.2 a	0.5 a	0.3 a	0.2 a	0.2 a	0.1 a	0.5 a	1526 a
Biobit	1 lb	6.5 b	9.3 b	8.3 b	7.4 b	5.8 b	1.5 a	6.5 b	127 b
XPL-012	2.84 qt	5.6 b	7.1 b	6.7 b	7.6 b	5.7 b	2.2 a	5.8 b	163 b
Untreated		17.3 c	18.4 c	15.4 c	11.9 c	8.8 c	1.6 b	12.6 c	109 b

Table 6. Insect control on fresh market tomatoes in West-Central Florida, spring 1995.

Treatment/ formulation	Rate amt lb(AI)/acre	Total no. fruit	Fruit yield/10 plants: Undamaged No.	Undamaged Wt(lb)	Armyworm Damaged No.	Armyworm Damaged %	Thrips Damaged No.	Thrips Damaged %	No. leafmines/ 1 min search	No. tomato pinworm leafrolls/2 min search May 10	June 19
Alert 2SC	0.15	162	151	42.1	4	2.5	2	1.3	74	3	8
Alert 2SC	0.105	166	154	41.0	4	2.7	5	3.0	68	2	8
Alert 2SC	0.075	154	140	37.6	3	1.8	5	3.4	63	2	10
Alert 2SC	0.045	103	91	35.7	7	8.3	3	3.3	65	3	7
Crymax WDG**	1.0*	131	103	26.5	15	11.1	4	3.1	46	15	26
Crymax WDG**	0.5*	137	108	28.9	15	13.5	7	5.5	51	14	22
Lannate 1.8L	0.45	158	137	37.7	9	5.2	2	1.1	53	4	25
Larvin 80DF	0.4	154	133	36.6	8	4.9	3	1.8	57	9	26
Larvin 80DF	0.25	168	136	34.1	9	5.7	8	4.2	59	8	36
Lorsban 50WP	1.0	174	146	40.0	11	7.8	0	0.0	45	10	34
MK-244 0.16EC + Leaf Act 80A	0.01 8 oz*	148	133	32.7	5	3.2	3	2.2	2	3	7
Sevin XLR Plus	2.0	150	113	29.2	24	15.2	1	0.9	53	13	27
Sevin GEL	2.0	112	88	23.2	19	14.1	<1	0.1	46	9	18
Warrior 1EC	0.025	143	123	33.0	6	4.5	1	0.9	61	4	31
Xentari WDG	1.0	151	109	28.3	17	11.7	19	10.6	51	12	24
Check (water)	---	104	65	17.4	30	29.2	6	5.7	43	21	36
LSD P = 0.05		56	45	14	12	10	10	6	14	7	13

*Amount of product per acre.
**Bt.

Table 7. Insect control on fresh market tomatoes in West-Central Florida, spring 1995.

Treatment/ formulation	Rate lb(AI) acre	Total no. fruit	Fruit yield/10 plants						leafmines/ 1 min search	No. tomato pinworm leafrolls/2 min search	
			Undamaged		Armyworm damaged		Thrips damaged				
			No.	Wt(lb)	No.	%	No.	%		May 10	June 19
Alert 2SC	0.15	433	410	141.7	6	1.3	8	1.8	74	3	8
Alert 2SC	0.105	448	424	144.6	10	2.2	10	2.2	68	2	8
Alert 2SC	0.075	406	377	118.0	9	2.1	10	2.4	63	2	10
Alert 2SC	0.045	288	364	101.8	9	3.5	11	3.4	65	3	7
Crymax WDG**	1.0*	398	349	119.8	20	5.1	10	2.6	46	15	26
Crymax WDG**	0.5*	400	337	112.2	27	7.0	17	4.4	51	14	22
Lannate 1.8L	0.45	426	399	136.1	13	3.0	2	0.6	53	4	25
Larvin 80DF	0.40	434	407	137.2	9	2.1	5	1.1	57	9	26
Larvin 80DF	0.25	389	350	117.6	11	3.0	11	2.9	59	8	36
Lorsban 50WP	1.0	445	408	140.1	18	4.1	1	0.2	45	10	34
Proclaim 0.16EC + Leaf Act 80A	0.01 8 oz*	420	389	136.0	12	2.9	7	1.6	2	3	7
Sevin XLR Plus	2.0	398	318	103.2	61	15.4	6	1.6	53	3	27
Sevin GEL	2.0	345	291	104.0	46	13.3	1	0.1	46	9	18
Warrior 1EC	0.025	413	388	131.0	8	1.9	2	0.5	61	4	31
Xentari WDG	1.0	355	301	98.0	21	5.1	23	5.2	51	12	24
Check (water)	---	342	218	70.6	101	31.3	18	5.2	43	21	36
LSD P = 0.05		79	73	29.3	15	5.6	13	2.9	15	7	14

*Amount of product per acre.
**Bt.

Table 8. Control of southern armyworm in staked tomato in Southwest Florida, fall 1995.

	21NOV95					29NOV95				
	SMALARV	MEDLARV	LARLARV	TOTLARV	DAMRATE	SMALARV	MEDLARV	LARLARV	TOTLARV	DAMRATE
Larvin@.4	0.0 b	0.0 c	0.0 d	0.0 c	2.0 b	0.0 b	0.0 b	0.0 c	0.0 c	1.7 d
Larvin@.25	0.1 b	0.0 c	0.0 d	0.1 c	2.1 ab	2.8 ab	0.1 b	0.0 c	2.8 bc	1.7 d
Baythroid	0.1 b	0.0 c	0.0 d	0.1 c	1.9 b	0.0 b	0.0 b	0.0 c	0.0 c	1.6 d
Lannate	0.0 b	0.0 c	0.0 d	0.0 c	2.1 ab	0.0 b	0.0 b	0.0 c	0.0 c	1.8 d
Lannate+UF	0.1 b	0.0 c	0.0 d	0.1 c	1.8 b	1.4 b	0.0 b	0.0 c	1.4 bc	1.8 d
Mattch	0.1 b	0.0 c	0.1 cd	0.2 c	2.0 b	0.1 b	0.2 b	0.0 c	0.3 c	1.8 d
Dipel	1.2 ab	0.1 c	0.3 bcd	1.6 bc	2.0 b	3.9 ab	0.6 a	0.3 bc	4.7 b	2.0 cd
Dipel+UF	1.2 ab	0.4 bc	0.8 a	2.4 ab	2.4 a	0.2 b	0.6 a	0.9 b	1.7 bc	2.3 bc
Ultra-Fine	1.9 a	0.8 ab	0.5 abc	3.2 ab	2.2 ab	2.1 b	0.5 a	1.9 a	4.6 b	2.7 a
Untreated	2.4 a	0.9 a	0.7 ab	4.0 a	2.2 ab	6.4 a	0.6 a	1.7 a	8.7 a	2.7 d
	06DEC95					13DEC95				
	SMALARV	MEDLARV	LARLARV	TOTLARV	DAMRATE	SMALARV	MEDLARV	LARLARV	TOTLARV	DAMRATE
Larvin@.4	0.0 c	0.0 b	0.0 d	0.0 d	1.8 c	0.0 c	0.0 b	0.0 c	0.0 b	1.7 c
Larvin@.25	0.0 c	0.0 b	0.0 d	0.0 d	1.5 c	0.1 c	0.0 b	0.0 c	0.1 b	1.8 c
Baythroid	0.0 c	0.0 b	0.0 d	0.0 d	1.6 c	0.0 c	0.0 b	0.0 c	0.0 b	1.6 c
Lannate	0.0 c	0.0 b	0.0 d	0.0 d	1.7 c	0.0 c	0.0 b	0.0 c	0.0 b	1.7 c
Lannate+UF	0.1 c	0.0 b	0.0 d	0.1 d	1.8 c	0.0 c	0.0 b	0.0 c	0.0 b	1.7 c
Mattch	0.0 c	0.1 b	0.0 d	0.1 d	1.7 c	0.8 bc	0.0 b	0.0 c	0.9 b	1.9 c
Dipel	4.0 b	0.3 b	0.1 cd	4.4 bc	2.2 b	4.6 a	0.2 b	0.1 c	5.0 a	2.4 b
Dipel+UF	0.1 c	0.3 b	0.4 bc	0.8 cd	2.5 b	0.2 c	0.1 b	0.1 c	0.4 b	2.6 b
Ultra-Fine	5.1 ab	1.0 a	1.0 a	7.1 ab	3.0 a	3.7 ab	0.8 a	0.7 a	5.2 a	3.5 a
Untreated	8.8 a	1.1 a	0.5 b	10.3 a	3.2 a	4.9 a	0.9 a	0.4 b	6.1 a	3.7 a
	20DEC95					MEAN OVER DATES				
	SMALARV	MEDLARV	LARLARV	TOTLAR	DAMRATE	SMALARV	MEDLARV	LARLARV	TOTLARV	DAMRAT
Larvin@.4	0.0 c	0.0 b	0.0 b	0.0 d	1.7 cd	0.0 c	0.0 c	0.0 c	0.0 c	1.8 c
Larvin@.25	0.0 c	0.0 b	0.0 b	0.0 d	1.6 cd	0.6 c	0.0 c	0.0 c	0.6 c	1.7 c
Baythroid	0.0 c	0.0 b	0.0 b	0.0 d	1.7 cd	0.0 c	0.0 c	0.0 c	0.0 c	1.7 c
Lannate	2.8 ab	0.0 b	0.0 b	2.8 abc	1.8 cd	0.6 c	0.0 c	0.0 c	0.6 c	1.8 c
Lannate+UF	0.0 c	0.0 b	0.0 b	0.0 d	1.5 d	0.3 c	0.0 c	0.0 c	0.3 c	1.7 c
Mattch	0.2 c	0.0 b	0.0 b	0.2 d	1,9 c	0.3 c	0.1 c	0.0 c	0.3 c	1.8 c
Dipel	3.5 a	0.2 b	0.1 b	3.8 ab	2.6 b	3.4 ab	0.3 b	0.2 b	3.9 b	2.2 b
Dipel+UF	1.1 abc	0.0 b	0.1 b	1.3 cd	3.0 b	0.5 c	0.3 b	0.5 ab	1.3 c	2.6 b
Ultra-Fine	0.7 bc	0.9 a	0.5 a	2.1 bcd	4.1 a	2.7 b	0.8 a	0.9 a	4.4 b	3.1 a
Untreated	3.2 ab	0.9 a	0.7 a	4.8 a	4.2 a	5.1 a	0.9 a	0.8 a	6.8 a	3.2 a

Table 9. Control of southern armyworm on fresh market tomatoes in West-Central Florida, fall 1995.

Treatment/ formulation	Rate amt lb(AI)/acre	Total no. fruit	Fruit yield/10 plants: Undamaged No.	Wt(lb)	Armyworm damaged No.	%
Baythroid 2EC	0.044	304	296	96.4	2	0.8
Lannate 1.8L	0.9	311	302	97.8	3	1.0
Lorsban 50WP	1.0	244	232	90.2	5	1.6
Spinosad NAF-144	0.089	310	304	98.8	3	1.0
Spinosad NAF-144	0.067	318	313	105.4	2	0.7
Spinosad NAF-127	0.089	231	226	73.1	2	0.6
Spinosad NAF-127	0.067	327	321	106.3	2	0.8
Warrior 1EC	0.031	286	277	90.0	2	0.9
Check (water)	---	285	266	85.4	11	3.8
LSD $\underline{P}$ = 0.05		82	77	34.7	6	1.6

*Amount of product per acre.

Table 10. Control of tomato pinworm with fermentation product insecticides at SWFREC, spring 1995.

Treatment/		Rate/	27 Apr	11 May	Culls	Value
Agri-Mek	0.15 EC	.094	1.75 d	1.00 ed	5.75 cd	5446 bc
SPINOSAD	NAF-127	.022	2.00 cd	13.00 c	15.25 a	8012 abc
SPINOSAD	NAF-127	.044	1.75 d	6.00 d	6.75 cd	9849 a
SPINOSAD	NAF-144	.011	6.00 ab	24.00 b	8.50 bcd	4033 c
SPINOSAD	NAF-144	.022	4.50 bc	16.75 c	9.75 abc	6022 abc
SPINOSAD	NAF-144	.044	1.50 d	6.25 d	5.25 cd	6091 abc
SPINOSAD	NAF-144	.088	1.25 d	2.25 ed	3.25 d	7368 abc
SPINOSAD	NAF-144	.176	0.25 d	0.00 e	4.50 cd	8531 ab
Untreated			8.50 a	37.00 a	13.50 ab	4327 c

Table 11. Control of silverleaf whitefly on fresh market tomatoes in West-Central Florida, spring 1994.

Treatment/ formulation	Rate amt (AI)/acre	No. sweetpotato whitefly immatures/30 leaflets				
		Eggs	Crawlers	Sessile nymphs	Pupae	Pupae exuviae
ABG 6385E***	1.0 lb*	198	215	290	83	55
ABG 6391***	1.0 lb*	157	227	128	67	53
Admire 2EC, then Danitol 2.4 EC + Monitor 4 EC	16 ozs* 0.2 lb 0.75 lb	43	36	33	6	3
Admire 2EC + Neemix 0.25%	16 ozs* 5 gm	70	55	91	13	6
CGA 215944 50WP + Kenetic	81 gm 0.08% v/v*	26	26	22	16	9
Neemix 0.25%	10 gm	553	444	240	73	51
Neemix 0.25%	5 gm	499	903	231	65	56
Neemix 0.25% + Xentari WP	5 gm 0.2 lb*	279	413	213	76	57
PFR* + Cell-U-Wett	1 gm/L* 1 gm/L*	126	181	134	47	23
PFR* + Cell-U-Wett + Neemix 0.25%	1 gm/L* 1 gm/L* 5 gm	444	638	187	79	34
Applaud 3.67 SC + Thiodan 3 EC	0.25 lb 1.0 lb**	65	114	68	26	21
Check (water)	---	386	336	236	80	42
LSD P=0.05		259	599	151	45	40

*Amount of product.
**Applaud applied biweekly and Thiodan applied weekly.
***Experimental Bt from Abbott.

Table 12. Control of silverleaf whitefly on tomato with sucrose esters, insect growth regulators and synthetic pyrethroid/organo-phosphate tank mix at SWFREC, Spring 1995.

Treatment/ Formulation	Rate	Whiteflies Adults (N)	Eggs (N)	Small nymphs (N)	Lg nymphs + pupae (N)	Fruit (N)
BAYTHROID 2 + Monitor 4EC	2.8* fl oz 0.75 lb	37.08 ab**	1.74 ab	2.03 b	1.94 b	104.75 ab
Fulfill 50 WP Fenoxycarb 25 WP	.0924 lb .0616 lb	17.26 cd	0.69 b	0.95 bc	0.52 d	94.75 ab
RH-0345	1.5 lb	27.02 bc	0.82 b	1.49 bc	1.86 b	117.25 a
Knack 0.83 EC	.044 lb	7.82 d	0.60 b	0.23 c	0.66 cd	67.75 bc
Sucrosester 1***	3.0 g/l	13.55 d	0.65 b	1.17 bc	1.79 b	43.75 c
Sucrosester 2***	3.0 g/l	13.21 d	0.54 b	0.98 bc	1.64 cb	70.25 bc
Sucrosester 3***	3.0 g/l	15.95 d	0.51 b	1.51 bc	1.93 b	66.50 bc
Sucrosester 4***	3.0 g/l	14.52 d	0.48 b	1.07 bc	1.50 bcd	63.50 bc
Sucrosester 5***	3.0 g/l	15.65 d	0.60 b	1.17 bc	1.24 bcd	76.00 abc
Untreated		45.36 a	2.93 a	4.28 a	4.29 a	75.25 bc

* Rate was changed to 1.9 fl oz of BAYTHROID on 12 April 95 by the cooperator.
** Means in columns followed by the same letter are not significantly different (LSD, $P < 0.05$).
***Natural extract from Nicotiania spp. containing sucrose esters or synthetic esters.

