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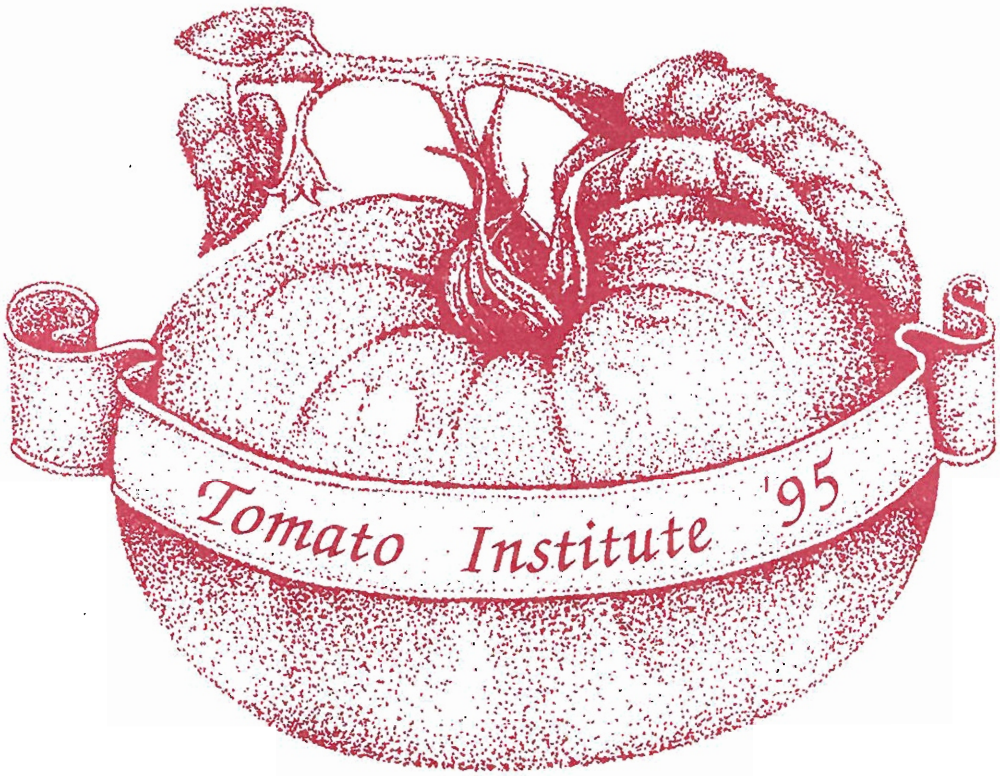

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Competition With Mexico

Wayne Hawkins
Florida Tomato Committee

The total acres of tomatoes harvested in Central and South Florida for the 1994-95 season was 43,735 compared to 45,189 the previous season. Total shipments for the season were 55,458,918 25-lb. equivalents compared to 58,983,923 for 1993-94. The season's average price was $7.00 per 25-lb. equivalent compared to $7.30 in 1993-94. The average varied throughout different growing areas with a high in the Homestead area of $8.27 and a low in Ruskin-Palmetto of $6.14. The total value of the crop at the farm level was $388,327,831, compared to $430,798,488 last season.

There are many factors that contributed to this very poor season. Tropical Storm Berl in late August followed by heavy rains in September delayed laying of plastic in all areas. Tropical Storm Gordon visited the State of Florida twice in mid-November adding more rain, blown down plants and blew off young fruit and bloom, particularly in Homestead and on the lower East Coast. Conditions in the fall were very wet and plants were damaged by strong winds, but sweet potato whitefly and geminivirus were not as bad as in previous years. Cold, windy weather in late January damaged crops which reduced yields. A near freeze in early February caused a lot of replanting in Ruskin and Palmetto. Finally, in late March the weather changed from winter to summer. We had beautiful crops with bumper yields in April and May with heavy rains in early June ending the season on a sour note.