Table 13. Insecticidal control of silferleaf whitefly in West-Central Florida, spring 1995.

Treatment/ formulation	Rate (AI)/acre	No. silverleaf whitefly immatures/30 leaflets				
		Eggs	Crawlers	Sessile nymphs	Pupae	Total nymphps
Admire 2EC, then Danitol 2.4 EC + Monitor 4 EC	0.25 lb 0.2 lb 0.75 lb	36	10	7	4	20
Baythroid 2 EC + Monitor 4 EC	0.034 lb 0.75 lb	102	41	34	38	112
Neemix 4.5%	5 gm	125	40	38	32	110
Neemix 4.5% + HM 8802-A	5 gm 0.5 gal	104	37	38	19	94
Neemix 0.25% + HM 8802-A	5 gm 0.5 gal	95	35	45	52	132
Silwet	12.8 oz*	61	30	17	10	56
Knack 0.83 EC	20 gm	118	10	7	3	19
Knack 0.83 EC & Danitol 2.4 EC + Monitor 4 EC**	20 gm 0.2 lb 0.75 lb	104	5	4	1	10
Warrior 1 CSO	0.03 lb	76	16	21	15	52
Warrior 1 CSO + Monitor 4 EC	0.03 lb 0.75 lb	69	27	15	19	61
Warrior 1 EC + Monitor 4 EC	0.03 lb 0.75 lb	48	24	12	12	47
Check (water)	---	251	108	84	80	272
LSD P=0.05		135	56	51	56	157

*Amount of product.
**Knack applied every two weeks and Danitol + Monitor alternated every other week.

New Whitefly-Vectored Closterovirus of Tomato in Florida

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INTRODUCTION

A new viral-caused disease of tomato was identified in January 1996 from the greenhouse-grown tomato industry in north central Florida. This virus represents a previously undescribed member of the Closterovirus genus of viruses and has been designated Tomato Chlorosis Virus (ToCV) (10). This diagnosis has finally provided an answer for the long-standing tomato malady known as 'yellow leaf disorder' that has existed in greenhouse-tomato production sites within Florida since as early as 1989 (unpublished data, G.W. Simone).

The greenhouse vegetable industry comprised some 66 acres of production in 1991, 32% of which was tomato production (7). These sites are scattered throughout Florida from Escambia county in the northwest to Dade county in the southeast. The appearance of 'yellow leaf disorder' between 1989-1995 was generally correlated to use of a contaminated fungicide (or its residual action) by most growers. Observation of 'yellow leaf disorder', however, in field tomato production in north Florida and in new greenhouse production sites without a history of the suspect fungicide seemed to negate the toxic fungicide explanation for this malady. No examination of nutrient levels by direct analysis or through plant tissue analysis revealed any significant macro- or minor element imbalances. The potential occurrence of autogenous necrosis in particular tomato cultivars (8) was pursued and discounted. Examination of plant samples for plant pathogens was also repeatedly negative. Such techniques as plant virus inclusion examination by light microscopy, electron microscopy, serology and mechanical transmission to bioassay host plants yielded no evidence of plant viruses.

The active research by USDA-ARS scientists at Salinas CA on a new closterovirus of tomato (Tomato Infectious Chlorosis Virus - TICV) prompted submission of symptomatic plant samples from Florida to the USDA-ARS staff in January 1996. Utilizing the greenhouse whitefly, *Trialeurodes vaporariorum* (Westwood), successful transmission of the unknown agent into *Physalis wrightii* and *Nicotiania clevelandii* spp. was obtained(10). These species proved to be superior hosts for the virus, allowing detection of long flexous rods conforming to the size range of a Closterovirus.

SYMPTOMATOLOGY

Onset of widespread ToCV symptoms in greenhouse grown tomatoes seems linked to late winter and early spring (Feb. - Apr.). Affected plants develop a progressive interveinal chlorosis. First symptoms in Florida greenhouse tomatoes often appear on leaves in the mid-section of the plant. The oldest leaves are pruned off of the plant, giving the appearance the symptoms initially started on the oldest leaves. The interveinal chlorosis is not uniform on either side of the leaflet midrib nor consistent among leaflets on a leaf. Symptom expression develops over a period of months, yet continues to lag 1-2 leaves behind the meristem. Chlorotic zones may develop maroon-to-brown necrotic flecks. Virus impact on greenhouse tomato cultivars is most serious in loss of photosynthetic area due to the pronounced foliar yellowing. Plants enter a long period of general decline. Observations indicate neither flower abortion, fruit abnormalities nor irregular ripening occur with greenhouse tomato cultivars. Fruit size is reduced as symptom expression becomes severe at the end of the season. Although development of viral symptoms in greenhouse tomato is slow, virus spread within the greenhouse proceeds effectively in the presence of the whitefly vector. Infection of all plants in a greenhouse is not uncommon.

TOMATO CHLOROSIS CLOSTEROVIRUS

The Closterovirus and Luteovirus genera are the two genera responsible for causing "yellow-type" diseases across many crops. Florida tomato producers have encountered one such virus with the 1977-79 outbreak of Tomato Yellow Top Luteovirus (11)(Luteovirus). A closterovirus from tomato has been reported by McGovern et al (9) but the symptoms appear distinct from ToCV.

Closteroviruses are long, flexous rods with a range in size from 700-2,000 nm in length. Definitive members of the closterovirus group possess a single stranded RNA and represent viruses with poor or no mechanical transmissibility. Vector insect species that transmit Closteroviruses include aphids, pseudococcid mealy bugs, and whiteflies in a semi-persistent manner. Closteroviruses known to occur in Florida(1) include citrus tristeza virus (aphid vectored), alligator weed stunting virus, carnation necrotic fleck virus, Dendrobium necrotic vein virus, and Nandina stem pitting virus.

The ToCV addition to the Closterovirus genus is unique. This virus is bipartite, with an 850 nm particle length, and single-stranded RNA. This virus does not appear related to other Florida closteroviruses based upon the vector and particle morphology. ToCV seems most closely related to tomato infectious chlorosis virus (3,4) and lettuce infectious yellows virus (2) from California based on the bicomponent genome.

TRANSMISSION

As with the majority of the members of the virus genus *Closterovirus,* ToCV has not proven to be mechanically transmissible to an indicator host plant. Transmission of ToCV in the field and greenhouse is reliant upon the whitefly vector. Initial studies(10) indicated the greenhouse whitefly (*Trialeurodes vaporariorum* (Westwood) was the vector for ToCV. Since this initial research, this new virus has proven quite unique among Closteroviruses by being effectively vectored by four species of whitefly(10): the greenhouse whitefly, the sweet potato whitefly (*Bemisia tabaci* (Gennadius)), the silverleaf whitefly (*B. argentifolii,* Bellows and Perring) and the banded-wing whitefly (*Trialeurodes abutilonea* (Halderman)). These vectors transmit ToCV in a semi-persistent manner retaining the virus for 1-2 days. Vector acquisition, transmission, efficiency and transmission threshold studies are in process. All four vector species of whitefly occur in either field or greenhouse sites in Florida.

DISTRIBUTION AND HOST RANGE

Distribution of ToCV in Florida is largely based upon conjecture. Prior to February 1996, reports of this problem were confirmed by negative diagnostic assay data and obvious symptoms known widely as 'Yellow Leaf Disorder'. Plant disease clinic reports indicate the earliest likely ToCV reports from Columbia and Suwannee counties in 1989. Frequency and incidence of these suspected ToCV infected samples are summarized in Table 2. The high incidence of ToCV samples in 1991-1993 reflect the intensive search for the cause of the symptoms. Low numbers in 1994 and 1995 reflect the unsuccessful history of detecting the cause through traditional pathological techniques.

Host range investigation of ToCV has only just begun. Studies with one or more of the known whitefly vectors has produced an initial host range listed in Table 2(10). Known hosts include representatives of the *Amarantaceae, Chenopodiaceae and Solanaceae* families. Representatives of the *Asteraceae (Compositae), Cucurbitaceae* and *Malvaceae* were negative thus far. The two hosts of importance are tomato and tobacco. Based upon symptomatology, the cultivars Apollo, Belmondo, Bounty, Caruso, Cobra, Correct, Floramerica, Jumbo, LM-300, Laura, Match, Medallion, Panther, Trend, Tropic, Trust and Walter used in greenhouse tomato production between 1989-1996 are susceptible. The impact of ToCV on field tomato cultivars like Sunny (~16% of Florida's 1994-1995 acreage (6) is yet to be determined. To date, no symptoms have been observed on cucumber and bell pepper grown as companion crops with greenhouse tomatoes exhibiting severe ToCV symptoms.

Table 1. Distribution and incidence of Tomato Chlorosis Virus (ToCV) in Florida based upon symptomatic samples received at the Florida Extension Plant Disease Clinic between 1989-1996.

	Year of Occurrence							
County	1989	1990	1991	1992	1993	1994	1995	1996[1]
Alachua	--	1	--	8	--	--	--	--
Baker	--	1	1	2	1	1	--	--
Columbia	2	--	15	--	--	1	--	--
Marion	--	--	--	--	--	--	--	3
Suwannee	3	1	1	8	9	--	--	7
TOTAL	5	3	17	18	10	2	0	10
8 year total =65 samples								

[1]1996 samples were vectored with ToCV by whitefly transmission to bioassay host plants.

Table 2. Present Known Host Range for Tomato Chlorosis Virus (ToCV).

Hosts	Host Reaction
Capsicum annuum 'Jalapeno'	-
Chenopodium capitatum	+
Cucumis melo 'Top Mark'	-
Cucumis sativus	-
Cucurbita pepo	-
Datura stramonium	-
Gomphrena globosa	+
Lactuca sativa	-
Lycopersicon esculentum (Celebrity, Cherry, Jackpot, Moneymaker, Peto-19, Sunny, Trust, Valerie)	+
Malva sp.	-
Nicotiana benthamiana	+
N. clevelandii	+
N. glutinosa	+
N. megalasiphon	+
N. tobacum (Burley 21)	+
Physalis wrightii	+

[1]Host reaction: (+) = susceptible, (-) = immune

ToCV IMPACT IN FLORIDA

To date, the economic impact of ToCV has been limited to the greenhouse tomato industry. Distribution seems limited to the north central Florida area but this is probably due to the present lack of diagnostic technology to identify this virus (when present) in plant tissue. The potential of ToCV is considerable. This closterovirus is quite unique in possessing tremendous vector flexibility, utilizing the sweet potato, silver leaf, banded-wing and greenhouse whiteflies for dissemination. The limited host range information to date suggests a small host range (Solanaceae, Chenopodiaceae, and Amaranthaceae) but this may change rapidly with future collaborative research between Florida and California.

The existing occurrence of ToCV resides in the midst of the 7,200+ A of tobacco(5) and contiguous to the 3,650A of field tomatoes in the west, north and north central Florida production zone (1994-1995)(6). The greenhouse tomato crop is initiated 4-6 weeks after tobacco harvest is complete in this area and simultaneous to the fall tomato crop acreage in north Florida. Although tobacco harvest is complete by mid summer, stripped stalks may persist in fields through August or even September. The persistence of both virus and its vectors seems assured (even without weed hosts) in the north central area through the overlap of the greenhouse tomato crop with both the spring and fall field tomato crops as well as the overlap of tobacco (crop or stubble) between greenhouse production cycles. In addition, this geographical zone(5) is host to an increase in cotton acreage (~ 109,000 A, 1995) which may alter the incidence of the banded-wing whitefly in the presence of a preferred host - cotton.

Present efforts are directed to define weed hosts of importance in north central Florida, further define the economically important host range, evaluate tomato cultivar reaction to this virus, and develop a diagnostic method to quickly and accurately define the incidence of ToCV.

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A Brief Treatise on Spray Tank Mixing For Fungicides Used on Row Crops

Tom Kucharek
June, 1996

Tank mixing of sprayable materials is the placement of chemicals into a spray tank for later discharge onto the crop (or some other target). Tank mixing allows the grower to reduce the number of times spray machinery is used. The benefits are obvious. Fewer trips reduces cost, soil compaction, damage to the crop, and probability that spread of disease or other pests will occur by the machinery itself. Also, same tank mixes are essential to achieve pest control. For example, tank-mixing maneb or mancozeb with a copper-containing fungicide is essential to achieving control of bacterial spot of peppers or tomatoes. However, adding additional ingredients into the tank mix could offset the benefits of adding maneb or mancozeb to the copper-containing fungicide. Addition of epsom salts or some other source of magnesium for the purpose of greening pepper fruit provides a beneficial growth factor for the bacterium that causes bacterial spot. Also, addition of some adjuvants to the spray mix can increase infection by the bacteria. Some grass-killing herbicides like Poast and Fusilade are much more effective if tank mixed with certain oil type adjuvants. TANK MIXING IS A COMPLEX ISSUE. SOME TANK MIXES ARE BENEFICIAL AND OTHERS MAY BE DELETERIOUS.

The types of chemicals that are used in a sprayer include water, pesticides, adjuvants, and fertilizers. Water is the conduit by which the other chemicals are delivered. As the number of ingredients increase in a tank mix, chances for incompatiblity increase, particularly at lower spray volumes. Higher spray volumes are often used so that complex tank mixes do not plug up pumps and nozzles. Rates of water per acre for agronomic and vegetable crops vary in Florida from three-five to over 100 gallons per acre. With certain types of overhead chemigation, thousands of gallons of water per acre may be used but this is not a common way, or a desirable way, to deliver fungicides in Florida.

THE SOURCE OF WATER for sprayers is important. Well water is best because it is cleaner than other sources. Other sources that have been used are ditch and pond water. These latter sources harbour particulate matter that can plug up screens, pumps, and nozzles. Also, pond or ditch water can be sources of inoculum for plant diseases.

WELL WATER TENDS TO BE ALKALINE. It is often thought that as the pH of the final spray mix increases, the effectiveness of chemicals against the target pests is reduced. The idea is that higher pH,s cause "alkaline hydrolosis" of the chemicals which alters effectiveness of the chemicals against the target pests.

This may or may not be factual in actual field useage because most statements made about this phenomenon are based on tests that measure the half-life of the chemical in the laboratory.

One can not assume that a longer half life, based upon laboratory tests, relates to actual efficacy in the field. Numerous other variables in the field can override this assumption. For example, if the pest population is low, because of proper timing of a spray, either a spray mix with a normal or a shorter half-life may be adequate for control. Also, sensitivity of the pest to the pesticide needs to be considered. The number of variables that influence a successful spray program and that may override pH of the spray mix are numerous.

While spray pH is a great topic for discussion, it is rarely based on fact because few facts on this topic exist. Most facts that exist are likely to be available from the manufactures of the chemicals. I would think that if spray pH was a critical variable, the labels would provide us information on this subject. Chemical users often report to company representatives or Extension personnel about substandard pest control, but usually variables other than spray pH are the culprits.

While numerous insecticides are deemed ineffective when used at higher pH because of half-life measurements in the laboratory, this may not be the case with fungicides. Information on pH is scant for fungicides but the information in Table 1 provides some cursory information on this topic.