Prices were good in the fall and continued good through January. Beginning in early February, Mexico flooded the market with excessive shipments which continued at higher than normal amounts for the balance of the season. Although Florida shipments were light until late April, every time an effort was made to raise the price for Florida tomatoes, Mexico immediately increased shipments by thousands of packages daily forcing adjustments and lowering prices. By late April, Florida had bumper crops and cheap prices. Mexico's unusually large shipments in May prevented Florida shipments to the West Coast and caused depressed prices for the balance of the season. Many tomatoes in Ruskin and Palmetto were sold for less than the picking and packing costs and millions of boxes were left in the field.

In January, the Florida Tomato Exchange began a very active roll in Washington, D.C. to try and get some relief from excessive Mexican shipments. Due to surge shipments Mexico dumped tomatoes in the U.S. in the Spring of 1993 and 1994. As it turned out, 1995 was even worse with Mexican imports for January through April exceeding 1994 shipments by 39%. Many of these were consigned all over the United States. I know repackers in Tampa and Miami that paid $1.00 a box for Mexican tomatoes during the peak of the Florida season.

Many meetings were held in Washington with members of the Florida Congressional Delegation and Representatives from other states. Senator Graham and Representatives Canady, Foley and Thurman earned gold stars for their efforts. In spite of all this help, very little was accomplished.

Two meetings were held with Ambassador Mickey Kantor, the Trade Representative for the U.S. These meetings were attended by a representative of the President; Senator Graham; Florida Commissioner of Agriculture Bob Crawford and his Deputy, Martha Roberts; a representative of the Governor's office; a representative from FFVA; and Paul DiMare, Peter Harllee and Wayne Hawkins representing the Florida Tomato Exchange.

As a result of the first meeting with Ambassador Kantor, the Florida Tomato Exchange filed a Section 202 petition under the Trade Laws of 1974 with the International Trade Commission (ITC) asking for provisional relief from imports of fresh winter tomatoes from Mexico.

It was decided to take this action instead of filing a Section 201 petition under the same laws or an anti-dumping petition since the 202 petition requires the ITC to make a preliminary decision in 21 days and forward their recommendations for relief to the President of the United States, who has seven days to take action. The 201 petition and the anti-dumping actions take six to eight months to get any findings.

The Industry got a quick answer, but it was not the one they wanted. They did, however, prove that the trade remedies presently on the books are not designed for perishable or seasonal commodities. The Exchange knew this in advance, but could not convince the U.S. Trade Representative's office that they couldn't win under the present laws. Just to illustrate how ridiculous the situation really is, let me point out some of the ITC's findings.

1. The ITC determined there was no difference between regular round tomatoes, pear-shaped tomatoes, greenhouse and hydroponic tomatoes or cherry tomatoes, even though scientifically they are defined separately and have different number classifications in the tariff schedules of the U.S.

2. They ruled that Florida could not be classified as the "Winter Tomato Industry" even though Florida ships more than 95% of the domestically grown tomatoes in the U.S. during the months of January through April each year.

3. They ruled Florida must file for relief for a 12-month period even though we have practically no tomatoes for five of those months.

4. They ruled there is only one fresh tomato industry in the U.S. and it covers all 50 states and includes round tomatoes, pear or plum tomatoes, cherry tomatoes, greenhouse and hydroponic tomatoes and even back yard tomatoes if you sell some at a roadside stand.

5. All of the above would be included in an investigation and would be required to answer questionnaires that the ITC estimates would take 30 to 40 hours to complete. Unless a large percentage respond, the investigation would not continue.

6. Lastly, they stated, "that although 100 tomato growers and 23 tomato handlers have gone out of business in Florida in the last five years, we conclude that the domestic industry is not suffering serious injury or threat thereof."