Table 1
Comments about pH of spray mix
for select disease control chemicals for row crops*

Chemical	Comments
Aliette	Makes acid spray (do not mix with copper)
Bayleton	Stable from 3.5-9.5
Benlate	Opinions vary, but higher pH's may reduce effectiveness
Bleach	pH 7.0-7.5 optimum for dump tank sanitation
Chlorothalonil	Stable across wide pH range
Copper	Avoid acid spray mixes
Curzate M-8	pH from 5.5-6.5 is best according to manufacturer
Dyrene	Stable below pH of 9.5
EBDC's	Apparently stable based upon wide useage
Rovral	Stable across wide pH range.
Others	Information on pH not available

*Most information within this table is based upon generalized literature.

LOADING THE SPRAY MATERIALS INTO THE SPRAY TANK should be done when with the tank at least half filled with water and the agitation system should be operating to attain thorough mixing. This minimizes the risk for physical and chemical incompatiblities because of the dilution effect of water. Loading should be away from surface water and should be done in such a manner that the well is not contaminated. The handlers should wear the required protection as indicated on the label. Dry formulations should be added to the tank first followed by the liquid formulations. A general guide for chemical loading order is in Table 2. While tank mixing is often essential, the grower should tank mix only what is necessary. The more chemicals that are used in the same mix, the more likely that an adverse effect on the crop will occur and the less likely that an honest person can determine what caused a problem related to the tank mix.

Table 2
Loading order for spray tanks

First	Wettable powders
	Prills (DF's, DG's, & WDG's)
	Soluble powders
	Flowables
	Aduvants
	Emulsifiable concentrates (EC's)
Last	Oils

THE USE OF ADJUVANTS, like spray tank pH, is a controversial topic. However, considerably more information about the use of adjuvants is available than that for adjusting spray tank pH. Adjuvants are chemicals, generally classed as non-pesticidal, that when added to a spray mix are supposed to impart some sort of enhancement of the chemical effects or spray delivery. Spreaders, stickers, buffers, drift retardants, penetrants, and foam busters are but a few of the types of adjuvants. The key to success with adjuvants is to use them as little as possible because adjuvants can also cause damage to plants. Some adjuvants reduce the waxy-like coatings on the exterior of the plant. When these coatings are reduced, plants are more susceptible to chemical damage and are more likely to transpire water resulting in increased sensitivity to dry weather.

Indeed, adjuvants are needed for select situations, but the uninformed use of adjuvants has often caused severe burns on plants. Numerous herbicides and insecticides have enhanced activites against their target pests if used in conjunction with select adjuvants. Let the label be your guide when using adjuvants for fungicides, herbicides and insecticides.

Adjuvants can enhance the performance of fungicides, but they can also reduce the effectiveness of fungicides. Adjuvants have been most useful for the dry fungicides, particularly the wettable powders. For example, control of purple blotch and blast of onions in Florida with mancozeb was improved by more than 60% when the spreader-sticker Triton CS-7 (now sold as Latron CS-7) was added. Onions have slick, vertical leaves which are conducive to spray wash off with rain. The tenacity of mancozeb was enhanced by the use of an adjuvant with sticking properties. Also, because of the slickness of onion leaves, the spreader portion of the adjuvant was important to attain better initial coverage with the spray.

The use of spreader-sticker adjuvants with chlorothalonil-containing fungicides is not recommended. Formulations of chlorothalonil contain the internal adjuvants that the manufactures want used with that product. Adjuvant usage with chlorothalonil (e.g. Bravo) has resulted in more spray washoff with rains, phytotoxicity, and reduced yields in some situations.

The adjuvants most likely to cause deleteious effects to the plants when used with fungicides are crop oils, petroleum-based oils, and those with alcohols. Besides these adjuvants possessing phytotoxicological properties in themeselves, the tank mixing of them with some chemicals increases the probability for additional phytotoxicity. Another group of adjuvants that are of concern are silicon-based adjuvants (e.g. Silwet). While this type of adjuvant is likely to be very beneficial in attaining entrance of herbicides into weeds and insecticides into insects, it does increase movement of bacteria into plants. For example, in test and commercial situations, bacterial spot has been enhanced with the use of silicon-based adjuvants.

Spray adjuvants have been associated with increased disease in harvested tomatoes. Soft rot bacteria must enter the fruit to cause damage. Spray adjuvants used in the field are carried into the dump tank water where they provide an enhancement for ingress of bacteria causing soft rot.

JMS Stylet Oil is a beneficial spray oil for reducing aphid-transmitted viruses, some insects, and some fungal diseases like powdery mildew. However, because it is an oil, a natural incompatibility occurs if certain chemicals are used in the same spray tank or even within two to three weeks after the application of this oil. For example, phytotoxicity might occur if this oil is used within two or three weeks of an application of sulfur, before or after spraying the oil, respectively. The label of JMS Stylet Oil is unusual in that it provides considerable information about spray incompatibility for its usage.

Over the years, I have noted certain chemicals that are more likely to be associated with phytotoxicity in plants or more disease. Table 3 provides a list of those compounds that seem to be associated with phytotoxicity to plants or more disease.

Table 3
Some possible tank mix hazards with fungicides

Crop oils
Petroleum oils
Fertilizer salts
Phosphatic insecticides
Copper fungicides (sometimes)
Tin fungicides (sometimes)
Sulfur
Alcohol-based adjuvants
"mild adjuvants" (sometimes)
Silicon-based adjuvants (more bacterial disease)
Snake oils (sold by fast departing sales persons)

Tank mixing is a necessity. However, success with tank mixing is based upon slowly acquired experience. It is not possible to test the millions of combinations that exist with tank mixing. If your cocktail works don't change it until you have tested the new idea on a small scale or have asked informed sources for their opinions. Remember with tank mixing, opinions can outnumber facts.

How to Promote Agriculture: Examples from Palm Beach County

TOM GREGORY
Courtesy Extension Agent
Agricultural Economic Development Program Coordinator
Palm Beach County, FL

INTRODUCTION

Agriculture in Palm Beach County is under pressure like never before. The entire industry is under siege from competitive issues favoring NAFTA, GATT, *and* legislative reforms within the Farm Bill, Sugar Programs, *and* excessive business regulation with extreme environmental demands.

All of this pressure is forcing profound changes in how food is grown, processed, distributed, and marketed within Palm Beach County ... and across the nation! The pressure is forcing a revolution. Growers are making dramatic strategic changes to be successful in the rapidly evolving agricultural industry.

The Agricultural Economic Development Program (AEDP) in Palm Beach County is assisting producers in adapting to the pressures from change and preparing to meet the challenges of new competition and new opportunities.

The Agricultural Economic Development Program was approved and funded in December, 1994 with 500 thousand dollars by the Board of County Commissioners. The Program is governed by the Agricultural Enhancement Council which represents leadership from nine industry segments.

MISSION

The purpose of the initiative is to increase the economic viability of Palm Beach County's agricultural and equine industries. AEDP's responsibility is to promote job creation and growth through many activities, including:

* increase the agricultural uses of land and other resources;
* develop and maintain producer directories;
* identify and develop new markets and products;
* develop identification and marketing programs for

Palm Beach County products; and
* promote research on agricultural products.

These mandates are leading to the AEDP's activity and leadership in developing local, state, national, and international markets for Palm Beach County agricultural products.

For Palm Beach County's agricultural and equine industries to remain viable and sustainable, it must remain profitable. The primary goal of the AEDP is to encourage the profitability of Palm Beach County agriculture through the enhancement and continued development of an effective business infrastructure. This goal is being pursued respecting the interrelationships of agriculture with tourism, the environment, and other non-agricultural aspects of Palm Beach Counties diverse economy.

OVERVIEW

Economic Impact of Agriculture

Numerous reports cite agriculture's economic contribution to Palm Beach County: 24,300 full time jobs and $2 billion each year in direct value to our local economy. Agriculture and equestrian activities are also recognized as a direct link with the viability of the Counties' equally important tourism industry.

Industry Considerations

Palm Beach County Agriculture, substantially more than other industries, relies on conditions largely outside of the producer's control:

* lead times for increasing production are frequently long;
* production is largely influenced by the forces of nature;
* products tend to be highly regulated;
* production has seasonal skews;
* markets for products are highly competitive;
* agricultural products tend to be perishable; and,
* capital investments are relatively high.

The Agricultural Economic Development Program is addressing handicaps of geographic location, lack of certain production economies of scale, and the limited County budget. This is being accomplished through a favorable and innovative marketing position, closely related to quality products, climate, and weather. Recognizing the programs limited resources, activities are allocated on those areas holding the greatest economic and job creation impact.

The Program's responsibilities are diverse, involving coordination with numerous different commodity and producer organizations who have marketing responsibilities ranging from roadside stands to international exports; and clients including producers, educators, distributors, brokers and buyers from retailers, restaurants and institutions.

MARKETS

Markets for Palm Beach County agricultural products are as great as the variety of products themselves. The urban corridor in the Northeastern U.S. is a substantial consumer base for many products. Industrial and commercial customers are located across the nation. Both value-added and commodity items are being exported to countries in the Caribbean, South America, Europe and the Pacific Rim.

Local sales are not overlooked. The AEDP has developed the countywide GreenMarket Association to support new retail, community based farmers markets. This recognizes resident Palm Beachers as important consumers of many locally produced agricultural products. Also of significance to the sale of Palm Beach County products are the 3.8 million tourists that visit our communities each season. Tourists patronize hotels, restaurants and retail establishments. Many of those visitors can remain important consumers when they return home - as mail order customers, as users of Palm Beach County products purchased from their local retail and specialty stores, and as goodwill ambassadors for Palm Beach County and its products.

STRATEGIES

General

The AEDP is assisting producers in identifying, reaching, and developing the best markets for their products, leading to local, state, regional, national, and international sales. Crucial to these efforts is the development of an infrastructure encouraging value-added enterprises. Program projects include:

* strategic business planning;
* supply / production development;
* processing;
* packaging;
* distribution / transportation;
* marketing;
* merchandising / promotion / public relations.

Staff is ready to assist producers in determining which markets are most appropriate for their products, given their production capacity, the product's price sensitivity, tariffs/duties, technical restrictions of certain markets, and other practical industry considerations.

Costs of reaching out-of-state consumers are generally greater than for local markets. However, since sales opportunities within Palm Beach County are limited by our population base, it is critical to look beyond the County to other markets. Marketing efforts are largely directed at the wholesale trade rather than directly at retail consumers. The staff assists producers in gaining access to these various markets through its services.

Market Development

The AEDP is instrumental in forming public and private partnerships to create jobs and new markets for Palm Beach County products. Ongoing efforts to identify advantages focus towards the establishment of value-added enterprises. Staff monitors the marketplace and assist clients in adding products in support of local market growth. If obstacles are encountered, solutions to overcome them through changes, improvements, or culture are recommended.

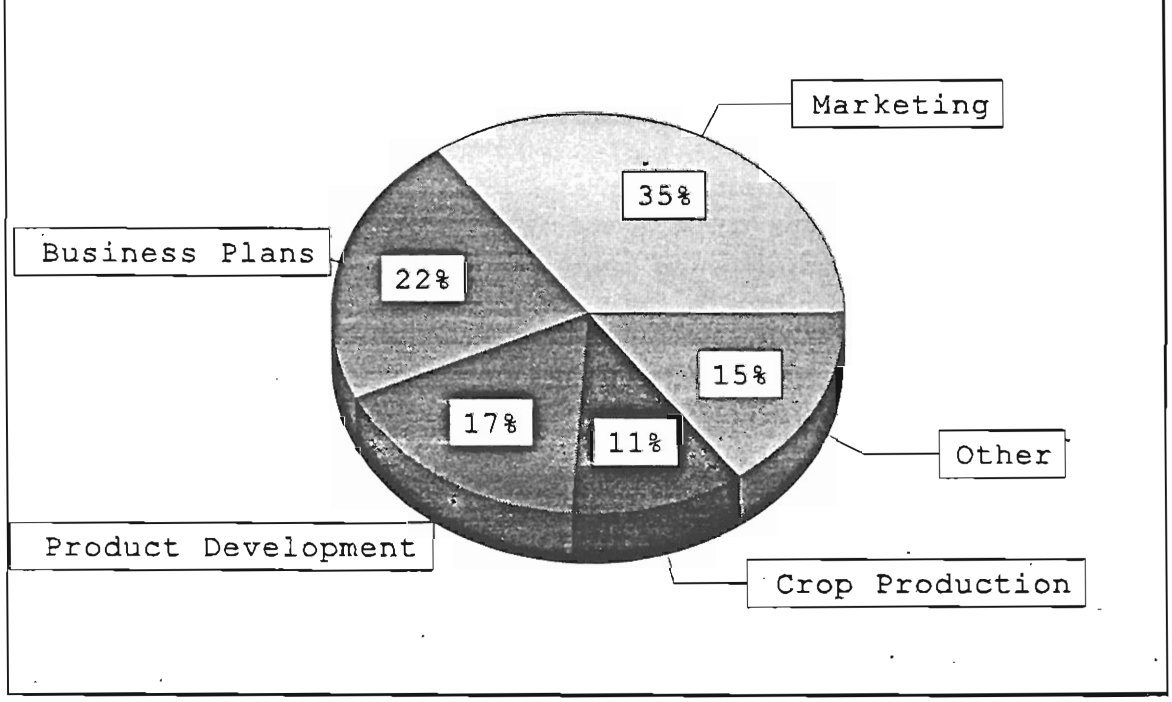
Technical Assistance

Providing technical assistance to producers is a complex and comprehensive service provided by the Program.

AEDP Staff advises clients on strategic business planning, production, processing, labeling, packaging, sourcing, distribution and other aspects of infrastructure development.

This assistance is provided to start-up businesses, as well as to established firms interested in increasing their presence in current markets or looking at geographic

Survey of "Assistance Needed", 7/95



expansion. Staff expertise is offered in individual consultations, and through seminars to large groups.

<u>Communications</u>

Good and effective communications with producers is essential to their participation in various activities sponsored or coordinated by the Program staff, including trade-shows and conferences.

Promotion boards, commodity organizations and field visits are other important avenues of regular communications. Phone, fax, and direct mail are regular aspects of day-to-day communications with clients.

Trade Shows

By participating in selected industry trade shows, producers effectively and efficiently meet large numbers of prospective buyers. AEDP staff coordinates regional, national, and international trade show participation with producers, selecting only those shows determined to be most effective. Shows recently participated in include:

* EQUITANA
* National Fancy Food & Confectionery Show
* Produce Marketing Association

Product Logo Identification

A Palm Beach County Agricultural logo is being created to assist producers in the marketing of their products. This will be available to feature products substantially comprised of Palm Beach County grown ingredients that meet or exceed quality standards. AEDP staff cooperates in inter-agency marketing opportunities to recognize products from Palm Beach County.

Media

Program staff is committed to maximize endeavors reflecting the positive aspects of Palm Beach County agriculture through use of various media. Regular news releases, generally focused on job growth and economic issues relating to Palm Beach County agriculture are prepared for local, state, regional, and national news organizations. Releases are tailored to the specific format, whether a farm publication or upscale consumer magazine.

Weekly, Palm Beach County Cooperative Extension Service staff prepares the television show *Growing Together*, for broadcast over County TV channel 20. Paid advertising is limited by budgets. Various funding sources are combined to provide greater effectiveness of the ads.

Publications

In an effort to effectively match buyers and sellers, the AEDP is evaluating development of several publications.

These documents will be directed at the trade for wholesale business, and towards consumers promoting retail sales. Directories may include: Palm Beach County Wholesale Producers, Palm Beach County Specialty Foods, Palm Beach County Agricultural Exports.

Depending on available budgets, special brochures can be prepared and distributed as inserts in newspapers throughout Palm Beach County. Specific focus on vegetables, seasonal plants, special activities, recipes, holidays, gifts, and entertaining can provide an effective and helpful consumer sales theme. The brochures can also be distributed at Chamber of Commerce welcome centers, special community events, and fairs.

Special Events

When cost effective, AEDP staff participates in consumer focused promotional activities involving particular commodities, general agriculture, or in association with other organizations. Trade focused special events can also include participation in promotions with retailers, restaurants, wholesale buyers, and media.

Opportunities to capitalize on agricultural tourism are also be explored. Currently the Program is testing the *Palm Beach County Growing Tours*℠ concept as an on-farm educational vehicle to positively position the benefits of agriculture with the general public. Survey results confirm (AEDP January 1996 Growers Survey) grower interest in the development of ag-tourism by ranking it first of fifteen AEDP measures, with 73.4% of responses at "very helpful".

Other Special Event promotions reflect the grave concern for the continued viability of the local industry. The project to fight imports include the "Ask Where It's Grown" campaign. Materials were developed and distributed through paid media, public service announcements, and inserts in utility bills. The message is to inform consumers about the choices they have when purchasing produce, and that there is a real difference in Palm Beach County farm products.

Resource Coordination

Recognizing the limits of the AEDP's resources, staff activity coordinates with many privately and publicly funded organizations. Among them:

* Palm Beach Ag Awareness Council
* Palm Beach Horse Industry Council
* Congressional Staffs
* Palm Beach County
    - Board of County Commissioners
    - Business Development Council
    - Public Affairs Department
    - Tourist Development Council
    - Economic Development Office
* State of Florida
    - Department of Agriculture & Consumer Services
    - South Florida Water Management District
* University of Florida
    - Institute of Food and Agricultural Sciences
* United States Department of Agriculture
    - Agriculture Marketing Service
    - Foreign Agricultural Service

A key Program focus is regulatory reform. The AEDP is taking the local lead in efforts to find solutions to the current regulatory approach in addressing environmental issues. Staff is defining a team approach on multi-agency problems to improve coordination by changing emphasis from enforcement to compliance monitoring.

Associations

The AEDP coordinates its activities with different promotion boards and commodity associations, ensuring that the Program remains responsible to producers needs.

EXECUTION

The complexity of Palm Beach County's agricultural base has compelled the AEDP to engage in a large number of activities at any given time. Some of these activities are highly visible; many others involve quiet, behind-the-scenes research, planning and negotiations. In order to continue making reasonable advances, the Program maintains a focus on the business of agriculture, with emphasis on the ability to attract and encourage the establishment of value-added enterprises.

Several issues are continuously being evaluated:

* the development of databases to provide growth measurement of Palm Beach County agriculture;
* establish the capabilities to research and identify the best market opportunities;
* review the commodities and products positioned for success;
* capitalize on Palm Beach County's favorable image to enhance sales of agricultural products; and,
* unification of agricultural agendas by finding common ground among various groups.

To effectively fulfill its responsibilities, the AEDP must always focus its resources on activities positioned for success. Concurrently, it must develop greater support from the extended agricultural community, including producers, lawmakers, administrators, as well as representatives from key Palm Beach County industries and organizations.

Contact

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Crisis Management and the News Media: Lessons Learned From The Mexican Imports Surge

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Situation
For several years, imports of Mexican vegetables during Florida's prime winter season have been steadily increasing. However, in the fall of 1995, imports of tomatoes, peppers and many other commodities rose dramatically. Mexican vegetables, priced below the cost of production, were surging into the U.S. market at up to six times the rate for the previous season. Market prices dropped, and Florida growers suffered significant losses.

Research
Right away, public relations was seen by growers and farm organizations as a method for generating political pressure and public support for immediate action. No pre-existing crisis plan was in place, but a core group of concerned farm owners and association managers formed an ad-hoc alliance to focus attention on the imports issue.

FFVA used USDA and Florida Department of Agriculture data to determine market pricing and production trends for both Florida and Mexico products. FFVA directly communicated with dozens of Florida growers, as well as importers and brokers at terminal markets in Nogales, Arizona, the primary point of entry for Mexican produce. Unfortunately, growers' outspoken outrage over the issue could have resulted in a misperception by key audiences that the industry was unreasonable and not cohesive.

FFVA immediately sought counsel from state and federal lawmakers including Senator Bob Graham, Senator Connie Mack and several other members of the Florida delegation representing grower districts. Further, FFVA conducted meetings with staff at the United States Trade Representative and the Secretary of Agriculture. These discussions helped establish what immediate and long-term remedies were available under U.S. and international law, and which strategies might be most politically expedient.

Program Objective
The objective of the program was boiled down to this:
Resolve this unfair trade situation by raising public and political awareness of the issue, thereby encouraging action from state and federal officials to seek legal remedies that would provide meaningful relief for Florida growers.

Strategies and Tactics
A three-part strategy was established: 1) Immediately start discussions with key state and federal officials to seek remedies for Florida's vegetable industry under law. Tactics included direct talks with Mexican officials, introducing legislation to reform trade laws and marketing guidelines, gathering information on shipments and pricing to file an antidumping suit, and filing a Section 201 petition under the Trade Act of 1974. 2) Launch a media awareness program designed to put political pressure on Governor Lawton Chiles, Agriculture Commissioner Bob Crawford, President Clinton (including USDA, USTR and other Administration officials) and Congress. 1996 is an election year, and special focus was given to tactics regarding the Florida presidential primary and posturing for the fall election. 3) A national grower coalition should be created to serve as a platform for the message and provide a single voice to media, the public and other key audiences.

FFVA, working with other industry organizations, initiated multiple strategies to target key state and federal officials as well as consumers. Two grower rallies (Palm Beach and Dade counties) kicked off the program in early December, garnering significant publicity and adding to the political pressure in Washington and Tallahassee.

It was clear that the grower rallies needed visual spice to get noticed by television and newspaper photographers. With this in mind, symbolic dumping of vegetables were scheduled for the rallies, making the events much more attractive to media. Further, signs were developed specifically to be captured in video and photography at the rallies. These signs echoed the grower messages about saving Florida farms and the severity of the imports situation. One set of signs which graphically depicted the alarming increase in Mexican imports, was repeatedly picked up by reporters and photographers in their coverage. Fact sheets and news releases were distributed at the event sites, as well as faxed to targeted media.

These two successful rallies served to introduce dozens of reporters and editors to the Mexican vegetables issue. Coverage also contributed to much improved public awareness.

Key state and national media were continuously pitched about the issue. Editorial board briefings were held with major Florida newspapers, the *Washington Post, New York Times,* and other news outlets to increase positive coverage. These editorial meetings provided face-to-face discussions with key journalists and, in many cases, resulted in favorable editorials. Those positive editorials were then merchandised back to key government officials and other media.

A handful of key spokespeople were trained using message points developed by FFVA. However, the scope of the story required much more media training be done. The inability to adequately train potential spokespeople probably resulted in some missed media opportunities, and in at least one case, led to damaging coverage of the issue.

A grassroots activity kit was developed and mailed to more than 2,000 growers, suppliers and other agricultural organizations to help supporters communicate with lawmakers. The kits came with a list of message points, fact sheets, congressional district maps and letters that could be sent to lawmakers. Utilization of the kits by industry members, however, may not have been very high.

Recognizing the need for a cohesive voice from the industry, FFVA helped form a coalition (Grown in the USA Coalition) to provide a united image for agriculture that included the Florida Department of Agriculture and other farm organizations. Grown in the USA was chosen to help portray the issue as one affecting farms across the country, not just in Florida.

Advertising was created by the Dade County Farm Bureau, FFVA and others containing political and consumer messages for placement in Florida and Washington, DC newspapers. The ads had a variety of messages including direct appeals to President Clinton to protect the industry, appeals to Congress to support trade reform, and messages to consumers about the security and safety of the food supply.

The political pressure generated by a combination of direct discussions with government officials, media placements and grassroots support successfully resulted in the introduction of legislation by Sen. Bob Graham and Rep. Clay Shaw designed to help Florida growers seek relief from unfair trade with Mexico. Further, the USDA proposed rule changes that would help domestic growers compete. The program was instrumental in persuading Mickey Kantor, then U.S. Trade Representative, and Dan Glickman, U.S. Secretary of Agriculture, to arrange face-to-face meetings with Mexican officials in attempts to seek a negotiated resolution to the trade dispute. The program helped convince Florida Agriculture Commissioner Bob Crawford to launch measures to closely monitor Mexican produce imports and strictly enforce the state's country-of-origin labeling laws. Media placements included CNN, CNN International, NBC Radio, WPEC - West Palm Beach, WPTV - West Palm Beach, WCPX - Orlando, Florida Radio Network, *Wall Street Journal* (national and state editions), Associated Press, United Press International, Reuters, Knight-Ridder, *Inside U.S. Trade, Miami Herald, Tampa Tribune, Orlando Sentinel, Orlando Business Journal, Palm Beach Post, Tallahassee Democrat, Naples Daily News and Sun-Sentinel* (Ft. Lauderdale).

Summary

Without question, media coverage of the Mexican imports issue helped get action from government officials. Public awareness of the issue was relatively higher, but it was difficult for consumers to understand why they should care. This may reflect a basic lack of background knowledge about Florida agriculture and suggests that much needs to be done in this area.

A unified alliance (Grown in the USA Coalition) was formed, but not as early as it should have been. Such coalitions help portray the industry as cohesive and focused, and the lack of such a coalition in the early stages may have hurt the program.

Coordination with key government officials and industry leaders was critical. The industry's public relations program in many ways echoed the strategies and messages developed jointly with these officials.

Adequately trained spokespersons were not immediately available at the start of the program. There is little time during a crisis to properly train media spokespeople.

While 2,000 grass roots activity kits were provided to the industry, their use was difficult to document. Feedback indicates that the majority of growers and other industry representatives failed to utilize them.

APPENDICES

TOMATO VARIETIES FOR FLORIDA

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

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

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

*Disease Resistance - Varieties selected for use in Florida must have resistance to Fusarium wilt, race 1 and race 2; 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.

*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 acreages.

'Agriset 761' was grown on 41% of the acreage in Florida in the 1995-96 season - up somewhat from the 35% planted the previous season. 'Agriset 761' was grown on 54% of the acreage in southwest Florida, 34% of the acreage in west central Florida, and was the predominant variety in north Florida.

'Solar Set' had over 13% of the state acreage, a marked increase from 1994-95. It was the most popular variety in Dade County, and had significant acreage on the East Coast, in Palmetto, Ruskin, and in north Florida.

'Sunbeam', 'Sunny' and 'Solimar' each had between 5 and 10% of the state acreage. 'Sunny' was the most widely planted variety in Florida for many years, but is rapidly being replaced by other varieties.

'BHN 26' and 'Florasette' each were grown in about 5% of the acreage; and 'Bonita', 'Merced', 'Cobia', 'BHN 22' and 'Olympic' were grown on 1 or 2% of the Florida tomato acreage. Several other varieties and experimental lines were grown on less than 1% of the state acreage.

TOMATO VARIETY TRIAL RESULTS

Summary results listing the five highest yielding and the five largest fruited varieties from trials conducted at the University of Florida's Gulf Coast Research and Education Center, Bradenton; Indian River Research & Education Center, Ft. Pierce; and North Florida Research & Education Center, Quincy for the Spring 1995 season are shown in Table 1. High total yields and large fruit size were produced by 'Merced' at Bradenton and 'Agriset 761', 'Merced', and 'Solar Set' at Ft. Pierce. 'Equinox', 'Merced' and RXT 3096 produced high yields at two of the three locations. 'Merced' and 'Sunbeam' produced large sized fruit at all three locations in Spring 1995 trials. It is important to note that the same entries were not included in all trials.

Table 1. Summary of University of Florida tomato variety trial results. Spring 1995.

Location	Total Yield (ctn/acre)		Large Fruit Size (oz)	
Bradenton(1)	Equinox	2644	XPH 10046	6.9
	Florida 7514	2605	Merced	6.7
	RXT 3096	2509	Sunbeam	6.6
	Florida 7578	2451	RXT 3096	6.5
	Merced	2424[1]	Florida 7658	6.4[2]
Ft.Pierce(3)	Agriset 761	1383	Agriset 761	6.7
	Merced	1183	Merced	6.4
	Florida 7579	1033	Sunbeam	6.2
	Solar Set	1007	Solar Set	5.9
	Sunny	972[3]	Florida 7658	5.9[4]
Quincy(4)	Monte Verde	2482	XPH 10046	8.2
	Mountain Fresh	2349	Tango	7.9
	Equinox	2298	Merced	7.7
	Mountain Supreme	2292	Sunbeam	7.3
	RXT 3096	2268[5]	XPH 10047	7.2[6]

[1] 16 other entries had yields similar to those of 'Merced'.
[2] 14 other entries had fruit weight similar to that of Florida 7658.
[3] No significant yield difference.
[4] 8 other entries had fruit weight similar to that of Florida 7658.
[5] 18 other entries had yields similar to those of RXT 3096.
[6] 13 other entries had fruit weights similar to those of XPH 10047.

Seed Sources:

Agrisales: Agriset 761, Equinox
Asgrow: Mountain Supreme, Solar Set, Sunbeam, Sunny, XPH 10046, XPH 10047
Ferry-Morse: Monte Verde, Mountain Fresh
Rogers: Merced, Tango, RXT 3096
University of Florida: Florida 7514, Florida 7578, Florida 7579, Florida 7658

Summary results listing outstanding entries in order from trials at the University of Florida's Gulf Coast Research & Education Center, Bradenton; the Indian River Research and Education Center, Ft. Pierce; and the North Florida Research and Education Center, Quincy for the fall 1995 season are shown in Table 2. High total yields and large fruit size were produced by Florida 7514 and Florida 7578 at Bradenton; Florida 7658, 'Agriset 761', 'Sunny' and

'Solar Set' at Ft. Pierce; and by Florida 7514, Florida 7578 and Florida 7658 at Quincy. Accordingly, high yields and large fruit size were produced by Florida 7578, Florida 7514, and Florida 7658 at two of the three locations. As in the spring trial, not all entries were included at all locations.

Table 2. Summary of University of Florida tomato variety trial results. Fall 1995.

Location	Total Yield (ctn/acre)		Large Fruit Size (oz)	
Bradenton(2)	Florida 7514	2351	Merced	5.9
	Equinox	2285	Florida 7658	5.7
	Florida 7578	2237	Florida 7514	5.5
	FT 4029	2151	Florida 7578	5.4
	Solar Set[1]	2144	Sunex 6590[2]	5.4
Ft. Pierce(3)	Florida 7514	2684	Agriset 761	7.2
	Florida 7658	2495	Merced	7.2
	Agriset 761	2471	Florida 7658	7.1
	Sunny	2411	Solar Set	6.7
	Solar Set[3]	2380	Sunny	6.6
			Bonita[4]	6.6
Quincy(4)	Equinox	1441	XPH 10035	5.9
	Florida 7514	1423	Florida 7578	5.6
	Florida 7578	1347	Florida 7658	5.5
	Florida 7658	1335	Merced	5.4
	Solar Set	1268[5]	Florida 7514[6]	5.4
			PSR 861894[6]	5.4

[1]10 other entries had yields similar to those of 'Solar Set'.
[2]13 other entries had fruit size similar to that of Sunex 6590.
[3]7 other entries had yields similar to those of 'Solar Set'.
[4]6 other entries had fruit size similar to that of 'Sunny' and 'Bonita'.
[5]16 other entries had yields similar to those of 'Solar Set'.
[6]18 other entries had fruit size similar to that of Florida 7514 and PSR 861894.