Follow-up meetings with the ITC after their ruling confirmed our belief that subsequent actions under Section 201 or an anti-dumping petition would result in the same finding. With this information, the Exchange, Senator Graham and Commissioner Crawford went back to Ambassador Kantor and the President's representative. We got a lot of promises! Only time will tell if we really won anything. We were assured that:

1. The USTR and the President would support our efforts to amend the trade laws so petitions for relief can be filed by perishable commodity groups or seasonal industries.

2. Efforts would be made with ITC to administratively change their definitions of an "industry" and "like or competitive products."

3. Strong efforts will be made to enforce the laws presently on the books or amend them to make them enforceable. These include:

(a) Country of Origin Labelling;

(b) Require Mexico to use the same terms and definitions in the U.S. Grade Standards that are used by the domestic industry; and

(c) Require Mexico to pack tomatoes the same as Florida does.

4. It was agreed to find out why monitoring of Mexican tomato and pepper imports as required by NAFTA is not being done.

5. Formal consultations will be held with Mexico to try and arrange an exchange of accurate planting and harvesting information.

6. Appoint a NAFTA Dispute Group as required by law to work on solving some of these problems.

7. Change the tariff rate quota (TRQ) to a weekly basis instead of the present multi-month basis. This is the snap-back provision of NAFTA that requires the duty to go back to the pre-NAFTA level when the TRQ is exceeded. The present system is non-workable.

8. Correct incompatible statistics. Presently, statistics are compiled by the Market News Service, the Customs Service, and APHIS. None of them are the same. The goal is to develop one set of accurate figures and make them available daily instead of weeks after the fact.

They also agreed to increase purchases of fresh tomatoes for use in the school lunch program and expedite Market Promotion Funds for our use in expanding foreign markets, such as Canada.

The Exchange was also successful in having several Representatives from Florida introduce a peso devaluation bill. It simply states that a duty equal to the peso devaluation will be charged on all imports of tomatoes from Mexico until the peso stabilizes at the rate it was when NAFTA passed. It may not be approved, but it will bring attention to the very unfair trade practices going on between the U.S. and Mexico. The Florida tomato industry has always supported "free trade," but we have also said it must be "fair trade."

I have pages of promises from President Clinton and Ambassador Kantor in my files that are now being ignored. Hopefully, this list will not join my "dead" file. Only time will tell. I can assure you, the Florida Tomato Exchange will not give up. We will push hard for all of the things we were promised and will continue to seek other remedies if and when they develop.

Thank you.

THE SITUATION AND COMPETITION BETWEEN FLORIDA AND MEXICO: THE RULES OF THE GAME ARE CHANGING

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Introduction

Mexico has significantly increased its role in the supply of fresh fruit and vegetables in the North American market over the last 3 decades. Its diverse agronomic environment allows it to ship produce all year. In 1994, Mexico supplied more than 10 percent of the most competitive fresh vegetables marketed in the U.S. in the winter season (tomatoes, bell peppers, cucumbers, squash, eggplant and green beans) in 7 months of the year (table 1) and more than 5 percent of the U.S. market in the remaining 5 months. Most of Mexico's exports to the U.S. occur in the winter months of January to April, in direct competition with Florida. Mexico shipped 75% of its total fresh vegetable exports in the January to April market window. While the domestic market in Mexico has been growing in importance, the U.S. remains the primary market for fresh vegetables grown in many of the key producing areas of Mexico. VanSickle et al. (1994) report that up to 30% of the vegetables grown in Sinaloa for the export market was actually shipped to domestic markets. These vegetables were shipped to Mexican markets in part because of increasing demand for higher quality product in Mexico, but more so because of not being able to meet higher export standards imposed by the Mexican Confederation of Agricultural Associations in Sinaloa (CAADES).

Prior to World War II, Mexico played a small role in the supply of fresh vegetables to U.S. markets. Encouraged with considerable U.S. investment and expertise, and the support of the Mexican government, the commercial fresh produce industry grew in significance after World War II. Mexican exports to U.S. markets were relatively minor until the mid-1950's when ,led by tomatoes, considerable expansion really began (table 2).