Seed Sources:

Agrisales: Agriset 761, Equinox
Asgrow: Solar Set, Sunny, XPH 10035
Petoseed: PSR 861894
Rogers: Bonita, Merced, FT 4029
Sun: Sunex
University of Florida: Florida 7514, Florida 7578, Florida 7658

For spring and fall trial results combined, high yields and/or large fruit size were achieved by 'Merced' eight times, Florida 7658 seven times, 'Solar Set' and Florida 7514 six times, Florida 7578 five times and 'Equinox' and 'Agriset 761' four times each.

TOMATO VARIETIES FOR COMMERCIAL PRODUCTION

The varieties listed have performed well in University of Florida trials conducted in various locations.

Agriset 761. An early midseason, determinate, jointed hybrid. Fruit are deep globe and green shouldered. Resistant: Verticillium wilt (race 1), Fusarium wilt (race 1 and 2), Alternaria stem canker, gray leaf spot.

Bonita. A midseason, jointless hybrid. Fruit are globe-shaped and green-shouldered. Resistant: Verticillium wilt (race 1), Fusarium wilt (race 1 and 2), gray leaf spot.

Equinox. A determinate, jointed, heat-tolerant hybrid that also performs well in the spring. Fruit are flattened globe-shaped with light-green shoulders. Resistant: Verticillium wilt (race 1), Fusarium wilt (race 1 and 2), and gray leaf spot.

Merced. Early, deep-globe shaped, green-shouldered fruit are produced on determinate vines. Jointed hybrid. Resistant: Verticillium wilt (race 1), Fusarium wilt (race 1 and 2), gray leaf spot, tobacco mosaic virus.

Olympic. A mid-season determinate, jointed hybrid. Fruit are deep oblate with green shoulders. Resistant: Verticillium wilt (race 1), Fusarium wilt (race 1 and 2), Alternaria stem canker, and gray leaf spot.

Solar Set. An early, green-shouldered, large-fruited, jointed hybrid. Determinate. Fruit set under high temperatures (92°F day/72° night) is superior to most other commercial cultivars. Resistant: Fusarium wilt (race 1 and 2), Verticillium wilt (race 1) and gray leaf spot.

Solimar. A mid-season, jointed, hybrid producing globe-shaped, green shouldered fruit. Resistant: verticillium wilt (race 1), Fusarium wilt (race 1 and 2), Alternaria stem canker, gray leaf spot.

Sunbeam. Early mid-season, deep-globe shaped, jointed fruit are produced on determinate vines. Resistant: Verticillium wilt (race 1), Fusarium wilt (race 1 and race 2), gray leaf spot, Alternaria stem canker.

Sunny. A midseason, jointed, determinate, hybrid. Fruit are large, flat-globular in shape, and are green-shouldered. Resistant: Verticillium wilt (race 1), Fusarium wilt (race 1 and 2), Alternaria stem canker, gray leaf spot.

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TOMATO FERTILIZER MANAGEMENT

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Prior to each cropping season, soil tests should be conducted to determine fertilizer needs. Obtain an IFAS soil sample kit from the local agricultural Extension agent for this purpose. Commercial soil testing laboratories also are available, however, be sure the commercial lab uses methodologies calibrated for Florida soils. Routine soil testing will help reduce overfertilization which reduces farming efficiency and increases the risk of groundwater pollution.

The crop nutrient requirements of nitrogen, phosphorus, and potassium (designated in fertilizers as N-P_2O_5-K_2O) Table 1 represent the optimum amounts of these nutrients needed for maximum production (8).

A portion of this required nutrition will be supplied by the native soil and by previous crop residue. The remainder of the nutrient requirements will be supplied by fertilizer, and this amount must be determined by soil testing. Therefore, nutrient amounts in these tables are applied as fertilizers only to soils testing very low in the specific plant nutrients. Automatic use of the amounts of nutrients in the tables without a soil test may result in wasted fertilizer, crop damage from salt injury, reduced yields and quality, and a risk to the environment if fertilizer runs off or leaches to the watertable.

Liming.

The optimum pH range for tomatoes is between 6.0 and 6.5. Fusarium wilt problems are reduced by liming within this range, but it is not advisable to raise the pH higher than 6.5 because of reduced micronutrient availability.

Calcium and magnesium levels should be corrected according to the soil test. If both elements are low and lime is needed, broadcast and incorporate dolomitic limestone. Where calcium alone is deficient, lime with "hi-cal" limestone. 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 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 modification, but magnesium is low, apply magnesium sulfate or potassium-magnesium sulfate with the fertilizer.

Blossom-end rot. At certain times, growers have problems with blossom-end-rot, especially on the first one or two fruit clusters. Blossom-end rot (BER) is basically a Ca deficiency but is often more related to water stress than to Ca concentrations in the soil. This is because Ca movement in the plant is with the water stream. Anything that impairs the ability of the plant to obtain water will increase the risk of BER. These factors include damaged roots from flooding or mechanical damage, clogged drip emitters, inadequate water applications, and alternating dry-wet periods. Other causes include high fertilizer rates, especially potassium and nitrogen. High fertilizer increases the salt content and osmotic potential in the soil reducing the ability of roots to obtain water. Excessive N encourages excessive vegetative growth reducing the proportion of Ca that is deposited in the fruit.

There should be adequate Ca in the soil if the double-acid 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. Foliar-applied Ca stays on the leaf from where it more likely will wash during a rain.

BER is most effectively controlled by attention to irrigation. Maintaining adequate and uniform amounts of water are keys to reducing BER potential. Growers who keep N and K rates at soil-test-predicted levels are at least risk from BER.

Micronutrients

For virgin, sandy soils, or sandy soils where a proven need exists, a general guide for fertilization is the addition of micronutrients (in pounds per acre) manganese -3, copper -2, iron -5, zinc -2, boron -2, and molybdenum -0.02. Micronutrients may be supplied from oxides or sulfates. Growers using micronutrient-containing fungicides need to consider these sources when calculating fertilizer micronutrient needs. More information on micronutrient use is available (2, 5, 9).

Table 1. Fertility recommendations for mulched tomatoes on irrigated soils testing very low in phosphorus and potassium.

		Nutrient requirements	Supplemental Applications[1]	
Soil	Number of expected harvests	lbs/A[2] $N-P_2O_5-K_2O$	lbs/A $N-P_2O_5-K_2O$	Number of Applications
Mineral	2-3	175-150-225	30-0-20	0-2
Rockdale	2-3	150-200-200	30-0-20	0-2

[1]Sidedressing to replenish nitrogen and potassium can be accomplished by the use of a liquid fertilizer injection wheel.

[2]Approximately 7200 linear bed feet of crop per acre (43,560 square feet).

Properly diagnosed micronutrient deficiencies can often be corrected by foliar applications of the specific micro nutrient. 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. For more information on foliar micronutrient fertilization or tomatoes, consult the Commercial Vegetable Fertilization Guide, Circular 225-C (2).

Fertilizer Application

Full-Bed Mulch with Seep 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 new fertilizing equipment, such as 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 "starter" fertilizer or "in-bed" mix. This should comprise only 10 to 20 percent of the total nitrogen and potassium seasonal requirement and all of the phosphorus and micronutrients. Starter fertilizer 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 soils.

3. Formation of beds, incorporation of herbicide, and application of mole cricket bait.

4. Application of remaining fertilizer. The remaining 80 to 90 percent of the nitrogen and potassium is placed in narrow bands 9 to 10 inches to each side of the plant row in furrows. The 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.

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.

There is equipment that will do most of the operations in steps 4 and 5 above in one pass over the field. More information on fertilization of mulched crops is available (1, 10).

Water management with the seep irrigation system is critical to successful crops. Use water-table monitoring devices and tensiometers in the root zone to help provide an adequate water table but no higher than required for optimum moisture. Do not fluctuate the water table since this can lead to increased leaching losses of plant nutrients.

Mulched Culture with Overhead Irrigation. For the sandy soils, maximum production has been attained by broadcasting 100 percent of the fertilizer in a swath 3 to 4 feet wide and incorporating prior to bedding and mulching. Be sure fertilizer is placed deep enough to be in moist soil. Where soluble salt injury has been a problem, a combination of broadcast and banding should be used. Incorporate 30 percent to 40 percent of the nitrogen and potassium and 100 percent of the phosphorus and micronutrients into the bed by rototilling. The remaining nitrogen and potassium is applied in bands 6 to 8 inches to the sides of the seed or transplant and 2 to 4 inches deep to place it in contact with moist soil. Perforation of the plastic is needed on soils such as coarse sands and Rockdale where lateral movement of water through the soil is negligible.

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 the crop. Where drip irrigation is used, before planting apply all phosphorus and micronutrients, and 20 percent to 40 percent of total nitrogen and potassium prior to mulching. Use the lower percentage (20 percent) on seep-irrigated tomatoes. 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 K_2O were applied through the drip system. Some growers find this method helpful where they have had problems with soluble-salt burn. This approach would be most likely to work on soils with relatively high organic matter and some residual potassium. However, it is important to begin with rather high rates of N and K_2O to ensure young transplants are established quickly. In most other situations, some preplant N and K fertilizer are needed.

Suggested schedules for nutrient injections are presented in Table 2. These schedules have been successful in both research and commercial situations, but might need slight modifications based on potassium soil-test indices and grower experience.

Additional nutrients can be supplied through drip irrigation if deficiencies occur during the growing season. Be careful not to apply excessive amounts of water with the fertilizer because severe leaching can occur. Tensiometers can be used to help monitor soil moisture and guide the application of water. More detail on drip-irrigation management for fertilization is available (6).

Sources of N-P_2O_5-K_2O. About 30 to 50 percent of the total applied nitrogen should be in the nitrate form for soil treated with multi-purpose fumigants and for plantings in cool soil temperature.

Slow-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) or isobutylidene diurea (IBDU) incorporated in the bed. Nitrogen from natural organics and most slow-release materials should be considered ammoniacal nitrogen when calculating the amount of ammoniacal nitrogen.

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

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

Tissue analyses. Analysis of tomato leaves for mineral nutrient content can help guide a fertilizer management program or assist in diagnosis of a suspected nutrient deficiency. Tissue nutrient norms are presented in Table 3.

Growers with drip irrigation can obtain faster analyses for N or K by using a plant sap quick test. Several kits have been calibrated for Florida tomatoes (4). Interpretation of these kits is provided in Table 4. More information is available on plant analysis (7).

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Table 2. Schedules for N and K_2O injection for mulched tomato on soils testing low in K.

Crop development		Injection (lb/A/day)[z]	
stage	weeks	N	K_2O
1	2	1.0	1.5
2	2	1.5	2.0
3	7	2.5	3.0
4	1	1.5	2.0
5	1	1.0	1.5

Total nutrients applied are 175 lb N and 225 lb K_2O per acre (7260 linear bed feet). These injection programs assume no N or K preplant. If 20% of N and K are applied preplant in the bed, then first two week's of injection can be reduced or omitted.

Table 3. Deficient, adequate, and excessive nutrient concentrations for tomatoes [most-recently-matured (MRM) leaf (blade plus petiole)].

				N	P	K	Ca	Mg	S	Fe	Mn	Zn		B	
Cu	Mo														
				%						ppm					
Tomato	MRM[z] leaf	5-leaf stage	Deficient	<3.0	0.3	3.0	1.0	0.3	0.3	40	.30	25	20	5	0.2
			Adequate range	3.0 5.0	0.3 0.6	3.0 5.0	1.0 2.0	0.3 0.5	0.3 0.8	40 100	30 100	25 40	20 40	5 15	0.2 0.6
			High	>5.0	0.6	5.0	2.0	0.5	0.8	100	100	40	40	15	0.6
	MRM leaf	First flower	Deficient	<2.8	0.2	2.5	1.0	0.3	0.3	40	30	25	20	5	0.2
			Adequate range	2.8 4.0	0.2 0.4	2.5 4.0	1.0 2.0	0.3 0.5	0.3 0.8	40 100	30 100	25 40	20 40	5 15	0.2 0.6
			High	>4.0	0.4	4.0	2.0	0.5	0.8	100	100	40	40	15	0.2
			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	

continued

Table 3. Deficient, adequate, and excessive nutrient concentrations for tomatoes [most-recently-matured (MRM) leaf (blade plus petiole)].

				N	P	K	Ca	Mg	S	Fe	Mn	Zn		B	
Cu	Mo														
				%						ppm					
Tomato	MRM leaf	First ripe fruit	Deficient	<2.0	0.2	2.0	1.0	0.25	0.3	40	30	20	20	5	0.2
			Adequate range	2.0 3.5	0.2 0.4	2.0 4.0	1.0 2.0	0.25 0.5	0.3 0.6	40 100	30 100	20 40	20 40	5 10	0.2 0.6
			High	>3.5	0.4	4.0	2.0	0.5	0.6	100	100	40	40	10	0.6
	MRM leaf	During harvest period	Deficient	<2.0	0.2	1.5	1.0	0.25	0.3	40	30	20	20	5	0.2
			Adequate range	2.0 3.0	0.2 0.4	1.5 2.5	1.0 2.0	0.25 0.5	0.3 0.6	40 100	30 100	20 40	20 40	5 10	0.2 0.6
			High	>3.0	0.4	2.5	2.0	0.5	0.6	100	100	40	40	10	0.6

[z]MRM=Most recently matured leaf.

Table 4. Suggested nitrate-N and K concentrations in fresh petiole sap for tomatoes.

Stage of growth	Sap concentration (ppm) NO_3-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

Weed Control in Tomato

William M. Stall and J. P. Gilreath

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 it from drifting onto the tomato crop.

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

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 buildup on the rye, contact herbicide can be applied to kill it and eliminate it as a host, yet the remaining stubble could continue serving as a windbreak.

The greatest row middle weed control problem confronting the tomato industry today is control of 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 are 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 is 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 commer-

Fact Sheet HS-200, November 1994, Institute of Food and Agricultural Sciences, University of Florida, Gainesville, FL 32611.

cially. Some adjuvants contain more active ingredient then 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.

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

The importance of rapid vine destruction 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: tomatoes.

Herbicide	Labelled crops	Time of application to crop	Rate (lbs ai/acre) Mineral	Muck
DCPA (Dacthal W-75)	Established Tomatoes	Posttransplanting after crop establishment (non-mulched)	6.0 to 8.0	—
		Mulched row middles after crop establishment	6.0 to 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 of replanting non registered crops within 8 months.				
Diquat (Diquat H/A)	Tomato Vine Burndown	After final harvest	0.375	—
Remarks: Special Local Needs (24c) label for use for burndown of tomato vines after final harvest. Applications of 1.5 pts material per acre in 60 to 120 gals of water is labelled. Add 16 to 32 ozs of Valent X-77 spreader per 100 gals of spray mix. Thorough coverage of vines is required to insure maximum burndown.				
Diquat dibromide (Diquat)	Tomatoes (Fresh Market)	Pretransplant Postemergence directed shielded	0.5	—
Remarks: Diquat can be applied as a post-directed application to row middles either prior to transplanting or as a post-directed hooded spray application to row middles when transplants are well established. Apply 1 qt of Diquat in 20-50 gallons of water per treated acre when weeds are 2-4 inches in height. Do not exceed 25 psi spray pressure. A maximum of 2 applications can be made during the growing season. Add 2 pts non-ionic surfactant per 100 gals spray mix. Diquat will be inactivated if muddy or dirty water is used in spray mix. A 30 day PHI is in effect. Label is a special local needs label for Florida only.				
MCDS (Enquik)	Tomatoes	Postemergence directed/shielded in row middle	5 to 8 gals	—
Remarks: Controls many emerged broadleaf weeds. Weak on grasses. Apply 5 to 8 gals of Enquik in 20 to 50 gals of total spray volume per treated acre. A non-ionic surfactant should be added at 1 to 2 pts per 100 gals. Enquik is severely corrosive to nylon. Non-nylon plastic and 316-L stainless steel are recommended for application equipment. Read the precautionary statements before use. Follow all restrictions on the label.				
Metribuzin (Sencor DF; Sencor 4; Lexone DF)	Tomatoes	Postemergence; posttransplanting after establishment	0.25 to 0.5	—
Remarks: Controls small emerged weeds after transplants are established 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; Lexone DF)	Tomatoes	Directed spray in row middles	0.25 to 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, tall panicum, *amaranthus sp.*, Florida pusley, common ragweed, sicklepod, and spotted spurge.				

Table 1. Chemical weed controls: tomatoes.

Herbicide	Labelled crops	Time of application to crop	Rate (lbs ai/acre) Mineral	Muck
Napropamid (Devrinol 50WP; Devrinol 50DF; Devrinol 2E)	Tomatoes	Preplant incorporated	1.0 to 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 2E; Devrinol 50WP)	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.				
Paraquat (Gramoxone Extra)	Tomatoes	Preemergence; pretransplant	0.62 to 0.94	—
Remarks: Controls emerged weeds. Use a non-ionic spreader and thoroughly wet weed foliage.				
Paraquat (Gramoxone Extra)	Tomatoes	Post directed spray in row middle	0.47	—
Remarks: Controls emerged weeds. Direct spray over emerged weeds 1 to 6 inches tall in row middles between mulched beds. Use a non-ionic spreader. Use low pressure and shields to control drift. Do not apply more than 3 times per season.				
Sethoxydim (Poast)	Tomatoes	Postemergence	0.188 to 0.28	—
Remarks: Controls actively growing grass weeds. A total of 4½ pts product per acre may be applied in one season. Do not apply within 20 days of harvest. Apply in 5 to 20 gals of water adding 2 pts of 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 (1½ pts) to perennial grasses emerging from rhizomes etc. Consult label for grass species and growth stage for best control.				
Trifluralin (Treflan EC; Treflan MTF; Treflan 5; Treflan TR-10; Tri-4; Trilin)	Tomatoes (except Dade County)	Pretransplant incorporated	0.75 to 1.0	—
Remarks: Controls germinating annuals. Incorporate 4 inches or less within 8 hours of application. Results in Florida are erratic on soils with low organic matter and clay contents. Note label precautions of planting non-registered crops within 5 months. Do not apply after transplanting.				
Trifluralin (Treflan EC; Treflan MTF; Treflan 5; Treflan TR-10; Tri-4; Trilin)	Direct-seeded tomatoes (except Dade County)	Post directed	0.75 to 1.0	—
Remarks: For direct-seeded tomatoes, apply at blocking or thinning as a directed spray to the soil between the rows and incorporate.				

Tomato Insect Control

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Insecticide	Formulation	Formulation Rate/Acre	Min Days to Harvest
ANTS			
carbaryl (Sevin)	5 B	20 - 40 lbs	0
pyrethrins + piperonyl butoxide (Pyrenone)	66% L (EC)	2 - 12 ozs	0
APHIDS			
aliphatic petroleum (JMS Stylet Oil)	97.6% EC	see label	see label
azinphosmethyl (Guthion)	2S, 2L (EC)	2 - 3 pts	up to day of harvest
cyfluthrin (Baythroid)	2 EC	1.6 - 2.8 ozs	0 - potato aphid
cyhalothrin (Karate, Warrior)	1 EC	1.92 - 3.2 ozs	5 - caution, read label
diazinon AG500	4 EC	1/2 pt	1
dimethoate (Cygon)	4 EC	1/2 - 1 pt	7
disulfoton (Di-Syston)	8 E	1 - 3 pts	30
endosulfan (Phaser, Thiodan)	3 EC	2/3 - 1 1/3 qts	2 - field & greenhouse
esfenvalerate (Asana XL) (potato aphid)	0.66 EC	5.8 - 9.6 fl ozs	1
imidachloprid (Provado) (Admire)	1.6 EC 2.0 EC	3.75 ozs 16 - 24 ozs	0 - foliar - 21 - soil
lindane (Prentox)	1.63 EC	20 ozs/100 gals $H^{2}0$	Apply before fruit forms
malathion	5 EC	1 1/2 - 2 pts	1
methamidophos (Monitor)	4 EC	1/2 - 1 1/2 pts	7
methomyl (Lannate LV)	2.4 L	1 1/2 - 3 pts	1
oil (Sun Spray)	98.8%	1-2 gals/100 gals H_2O	1

Insecticide	Formulation	Formulation Rate/Acre	Min Days to Harvest
APHIDS (cont.)			
Note: Sun Spray oil can cause phytotoxic (plant) burns if used during periods of prolonged high temperature and high relative humidity. Do not spray plants under moisture stress. Do not use in combination with or immediately before or after spraying with dimethoate (Cygon) or fungicides such as Captan, Folpet, Dyrene, Karathane, Morestan, sulfur, or any product containing sulfur. Use with Bravo is not recommended.			
oxamyl (Vydate L)	2 L	2 - 4 pts	1
pyrethrins + piperonyl butoxide (Pyrenone) (green peach aphid)	66% L (EC)	2 - 12 ozs per 100 gals	0
pyrethrins + rotenone (Pyrellin)	EC	1 - 2 pts	0
rotenone (Rotacide)	EC	1 gal	0
soap, insecticidal (M-Pede)	49% EC	1-2 gals/100 gals H_2O	0
ARMYWORMS (See also: **Beet, Fall, Southern, and Yellow-striped Armyworm**)			
azadirachtin (Neemix)	0.25%	2 1/2 pts/100 gals $H^{2}0$ 150 - 300 gals/acre	1
Bacillus thuringiensis	See individual brand labels		---
chlorpyrifos (Lorsban) (except cherry tomatoes)	50 W	2 lbs	14
cyhalothrin (Karate, Warrior)	1 EC	2.56 - 3.84 ozs	5 - caution, read label
diazinon AG500 (fall and southern armyworm)	4 EC	3/4 - 1 pt	1
esfenvalerate (Asana XL) (beet, Southern, Western yellow-striped)	0.66 EC	5.8 - 9.6 fl ozs	1
malathion	5 EC	1 1/2 - 2 pts	1
methomyl (Lannate LV)	2.4 L	3/4 - 1 1/2 pts	1
methyl parathion	4 EC	1 - 3 pts	15
pyrethrins + piperonyl butoxide (Pyrenone)	66% L (EC)	2 - 12 ozs per 100 gals	0
rotenone (Rotacide)	EC	1 gal	0
BEET ARMYWORMS (See also: **Armyworms**)			
cyfluthrin (Baythroid)	2 EC	2.8 ozs	0
cyhalothrin (Karate, Warrior)	1 E	2.56 - 3.84 ozs	5 - caution, see label

Insecticide	Formulation	Formulation Rate/Acre	Min Days to Harvest
BEET ARMYWORMS (cont.) **(See also: Armyworms)**			
esfenvalerate (Asana XL) (aids in control)	0.66 EC	5.8 - 9.6 fl ozs	1
methomyl (Lannate LV)	2.4 L	1 1/2 - 3 pts	1
permethrin (Ambush) (Pounce)	2 EC 3.2 EC	3.2 - 12.8 ozs 2 - 8 ozs	up to day of harvest
Note: Permethrin (Ambush, Pounce) only for Florida use where final market is for fresh tomatoes. Do not use on cherry tomatoes or any variety used to produce fruit less than 1" (one inch) in diameter. Permethrin can be applied by air or ground. Use sufficient water to obtain uniform coverage. Do not apply more than 1.2 lbs. active ingredient per acre per season which is equivalent to 76.8 ozs. of Ambush 2 EC or 48 ozs. of Pounce 3.2 EC.			
BANDED CUCUMBER BEETLES			
azinphosmethyl (Guthion)	2S, 2L (EC)	1 1/2 - 2 pts	0
diazinon AG500	4 EC	3/4 - 1 pt	1
BLISTER BEETLES			
cryolite (Kryocide)	96 WP	15 - 30 lbs	wash fruit
endosulfan (Phaser, Thiodan)	3 EC	2/3 - 1 1/3 qts	2 - field & greenhouse
methoxychlor	4 L	1 - 3 qts	1 - 1 3/4 qt; 7 - 1 3/4+ qt
CABBAGE LOOPERS **(See also: Loopers)**			
azadirachtin (Neemix)	0.25%	2 1/2 pts/100 gals H^20 150 - 300 gals/acre	1
Bacillus thuringiensis	See individual brand labels.		0
cryolite (Kryocide)	96 WP	15 - 30 lbs	wash fruit
cyfluthrin (Baythroid)	2 EC	2.8 ozs	0
cyhalothrin (Karate, Warrior)	1 EC	1.92 - 3.20 ozs	5 - caution, read label
endosulfan (Phaser, Thiodan)	3 EC	1 - 1 1/3 qts	2 - field & greenhouse
esfenvalerate (Asana XL)	0.66 EC	5.8 - 9.6 fl ozs	1
malathion	5 EC	1 1/2 - 2 pts	1
methomyl (Lannate LV)	2.4 L	1 1/2 - 3 pts	1
permethrin (Ambush) (Pounce)	2 EC 3.2 EC	3.2 - 12.8 ozs 2 - 8 ozs	up to day of harvest

Insecticide	Formulation	Formulation Rate/Acre	Min Days to Harvest
CABBBAGE LOOPERS (cont.) (See also: Armyworms)			
Note: Permethrin (Ambush, Pounce) only for Florida use where final market is for fresh tomatoes. Do not use on cherry tomatoes or any variety used to produce fruit less than 1" (one inch) in diameter. Permethrin can be applied by air or ground. Use sufficient water to obtain uniform coverage. Do not apply more than 1.2 lbs. active ingredient per acre per season which is equivalent to 76.8 ozs. of Ambush 2 EC or 48 ozs. of Pounce 3.2 EC.			
pyrethrins + piperonyl butoxide (Pyrenone)	66% L (EC)	2 - 12 ozs	0
rotenone (Rotacide)	EC	1 gal	0
COLORADO POTATO BEETLES			
azadirachtin (Neemix)	0.25%	2 1/2 pts/100 gals $H^2 0$ 150 - 300 gals/acre	1
azinphosmethyl (Guthion)	2S, 2L (EC)	1 1/2 pts	up to day of harvest
carbaryl (Sevin)	80S	2/3 - 1 1/4 lbs	0
cyfluthrin (Baythroid)	2 EC	1.6 - 2.8 ozs	0
cyhalothrin (Karate, Warrior)	1 EC	2.56 - 3.84 ozs.	5 - caution, read label
disulfoton (Di-Syston) --early season reduction	8 E	1 - 3 pts	30
endosulfan (Phaser, Thiodan)	3 EC	2/3 - 1 1/3 qts	2
esfenvalerate (Asana XL)	0.66 EC	5.8 - 9.6 fl ozs	1
imidachloprid (Provado) (Admire)	1.6 EC 2.0 EC	3.75 ozs 16 - 24 ozs	0 - foliar 21 - soil
methoxychlor	4 L	1 - 3 qts	1 - 1 3/4 qt; 7 - 1 3/4+ qt
oxamyl (Vydate L)	2 L	1.5 - 2.8 ozs	1
permethrin (Ambush) (Pounce)	2 EC 3.2 EC	3.2 - 12.8 ozs. 2 - 8 ozs	up to day of harvest
Note: Permethrin (Ambush, Pounce) only for Florida use where final market is for fresh tomatoes. Do not use on cherry tomatoes or any variety used to produce fruit less than 1" (one inch) in diameter. Permethrin can be applied by air or ground. Use sufficient water to obtain uniform coverage. Do not apply more than 1.2 lbs. active ingredient per acre per season which is equivalent to 76.8 ozs. of Ambush 2 EC or 48 ozs. of Pounce 3.2 EC.			
pyrethrins + piperonyl butoxide (Pyrenone)	66% L (EC)	2 - 12 ozs per 100 gals	0
pyrethrins + rotenone (Pyrellin)	EC	1 1/2 - 2 pts	0
rotenone (Rotenox) (Rotacide)	5% L EC	2/3 gal 1 gal	0 0

Insecticide	Formulation	Formulation Rate/Acre	Min Days to Harvest
CORN EARWORMS (See also: Tomato Fruitworms)			
azinphosmethyl (Guthion)	2S, 2L (EC)	3 - 6 pts	up to day of harvest for 3 pts or less; 14 for 3+ pts
Bacillus thuringiensis	See individual brand labels		0
cyhalathrin (Karate, Warrior)	1 EC	2.56 - 3.84 ozs	5 - caution, read label
pyrethrins + piperonyl butoxide (Pyrenone)	66% L (EC)	2 - 12 ozs	0
CRICKETS			
carbaryl (Sevin)	5 B	20 - 40 lbs	0
pyrethrins + piperonyl butoxide (Pyrenone)	66% L (EC)	2 - 12 ozs	0
rotenone (Rotacide)	EC	1 gal	0
CUCUMBER BEETLE (See also: Banded Cucumber Beetle)			
azinphosmethyl (Guthion) (banded cucumber beetle)	2 S, 2 L (EC)	1 1/2 - 2 pts	up to day of harvest
pyrethrins + piperonyl butoxide (Pyrenone)	66% L (EC)	2 - 12 ozs	0
pyrethrins + rotenone (Pyrellin)	EC	1 1/2 - 2 pts	0
rotenone (Rotacide)	EC	1 gal	0
CUTWORMS			
azadirachtin (Neemix)	0.25%	2 1/2 pts/100 gals $H^2 0$ 150 - 300 gals/acre	1
Bacillus thuringiensis	See individual brand labels		0
carbaryl (Sevin)	80S (WP) 5 B	2 1/2 lbs 20 - 40 lbs.	0 0
cyfluthrin (Baythroid)	2 ECB	2 - 8 ozs	0 - varigated cutworm
diazinon AG500	14 G	14 - 28 lbs	preplant
esfenvalerate (Asana XL)	0.66 EC	5.8 - 9.6 fl ozs	1
malathion	5 EC	1 1/2 - 2 pts	1
methomyl (Lannate LV) (variegated cutworm)	2.4 L	1 1/2 pts	1