Several factors contributed to this upward trend in Mexican production and exports to North American markets. First, cessation of trade with Cuba in 1962 created an opportunity for Mexico to export produce into U.S. markets. Cuba had been a major supplier of many fresh produce items in the U.S. winter market. The embargo eliminated Cuban produce from this market and opened a window of opportunity that Mexican growers siezed.

Second, the U.S. Bracero Program was terminated in 1964. This program allowed large-scale use of cheap guest labor in the production of fresh produce in the U.S. Termination of the program reduced the availability of low-cost labor and eroded the competitive position of many U.S. growing areas while enhancing the position of Mexican growers who still had access to this lower cost labor.

Finally, there was considerable flow of financial resources and technical expertise from the U.S. (Emerson, 1980; Bredahl et al., 1983),a factor which continues to be considerable. This flow of capital and expertise helped Mexican growers attain gains in productivity that enhanced their ability to compete with U.S. growers. Flows of financial resources and technical expertise continue to be important and are likely to grow as a result of the North American Free Trade Agreement (NAFTA) and other developments affecting production in major U.S. producing areas.

Mexico's sustained level of growth led to considerable competition in the U.S. winter produce market with growers primarily located in Florida. After experiencing market share losses, Florida growers sought protection in the 1970's and early 1980's through various channels which led to several trade and legal battles (Bredahl et al., 1987). In response, the Mexican Government adopted a set of export controls during the 1980's that had the effect of reducing the position of Mexican produce in U.S. markets. These controls included limiting acreage planted for export markets, and varying the quality and maturity restrictions in reaction to current market conditions.

These controls were implemented because of the sensitivity of Mexico's trade relations with the U.S. As a result, Mexico became more of a swing supplier to U.S. markets, supplying produce throughout the year and increasing their exports during periods of U.S. production shortfalls caused by weather (e.g., freezes, hurricanes and tropical storms). Mexico's policies during this period gave Florida the necessary breathing space to develop and apply new productivity enhancing technologies which allowed Florida to increase its market share.

The current macroeconomic climate in Mexico has resulted in some uncertainty in all of Mexico. It is unlikely, however, to hold any adverse implications for the Mexican fresh fruit and vegetable industry. It may even benefit a growing Mexican produce industry. Other factors impacting the outlook for Mexican fresh produce in the U.S. and Canada are NAFTA, land reform in Mexico and increasing government regulations in the U.S. All of these factors provide Mexican growers an opportunity to expand their production and exports to U.S. markets, maintaining the current level of damage being felt by Florida growers from increased Mexican imports.

Current State of Affairs

While Mexico sells fresh fruit and vegetables in the U.S. year round, capitalizing on its diverse agronomic environment, the winter market of January through April is the primary period when Mexico ships most of its fresh vegetables into the U.S. Most of those shipments come from the Mexican state of Sinaloa.

Since 1980, the U.S. market for fresh vegetables has increased significantly. Green beans, eggplant, squash, bell peppers, cucumbers and tomatoes have especially capitalized on this growing market (Table 3). For the period 1980 to 1991, these vegetables increased in total shipments from all domestic and foreign suppliers to U.S. markets by 54 percent in the December to April market window. Exports of these vegetables from Mexico to U.S. markets increased by more than 47 percent.

There are several factors currently impacting the economics of producing fresh vegetables in Mexico for North American markets. These include the North American Free Trade Agreement (NAFTA), increasing international competition, increasing government regulation and the macroeconomic situation in Mexico. Each of these stands to impact Mexico fresh vegetable production and trade.

Marketing channels for Mexican produce in U.S. markets is much the same as that for produce marketed from U.S. growers, after it reaches distributors sheds at the border. Distributors on the U.S. side of the border provide selling services similar to those provided by packer/shippers in the U.S. The major difference in the marketing channel lies in the extra steps required before reaching the distributors shed. In Mexico, produce is harvested and hauled to packing sheds where it is cleaned, sorted, and packed in cartons for shipment. Produce intended for the export market is then shipped to the border to enter the U.S. market. Most produce is shipped by truck, however an estimated 15 percent of the produce exported from Sinaloa is shipped by piggyback on rail to the border and then offloaded for entry into U.S. markets through Nogales, Arizona, the major point of entry for Mexican exports during the winter season. All produce is taken to Mexican compounds for inspection and clearance for export by Mexican customs. Produce is also inspected at that point by U.S. Federal-State inspectors to insure that it meets all minimum regulations required in U.S. markets.

Mexican trailer trucks then proceed to the U.S. customs compound where customs officials inspect the produce for contraband and where phytosanitary and FDA inspections are performed. Mexican carriers are then permitted to haul the trailers into border facilities on the U.S. side of the border where it must be offloaded into distributors storage sheds. These distributors then enter the produce into the U.S. marketing system much like packer/shippers of U.S. domestic produce.

Most fresh tomatoes are marketed vine ripe from Mexico and as mature greens from Florida. Most tomatoes shipped from Florida go through repackers who resort, grade and repack the tomatoes for marketing to the wholesale and institutional trade. These repacking fees add as much as $2.00 per carton to the cost of Florida tomatoes before they reach the same markets served by

Mexican distributors.

Currently, most growers in Mexico are private landholders who form groups to organize production and marketing. Past constraints imposed by land reform laws limited individuals to no more than 100 hectares of irrigated land. Large farms registered their land in the name of a number of individuals, usually family members. A few ejidos are also organized to export vegetables, but their production accounts for no more than 5 percent of Sinaloa's production, the Mexican state which accounts for most of the fresh vegetables shipped into the winter U.S. market.

The larger groups of producers tend to be vertically integrated by operating their own distributors at the border. These distributors not only handle their own production, but also that of smaller growers. In Nogales, Arizona, about 110 distributors operate to handle produce exported into U.S. markets. The bulk of these exports are concentrated, however, with the top 4 distributors accounting for more than 20 percent of the fresh vegetable shipments in 1990. This concentration was even higher for select produce items with the top 4 distributors of cherry and mature green tomatoes handling 68 and 77 percent, respectively.

Domestic markets in Mexico have been growing in importance over the last decade, claiming as much as 30 percent of the production for some items. The major markets are Mexico City, Guadalajara, Monterey and Torreon. About 60 percent of the volume goes to Mexico City with Guadalajara claiming 15 percent. Shipments from the major producing areas are generally controlled by government committees. For example, the Sinalao Committee for Regulating Vegetables regulates shipments from the Mexican State of Sinaloa. Each shipment must be accompanied by a manifest that is checked at one of the check stations located on the major roads en route to the major markets. Each load is inspected at these check stations to verify that the product is packaged properly and that the quality meets standards set by the Committee.

The Sinaloa Committee for Regulating Vegetables meets each week beginning around the first week of December to set quality standards for the domestic market. The Committee has representatives from private producers and the ejidos. In recent years quality standards have been similar to those required in export markets for many vegetables. One factor contributing to these improvements in quality standards is increasing competition from U.S. producers. U.S. producers have sold produce in Mexico during the Mexican growers off season, with a quality that has been higher than that produced and sold by Mexican growers. This has increased demand for higher quality produce in Mexico.

Produce is sold in Mexico much like it is in the U.S. Some produce is shipped to wholesale markets and consigned to brokers who are given the responsibility of selling the product for the best price possible. The alternative is to sell the product prior to shipment, to representatives of wholesalers located in the shipping area. Selling to wholesalers representatives is the most common method used, but as in U.S. markets, Mexican growers are not shy about shipping produce to markets unsold, hoping to get a fair return when it is sold by consignment brokers. Mexican shippers rely on consignment selling in Mexico and in the U.S., much more so than U.S. shippers.