Insecticide	Formulation	Formulation Rate/Acre	Min Days to Harvest
CUTWORMS (cont.)			
permethrin (granulate cutworm)			
(Ambush)	2 EC	3.2 - 12.8 ozs	up to day of harvest
(Pounce)	3.2 EC	2 - 8 ozs	
Note: Permethrin (Ambush, Pounce) only for Florida use where final market is for fresh tomatoes. Do not use on cherry tomatoes or any variety used to produce fruit less than 1" (one inch) in diameter. Permethrin can be applied by air or ground. Use sufficient water to obtain uniform coverage. Do not apply more than 1.2 lbs. active ingredient per acre per season which is equivalent to 76.8 ozs. of Ambush 2 EC or 48 ozs. of Pounce 3.2 EC.			
rotenone (Rotacide)	EC	1 gal	0
DARKLING BEETLES			
carbaryl (Sevin)	5 B	20 - 40 lbs	0
DROSOPHILAS (FRUIT FLIES, VINEGAR FLIES)			
azinphosmethyl (Guthion)	2S, 2L (EC)	1 1/2 - 2 pts	0
diazinon AG500 (vinegar fly)	4 EC	1/2 - 1 1/2 pts	1
malathion	5 EC	1 1/2 - 2 pts	1
pyrethrins + piperonyl butoxide (Pyrenone)	66% L (EC)	2 - 12 ozs	0
rotenone (Rotacide) (fruit fly)	EC	1 gal	0
EUROPEAN CORN BORERS			
azinphosmethyl (Guthion)	2S, 2L (EC)	2 - 3 pts	up to day of harvest
carbaryl (Sevin)	80S (WP)	1 1/2 - 2 1/2 lbs	0
cyfluthrin (Baythroid)	2 EC	1.6 - 2.8 ozs	0
cyhalothrin (Karate, Warrior)	1 EC	2.56 - 3.84 ozs	5 - caution, read label
pyrethrins + rotenone (Pyrellin)	EC	1 1/2 - 2 pts	0
FALL ARMYWORMS (See also: Armyworms)			
carbaryl (Sevin)	80S (WP)	1 1/2 - 2 1/2 lbs	0
cyhalothrin (Karate, Warrior)	1 EC	2.56 - 3.84 ozs.	5 - caution, read label
methomyl (Lannate LV)	2.4 L	1 1/2 pts	1
methoxychlor	4 L	1 - 3 qts	1 - 1 3/4 qt; 7 - 1 3/4+ qt

Insecticide	Formulation	Formulation Rate/Acre	Min Days to Harvest
FLEA BEETLES			
azinphosmethyl (Guthion)	2S, 2L (EC)	2 - 3 pts	up to day of harvest
carbaryl (Sevin)	80S (WP)	2/3 - 1 1/4 lbs	0
cryolite (Kryocide)	96 WP	15 - 30 lbs	wash fruit
cyhalothrin (Karate, Warrior)	1 EC	2.56 - 3.84 ozs	5 - caution, read label
disulfoton (Di-Syston)	8 EC	1 - 3 pts	30
endosulfan (Phaser, Thiodan)	3 EC	2/3 - 1 1/3 qts	2 - field & greenhouse
esfenvalerate (Asana XL)	0.66 EC	5.8 - 9.6 fl ozs	1
imidachloprid (Admire)	2.0 EC	16 - 24 ozs	21 - soil
methyl parathion	4 EC	1 - 3 pts	15
methoxychlor	4 L	1 - 3 qts	1 - 1 3/4 qt; 7 - 1 3/4+ qt
pyrethrins + piperonyl butoxide (Pyrenone)	66% L (EC)	2 - 12 ozs per 100 gals	0
pyrethrins + rotenone (Pyrellin)	EC	1 1/2 - 2 pts	0
rotenone (Rotacide)	EC	1 gal	0
FLEAHOPPERS			
malathion (Cythion)	5 EC	1 1/2 - 2 pts	1
pyrethrins + rotenone (Pyrellin)	EC	1 - 2 pts	0
GARDEN SYMPHYLANS (SYMPHYLANS)			
fonofos (Dyfonate)	10 G	20 lbs	preplant, broadcast
diazinon AG500	4 EC	10 qts	preplant, broadcast
GRASSHOPPERS			
azinphosmethyl (Guthion)	2S, 2L (EC)	2 - 3 pts	up to day of harvest
carbaryl (Sevin)	5 B 80 S	20 - 40 lbs 2/3 - 1 7/8 lbs	0 0
cyhalothrin (Karate, Warrior)	1 EC	2.56 - 3.84 ozs	5 - caution, read label
esfenvalerate (Asana XL)	0.66 EC	5.8 - 9.6 fl ozs	1
rotenone (Rotacide)	EC	1 gal	0

Insecticide	Formulation	Formulation Rate/Acre	Min Days to Harvest
HORNWORMS (TOMATO HORNWORM, TOBACCO HORNWORM)			
azadiractin (Neemix)	0.25%	2 1/2 pts/100 gals $H^{2}0$ 150 - 300 gals/acre	1
azinphosmethyl (Guthion)	2S, 2L (EC)	3 - 6 pts	up to day of harvest for 3 pts or less; 14 for 3+ pts
Bacillus thuringiensis	See individual brand labels.		0
carbaryl (Sevin) (tomato hornworm)	80S (WP)	1 1/2 - 2 1/2 lbs	0
cryolite (Kryocide)	96 WP	15 - 30 lbs	wash fruit
cyfluthrin (Baythroid)	2 EC	1.6 - 2.8 ozs	0
cyhalothrin (Karate, Warrior)	1 EC	1.92 - 3.20 ozs	5 - caution, read label
endosulfan (Phaser, Thiodan)	3 EC	2/3 - 1 1/3 qts	2
esfenvalerate (Asana XL)(tomato hornworm, tobacco hornworm)	0.66 EC	2.9 - 5.8 fl ozs	1
methomyl (Lannate LV)	2.4 L	1 1/2 - 3 pts	1
permethrin (Ambush) (Pounce)	2 EC 3.2 EC	3.2 - 12.8 ozs 2 - 8 ozs	up to day of harvest
Note: Permethrin (Ambush, Pounce) only for Florida use where final market is for fresh tomatoes. Do not use on cherry tomatoes or any variety used to produce fruit less than 1" (one inch) in diameter. Permethrin can be applied by air or ground. Use sufficient water to obtain uniform coverage. Do not apply more than 1.2 lbs. active ingredient per acre per season which is equivalent to 76.8 ozs. of Ambush 2 EC or 48 ozs. of Pounce 3.2 EC.			
LACE BUGS			
carbaryl (Sevin)	80S (WP)	1 1/2 - 2 1/2 lbs	0
LEAFHOPPERS			
azinphosmethyl (Guthion)	2S, 2L (EC)	2 - 3 pts	up to day of harvest
carbaryl (Sevin)	80S	2/3-1 1/4 lbs	0
cyhalothrin (Karate, Warrior)	1 EC	2.56 - 3.84 ozs	5 - caution, read label
dimethoate (Cygon)	4 EC	1/2 - 1 pt	7
disulfoton (Di-Syston)	8 E	1 - 3 pts	30
methoxychlor	4 L	1 - 3 qts	1 - 1 3/4 qt; 7 - 1 3/4+ qt

Insecticide	Formulation	Formulation Rate/Acre	Min Days to Harvest
LEAFHOPPERS (cont.)			
methyl parathion	4 EC	1 - 3 pts	15
oil (Sun Spray)	98.8%	1 - 2 gals/100 gals $H^2 0$	1
Note: Sun Spray oil can cause phytotoxic (plant) burns if used during periods of prolonged high temperature and high relative humidity. Do not spray plants under moisture stress. Do not use in combination with or immediately before or after spraying with dimethoate (Cygon) or fungicides such as Captan, Folpet, Dyrene, Karathane, Morestan, sulfur, or any product containing sulfur. Use with Bravo is not recommended.			
pyrethrins + piperonyl butoxide (Pyrenone)	66% L (EC)	2 - 12 ozs	0
pyrethrins + rotenone (Pyrellin)	EC	1 1/2 - 2 pts	0
rotenone (Rotacide)	EC	1 gal	0
soap, insecticidal (M-Pede)	49% EC	1 - 2 gals/100 gals H_2O	0
LEAFMINERS			
abamectin (Agrimek)	0.15 EC	8 - 16 ozs	7
azadirachtin (Nemix)	0.25%	2 1/2 pts/100 gals $H^2 0$ 150 - 300 gals/acre	1
azinphosmethyl (Guthion)	2S, 2L (EC)	1 1/2 - 2 pts	up to day of harvest
cyfluthrin (Baythroid)	2 EC	1.6 - 2.8 ozs	0
cyhalothrin (Karate, Warrior)	1 EC	2.56 - 3.84 ozs	5 - caution, read label
diazinon AG500 (dipterous leafminer)	4 EC 50 WP	1/2 pt 1/2 lb	1 1
dimethoate (Cygon)	4 EC	1/2 - 1 pt	7
disulfoton (Di-Syston)	8 E	1 - 3 pts	30
esfenvalerate (Asana XL)	0.66 EC	9.6 ozs	1
malathion (serpentine)	5 EC	1 1/2 - 2 pts	1
methamidophos (Monitor) adults (fresh fruit only)	4 EC	1/2 - 1 1/2 pts	7
oil (Sun Spray)	98.8%	1 - 2 gals/100 gals $H^2 0$	1
Note: Sun Spray oil can cause phytotoxic (plant) burns if used during periods of prolonged high temperature and high relative humidity. Do not spray plants under moisture stress. Do not use in combination with or immediately before or after spraying with dimethoate (Cygon) or fungicides such as Captan, Folpet, Dyrene, Karathane, Morestan, sulfur, or any product containing sulfur. Use with Bravo is not recommended.			
oxamyl (Vydate L) (serpentine leafminers except *Liriomyza trifolii*)	2 EC	2 - 4 pts	1

Insecticide	Formulation	Formulation Rate/Acre	Min Days to Harvest
LEAFMINERS (cont.)			
permethrin (Ambush) (Pounce)	2 EC 3.2 EC	3.2 - 12.8 ozs 2 - 8 ozs	up to day of harvest
Note: Permethrin (Ambush, Pounce) only for Florida use where final market is for fresh tomatoes. Do not use on cherry tomatoes or any variety used to produce fruit less than 1" (one inch) in diameter. Permethrin can be applied by air or ground. Use sufficient water to obtain uniform coverage. Do not apply more than 1.2 lbs. active ingredient per acre per season which is equivalent to 76.8 ozs. of Ambush 2 EC or 48 ozs. of Pounce 3.2 EC.			
pyrethrins + rotenone (Pyrellin)	EC	1 - 2 pts	0
rotenone (Rotacide)	EC	1 gal	0
LOOPERS (See also: Cabbage Looper)			
azadirachtin (Neemix)	0.25%	2 1/2 pts/100 gals H^20 150 - 300 gals/acre	1
Bacillus thuringiensis	See individual brand labels		---
cyhalothrin (Karate, Warrior)	1 EC	2.56 - 3.84 ozs	5 - caution, read label
methomyl (Lannate LV)	2.4 L	1 1/2 - 3 pts	1
pyrethrins + rotenone (Pyrellin)	EC	1 - 2 pts	0
MEALYBUGS			
malathion (Cythion)	5 EC	1 1/2 - 2 pts	1
MITES			
MITES (GENERAL):			
dicofol (Kelthane) (Pacific, tropical, two-spotted, tomato russet)	MF (4 EC)	3/4 - 1 1/2 pts	2
disulfoton (Di-Syston)	8 E	1 - 3 pts	30
malathion (Cythion)	5 EC	1 1/2 - 2 pts	1
methyl parathion	4 EC	1 - 3 pts	15
pyrethrins + rotenone (Pyrellin)	EC	1 - 2 pts	0
TOMATO RUSSET MITE:			
abamectin (Agrimek)	0.15 EC	8 - 16 ozs	7
dicofol (Kelthane)	MF- 4 EC	3/4 - 1 1/2 pts	2
endosulfan (Phaser, Thiodan)	3 EC	1 1/3 qts	2
malathion	5 EC	1 1/2 - 2 pts	1
oil (Sun Spray)	98.8%	1 - 2 gals/100 gals H^20	1

Insecticide	Formulation	Formulation Rate/Acre	Min Days to Harvest
MITES (cont.)			
Note: Sun Spray oil can cause phytotoxic (plant) burns if used during periods of prolonged high temperature and high relative humidity. Do not spray plants under moisture stress. Do not use in combination with or immediately before or after spraying with dimethoate (Cygon) or fungicides such as Captan, Folpet, Dyrene, Karathane, Morestan, sulfur, or any product containing sulfur. Use with Bravo is not recommended.			
pyrethrins + rotenone (Pyrellin)	EC	1 - 2 pts	0
soap, insecticidal (M-Pede)	49% EC	1 - 2 gals/100 gals H_2O	0
sulfur	see individual brand labels		---
SPIDER MITE:			
abamectin (Agrimek)	0.15 EC	8 - 16 ozs	7
dicofol (Kelthane)	MF- 4 EC	3/4 - 1 1/2 pts	2
malathion	5 EC	1 1/2 pts per 100 gals	1
MOLE CRICKETS			
diazinon	14 G	7 lbs	preplant
	AG500	1 qt	preplant, broadcast
PLANT BUGS			
carbaryl (Sevin) (tarnished plant bug)	80S (WP)	1 1/2 - 2 1/2 lbs	0
cyhalothrin (Karate, Warrior)	1 EC	2.56 - 3.84 ozs	5 - caution, read label
pyrethrins + rotenone (Pyrellin)	EC	1 - 2 pts	0
soap, insecticidal (M-Pede)	49% EC	1 - 2 gals/100 gals H_2O	0
PSYLLIDS			
azadirachtin (Neemix)	0.25%	2 1/2 pts/100 gals $H^2 0$	1
methyl parathion	4 EC	1 - 3 pts	15
pyrethrins + piperonyl butoxide (Pyrenone)	66% L (EC)	2 - 12 ozs	20
rotenone (Rotacide)	EC	1 gal	0
SALTMARSH CATERPILLARS			
Bacillus thuringiensis	See individual brand labels		0
SOUTHERN ARMYWORMS (See also: Armyworms)			
cyfluthrin (Baythroid)	2 EC	2.8 ozs	0
cyhalothrin (Karate, Warrior)	1 EC	2.56 - 3.84 ozs	5 - caution, read label
diazinon AG500	4 EC	3/4 - 1 pt	1
esfenvalerate (Asana XL)	0.66 EC	5.8 - 9.6 fl ozs	1

Insecticide	Formulation	Formulation Rate/Acre	Min Days to Harvest
SOUTHERN ARMYWORMS (cont.) (See also: Armyworms)			
methomyl (Lannate LV)	2.4 L	1 1/2 - 3 pts	1
permethrin (Ambush) (Pounce)	2 EC 3.2 EC	3.2 - 12.8 ozs 2 - 8 ozs	up to day of harvest
Note: Permethrin (Ambush, Pounce) only for Florida use where final market is for fresh tomatoes. Do not use on cherry tomatoes or any variety used to produce fruit less than 1" (one inch) in diameter. Permethrin can be applied by air or ground. Use sufficient water to obtain uniform coverage. Do not apply more than 1.2 lbs. active ingredient per acre per season which is equivalent to 76.8 ozs. of Ambush 2 EC or 48 ozs. of Pounce 3.2 EC.			
SOWBUGS			
carbaryl (Sevin)	5 B	20 - 40 lbs	0
STINK BUGS			
azinphosmethyl (Guthion) (green stinkbugs)	2S, 2L (EC)	1 1/2 - 2 pts	up to day of harvest
carbaryl (Sevin) (suppression)	80S (WP)	1 1/2 - 2 1/2 lbs	0
cyfluthrin (Baythroid)	2 EC	1.6 - 2.8 ozs	0
cyhalothrin (Karate, Warrior)	1 EC	2.56 - 3.84 ozs	5 - caution, read label
endosulfan (Phaser, Thiodan)	3 EC	1 - 1 1/3 qts	2 - field & greenhouse
pyrethrins + rotenone (Pyrellin)	EC	1 - 2 pts	0
THRIPS			
azinphosmethyl (Guthion)	2S, 2L (EC)	2 - 3 pts	up to day of harvest
cyfluthrin (Baythroid)	2 EC	1.6 - 2.8 ozs	0
imidachloprid (Admire)	2.0 EC	16 - 24 ozs	21 - soil
malathion (Cythion)	5 EC	1 1/2 - 2 pts	1
oil (Sun Spray)	98.8%	1 - 2 gals/100 gals H^2O	1
Note: Sun Spray oil can cause phytotoxic (plant) burns if used during periods of prolonged high temperature and high relative humidity. Do not spray plants under moisture stress. Do not use in combination with or immediately before or after spraying with dimethoate (Cygon) or fungicides such as Captan, Folpet, Dyrene, Karathane, Morestan, sulfur, or any product containing sulfur. Use with Bravo is not recommended.			
pyrethrins + piperonyl butoxide (Pyrenone)	66% L (EC)	2 - 12 ozs	0
pyrethrins + rotenone (Pyrellin)	EC	1 - 2 pts	0
soap, insecticidal (M-Pede)	49% EC	1 - 2 gals/100 gals H_2O	0