Most produce grown by commercial growers in Mexico is intended for the export market, however a growing domestic market has claimed more of the production from these farms. While the quality of produce marketed in Mexican markets has improved significantly over the last few years, the best quality is still generally reserved for the export market. Greater demands in the domestic market have led export growers to ship as much as 30 percent of their production to domestic markets.

While the domestic market has grown in importance, it still remains the market of second choice for most growers. Most growers produce for sales in U.S. markets. The growing Mexican market does however provide Mexican growers with alternatives that allow them to shift product to markets that return them higher returns. As of today, those higher returns still generally reside in the U.S.

Changing Stucture of the Mexican Produce Industry

While Mexico has established itself as a major supplier of many fresh fruits and vegetables in the U.S. market, several changes are in motion that will impact the role Mexican producers play in the supply of fresh produce in the next decade. These include international agreements and U.S. and Mexican policies that impact the profitability of the industries in their respective countries. Following is a brief discussion of some of the more interesting and important issues facing the produce industries in the U.S. and Mexico.

North American Free Trade Agreement

The North American Free Trade Agreement(NAFTA) includes many provisions that will change the competitive position produce growers hold in international markets. Two critical elements of NAFTA that are important to fresh produce growers are removal of tariff and non-tariff barriers and transportation reform.

Tariff Reduction. First of all, NAFTA will remove tariffs on most produce items within the 10 years following its implementation in January, 1994. The potential impact of these tariff removals were highly debated during NAFTA negotiations. Many growers in the U.S. believed that the removal of these tariffs would give Mexican growers an advantage they could not compete against and that it would drive U.S. growers out of the market. The economics of these arguments were difficult to prove however, because tariffs represent a small portion of the relative cost of production and marketing for Mexican growers, ranging from 4.2 percent for squash to 14.4 percent for cucumbers (VanSickle et al.). Tariffs comprise 13.7 percent of the costs for tomatoes. Stating these savings in absolute savings appear more significant, however, with savings ranging from $96.14 per acre for squash to $768.67 per acre for cucumbers.

A more important tariff impact will be felt from the removal of tariffs on grain and soybean products. Many of the agricultural areas within Mexico that grow vegetables are also important suppliers of grain and soybean products. Mexico imposes restrictive tariffs on U.S. exports of these products that have kept U.S. exports of these products at a minimum. Removal of these tariffs give U.S. producers a competitive edge in supplying these products to Mexican markets. As Mexico loses market share for these products within their domestic market, growers will begin searching for alternative crops to grow on their land. Vegetables will be one alternative that will likely increase in production as a result of their loss in competitive advantage in grains and soybeans.

Transportation Reform. Another important element of NAFTA that will be implemented in the 6 years following the January 1, 1994, is the opening of the transportation sector between the 2 countries. In 1997, 3 years after the initial implementation of NAFTA, trucks meeting in-country standards will be able to deliver products directly to markets in the bordering states of the 2 countries. Six years after implementation of NAFTA (January 1, 2000), transportation will be deregulated to the point where trucks will be able to deliver product anywhere throughout the 2 countries, eliminating the need to offload produce at the border. This element has the potential to significantly impact the competitive position of Mexican produce in U.S. markets. It offers the opportunity of significant savings in the handling of fresh produce since the requirements that currently impose offloading of produce at the border will be eliminated. Many shippers/distributors may welcome the opportunity to relocate their entire distribution operations to the shipping areas within Mexico as long as facilities are available for communicating with wholesale markets throughout the U.S. These savings could amount to as much as 2 times the impact of the removal of tariffs. It also provides the opportunity to reduce the handling of Mexican produce as one handler in the marketing system is eliminated, raising the possibility for improved quality of product. Combined, the removal of tariffs and reform in the transportation sector could save Mexican growers 7.9 to 19.5 percent of their total production and marketing costs to U.S. markets. Table 4 demonstrates how Mexican tomato growers stand to save 13.7 percent, by saving $0.46 per box on elimination of the tariff and $0.49 per box on reduction in the selling fees to levels comparable to those in Florida. These savings are significant and will shift the competitive advantage toward Mexico. According to VanSickle, et al., Florida growers enjoyed a slight advantage in producing and marketing fresh tomatoes in U.S. markets. Taking into account the savings that may result from tariff removal and transportation reform, competitive advantage will shift to Mexico.