Insecticide	Formulation	Formulation Rate/Acre	Min Days to Harvest
TOMATO FRUITWORMS (CORN EARWORM)			
azadirachtin (Neemix)	0.25%	2 1/2 pts/100 gals H^2O 150 - 300 gals/acre	1
azinphosmethyl (Guthion)	2S, 2L (EC)	3 - 6 pts	up to day of harvest for 3 pts or less; 14 for 3+ pts
Bacillus thuringiensis	See individual brand labels		0
carbaryl (Sevin)	80S (WP)	1 1/2 - 2 1/2 lbs	0
chlorpyrifos (Lorsban) (except cherry tomatoes)	50 W	2 lbs	14
cryolite (Kryocide)	96 WP	15 - 30 lbs	wash fruit
cyfluthrin (Baythroid)	2 EC	1.6 - 2.8 ozs	0
cyhalothrin (Karate, Warrior)	1 EC	2.56 - 3.84 ozs	5 - caution, read label
endosulfan (Phaser, Thiodan)	3 EC	1 1/3 qts	2
esfenvalerate (Asana XL)	0.66 EC	5.8 - 9.6 fl ozs	1
methamidophos (Monitor)	4 EC	1/2 - 1 1/2 pts	7
methomyl (Lannate LV)	2.4 L	1 1/2 - 3 pts	1
methyl parathion (Penncap M)	2 EC	4 pts	15
permethrin (Ambush) (Pounce)	2 EC 3.2 EC	3.2 - 12.8 ozs 2 - 8 ozs	up to day of harvest
Note: Permethrin (Ambush, Pounce) only for Florida use where final market is for fresh tomatoes. Do not use on cherry tomatoes or any variety used to produce fruit less than 1" (one inch) in diameter. Permethrin can be applied by air or ground. Use sufficient water to obtain uniform coverage. Do not apply more than 1.2 lbs. active ingredient per acre per season which is equivalent to 76.8 ozs. of Ambush 2 EC or 48 ozs. of Pounce 3.2 EC.			
bamectin (Agrimek)	0.15 EC	8 - 16 ozs	7
azinphosmethyl (Guthion)	2S, 2L (EC)	3 - 6 pts	up to day of harvest for 3 pts or less; 14 for 3+ pts
carbaryl (Sevin)	80S (WP)	1 1/2 - 2 1/2 lbs	0
chlorpyrifos (Lorsban) (except cherry tomatoes)	50 W	2 lbs	14
cryolite (Kryocide)	96 WP	15 - 30 lbs	wash fruit
cyfluthrin (Baythroid)	2 EC	2.8 ozs	0

Insecticide	Formulation	Formulation Rate/Acre	Min Days to Harvest
TOMATO FRUITWORMS (CORN EARWORM) (cont.)			
cyhalothrin (Karate, Warrior)	1 EC	2.56 - 3.84 ozs	5 - caution, read label
esfenvalerate (Asana XL)	0.66 EC	5.8 - 9.6 fl ozs	1
methamidophos (Monitor) (fresh fruit only)	4 EC	1/2 - 1 1/2 pts	7
methomyl (Lannate LV)	2.4 L	1 1/2 - 3 pts	1
permethrin (Ambush) (Pounce)	2 EC 3.2 EC	3.2 - 12.8 ozs 2 - 8 ozs	up to day of harvest
Note: Permethrin (Ambush, Pounce) only for Florida use where final market is for fresh tomatoes. Do not use on cherry tomatoes or any variety used to produce fruit less than 1" (one inch) in diameter. Permethrin can be applied by air or ground. Use sufficient water to obtain uniform coverage. Do not apply more than 1.2 lbs. active ingredient per acre per season which is equivalent to 76.8 ozs. of Ambush 2 EC or 48 ozs. of Pounce 3.2 EC.			
Pheromones (NoMate TPW Spiral) (NoMate TPW Fiber)	The product funtions by disrupting mating communications of adult moths. Read label carefully.		See label
TUBERWORMS			
azinphosmethyl (Guthion)	2S, 2L (EC)	2 1/4 - 3 pts	0
VEGETABLE WEEVIL			
pyrethrins + rotenone (Pyrellin)	EC	1 1/2 - 2 pts	0
WHITEFLIES			
azadirachtin (Neemix)	0.25%	2 1/2 pts/100 gals $H^{2}0$ 150 - 300 gals/acre	1
azinphosmethyl (Guthion)	2S, 2L (EC)	1 1/2 - 2 pts	up to day of harvest
chlorpyrifos (Lorsban) (except cherry tomatoes)	50 W	2 lbs	14
cyhalothrin (Karate, Warrior)	1 EC	2.56 - 3.84 ozs	5 - caution, read label
endosulfan (Phaser, Thiodan)	3 EC	1 1/3 qts	2 - field & greenhouse
esfenvalerate (Asana XL)	0.66 EC	5.8 - 9.6 fl ozs	1
imidachloprid (Provado) (Admire)	1.6 EC 2.0 EC	3.75 ozs 16 - 24 ozs	0 - foliar 21 - soil
malathion (Cythion)	5 EC	1 1/2 - 2 pts	1
methamidophos (Monitor) (apply in tank mix with pyrethroids)	4 EC	1 1/2 - 2 pts	7

Insecticide	Formulation	Formulation Rate/Acre	Min Days to Harvest
WHITEFLIES (cont.)			
oil (Sun Spray)	98.8%	1 - 2 gals/100 gals $H^2$0	1
Note: Sun Spray oil can cause phytotoxic (plant) burns if used during periods of prolonged high temperature and high relative humidity. Do not spray plants under moisture stress. Do not use in combination with or immediately before or after spraying with dimethoate (Cygon) or fungicides such as Captan, Folpet, Dyrene, Karathane, Morestan, sulfur, or any product containing sulfur. Use with Bravo is not recommended.			
permethrin (ambush)	25W	3.2 - 12.8 ozs	0-Ambush 7-Monitor Apply as a tank mix with Monitor 4, ground spray only.
pyrethrins + piperonyl butoxide (Pyrenone)	66% L (EC)	2 - 12 ozs	0
pyrethrins + rotenone (Pyrellin)	EC	1 - 2 pts	0
soap, insecticidal (M-Pede)	49% EC	1 - 2 gals/100 gals H_2O	0
WIREWORMS			
diazinon	14 G 4 EC	21 - 28 lbs 3 - 4 qts	preplant preplant, broadcast
dichloropropene (Telone)	II, C-17	see labels	---
YELLOW-STRIPED ARMYWORMS (See also: Armyworms)			
azinphosmethyl (Guthion)	2L, 2S (EC)	3 - 6 pts	up to day of harvest for 3 pts; 14 - 3+ pts
cyhalothrin (Karate, Warrior)	1 EC	2.56 - 3.84 ozs	5 - caution, read label
endosulfan (Phaser, Thiodan)	3 EC	1 1/3 qts	2
esfenvalerate (Asana XL) (Western Yellow Striped)	0.66 EC	5.8 - 9.12 ozs	1

NOTE OF IMPORTANCE: Cyhalothrin (Karate, Warrior) has recently been labeled statewide for use in Florida. Karate is labeled for use in some counties, but not others, likewise for Warrior (i.e. Warrior is to be used in south Florida counties while Karate is to be used in north and west Florida counties). Also if applied for control of beet, fall, yellow-striped or southern armyworms, it is to be used for first and second instar stages only. Cyhalothrin only suppresses populations of aphids, leafminers and whiteflies.

Nematicides Registered For Use on Florida Tomato

		Row Application (6' row spacing - 36" bed)[4]			
Product	Broadcast (Rate)	Recommended Chisel Spacing	Chisels (per Row)	Rate/Acre	Rate/1000 Ft/Chisel
FUMIGANT NEMATICIDES					
Methy Bromide[3]					
98-2	240-400 lb	12"	3	120-200 lbs	5.5-9.1 lb
80-20	225-350 lb	12"	3	112-175 lbs	5.1-8.0 lb
75-25	240-375 lb	12"	3	120-187 lbs	5.1-8.5 lb
70-30	300-350 lb	12"	3	150-175 lbs	6.9-8.0 lb
67-33	225-375 lb	12"	3	112-187 lbs	5.1-8.5 lb
57-43	350-375 lb	12"	3	175-187 lbs	8.0-8.5 lb
50-50	340-400 lb	12"	3	175-250 lbs	8.0-11.4 lb
Chloropicrin[1]	300-500 lb	12"	3	150-250 lbs	6.9-11.4 lb
Telone C-17	10-17 gal	12"	3	5-8.5 gal	30.3-50.2 fl oz
Telone II[2]	12-15 gal	12"	3	6-7.5 gal	26.4-52.8 fl oz
Vapam	50-100 gal	5"	3	25-50 gal	1.1-2.2 gal
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, dosage may be reduced by 33%.

[2] Telone II and Telone C-17 are for retail sale and use only by applicators who have completed the DowElanco training program or persons under their direct supervision.

[3] Use of methyl bromide for agricultural soil fumigation is scheduled for phaseout Jan 1, 2001.

[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.

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 May 25, 1996 as a reference for the commercial Florida tomato grower. The mentioning of a chemical or propietary 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.

Prepared by: J. W. Noling, Extension Nematology, CREC, Lake Alfred, FL

TOMATO PLANT DISEASE CONTROL GUIDE

T.A. Kucharek

Crop	Chemical	Maximum Rate/Acre/ Application	Crop	Min. Days to Harvest	Pertinent Diseases	Select Remarks
Tomato	**For best possible chemical control of bacterial spot, a copper fungicide must be tank-mixed with a maneb or mancozeb fungicide.					
	Ridomil 2E Ridomil 50W	8 pts/trtd acre 4 lbs.	12 pts/trtd acre 6 lbs/trtd acre		Pythium diseases	See label for use at & after planting.
	Kocide 101, Blue Shield, or Champion WP'S	4 lbs.		2	Bacterial spot	
	Kocide LF, Cuproxat or Champion FL'S	5⅓pts.		2	Bacterial spot	
	Kocide 606	3 qts.		2	Bacterial spot	
	Champ	2⅔ pts.		2	Bacterial spot	
	Basicop or Basic Copper 53	4 lbs.		2	Bacterial spot	
	Oxycop WP	6 lbs.		2	Bacterial spot	
	Microsperse C.O.C. 53WP	4 lbs.		2	Bacterial spot	
	Manex FL	2.4 qts.	16.8 qts.	5	Early & late blight, Gray leaf spot, Bacterial spot[1]	Field & Greenhouse use
	Kocide or Blueshield DF'S	4 lbs.		2	Bacterial spot	
	Maneb 80 WP	3 lbs	21 lbs.	5	Same as Manex FL	Field & Greenhouse use
	Dithane F 45 FL	2.4 pts.	16.8 qts.	5	Same as Manex FL	
	Dithane, Penncozeb or Manzate 200 DF'S	3 lbs.	21 lbs.	5	Same as Manex FL	

Crop	Chemical	Maximum Rate/Acre/ Application	Crop	Min. Days to Harvest	Pertinent Diseases	Select Remarks
	JMS Stylet Oil	3 qts.		NTL	Potato Virus Y Tobacco Etch Virus	See label for specific info on appl. technique (e.g. use of 400 psi spray pressure)
	Ridomil/Copper 70W	2.5 lbs.[3]		14	Late blight	Limit is 3 appl/crop
	Sulfur			1	Powdery mildew	Not yet found in field-produced tomatoes in Florida.
	Aliette WDG	5 lbs.	20 lbs.	14	Phytophthora root rot	Using potassium carbonate or Diammonium phosphate, the spray of Aliette should be raised to a pH of 6.0 or above when applied prior to or after copper fungicides.
	Bravo Ultrex 82.5 WDG	2.75 lbs.		2	Early & Late blights, Gray leafspot, Target spot, Botrytis, Rhizoctonia fruit rot	Use higher rates at fruit set.
	Botran 75W	1 lb.	4 lbs.	10	Botrytis	Greenhouse tomato only. Limit is 4 applications. Seedlings or newly set transplants may be injured.

Crop	Chemical	Maximum Rate/Acre/ Application	Crop	Min. Days to Harvest	Pertinent Diseases	Select Remarks
	Bravo 720, Terranil 6L or Echo 720	3 pts.		2	Early & late blight, Gray leaf spot, Target spot	Use higher rates at fruit set & lower rates before fruit set.
	Maneb 75DF	3 lbs.	22.4 lbs.	5	Same as Manex FL	
	Bravo 90DG or Terranil 90DF Echo 90DF	2 ¼ lbs. 2.3 lbs. 2.3 lbs.		2	Early & late blight, Gray leaf spot, Target spot	Use higher rates at fruit set & lower rates before fruit set.
	Bravo W75	3 lbs.		1	Early & late blight, Gray leaf spot, Target spot	
	Bravo 500, Chloronil 500, Terranil 4L, Evade, Supanil, Echo 500, or Agronil FL'S	4 pts.		2	Early & late blight, Gray leaf spot, Target spot	Use higher rates at fruit set & lower rates before fruit set.
	Ridomil Bravo 81W	3 lbs.		2	Early & late blight, Gray leaf spot, Target spot	Limit is 4 appl/crop
	Ridomil MZ58 WP[2] Ridomil MZ72WP[2]	2 lbs. 2.5 lbs.	8 lbs. 7.5 lbs.	5 5	Late blight Late blight	Limit is 4 appl/crop Limit is 3 appl/crop
	Benlate 50WP	1 lb.		1	Leaf mold, Botrytis, Sclerotinia	
	Bravo CM	6 lbs.		5	Bacterial spot, Bacterial speck, Target spot, Early & Late blights, Gray leaf spot	

Crop	Chemical	Maximum Rate/Acre/ Application	Crop	Min. Days to Harvest	Pertinent Diseases	Select Remarks
	Exotherm Termil	1 can/1000 sq.ft.		2	Botrytis, Leaf mold, Late & Early blights, Gray leafspot	Greenhouse use only. Allow can to remain overnight & then ventilate. Do not use when greenhouse temperature is above 75F

[1]When tank mixed with a copper fungicide

[2]Do not exceed limits of mancozeb active ingredient as indicated for Dithane, Penncozeb, Manex or Manzate 200.

[3]Maximum crop is 3.0 lbs. a.i. of metalaxyl from Ridomil/copper, Ridomil MZ 58 & Ridomil Bravo 81W.