Land Reform

Land reform measures implemented under the Salinas administration are additional elements likely to impact the Mexican produce industry. Prior to recent land reform measures, ownership of productive land was limited to 100 hectares of irrigated land. Larger land holdings were always in danger of being expropriated by the government for redistribution to smaller farmers. Recognizing the inefficiencies created by not allowing larger growers to capitalize on economies of scale, these recent reforms were implemented to allow ownership of larger land holdings with constitutional reform eliminating the fear of expropriation of land. The land reform measures may significantly enhance the efficiency in production and marketing by increasing the scale of operations. These reforms also make it easier for foriegn investors to become involved in agricultural production as it relaxes the restrictions placed on foreign investors.

Foreign Investment

Efforts to encourage foreign investment in agriculture and agribusiness have also been promoted at the Federal level. Privatization of the banking industry has promoted more investment in agriculture as the availablity of capital has increased. Joint venture capital has also complemented the capital available to agriculture.

These efforts have led to increased foreign investment, particularly in export shipping facilities in Mexico as it helps distributors and other shippers develop more formal relationships with growers.

Another advantage being realized from additional foreign investment is the implementation of more efficient production practices. Investment in technology has been low in Mexico since funding for the formal research establishment was cut and resulted in closure of several research centers in the 1980s. Foreign investment has allowed growers and shippers to take advantage of new technology developed in the U.S. and other countries. Hybrid varieties and automated packing sheds are but 2 of the many examples of foriegn based technology being implemented in Mexico as a result of relationships growers and shippers have developed with foriegn investors. Yields for many produce items have grown significantly in recent years, and the cost of growing and marketing produce has not increased as much in Mexico as it has in the U.S. because they have capitalized on technology developed in the U.S. Productivitiy has been credited with being the greatest resource advantage Florida growers have had in competing with Mexican growers in the U.S. domestic winter vegetable market (Taylor and Wilkowski). That advantage may be disappearing as Florida and other U.S. shippers increase their involvement in Mexico and help pass new technology to Mexican growers and shippers. Table 5 shows the savings in cost of production Mexican growers could realize by increasing yields to levels comparable to Florida growers. These savings combined with savings realized by tariff removal and transportation reform could save Mexican growers 27.5 percent of their total cost of producing and selling tomatoes in U.S. markets.

U.S. Government Regulations

Mexican growers are enjoying an additional advantage in the area of government regulation. U.S. growers are facing increasing regulations in the growing and marketing of agronomic crops. Regulations on availablity and quality of water have increased as have regulations on labor management and pesticide use. Competition for water with urban areas has complicated growers' acquisition of irrigation water. Land availablitiy has also become more restricted because of regulations concerning wetlands and endangered species. Growers in many cases have had to move their operations to deal with these problems.

An even more damaging regulation could come with the removal of methyl bromide as an available soil fumigant for use in growing vegetable crops in the U.S. Methyl bromide is a broad spectrum pesticide that controls `old land disease' problems that surface from intensive farming of land. An international agreement called the Montreal Protocol has identified methyl bromide as an ozone depletor. As such, the U.S. Clean Air Act requires that it be phased out of production and use by January 1, 2001. No effective alternative has been identified as a substitute to methyl bromide. Given today's known technology, productivity (yields) will be cut 20-40 percent for vegetable crops grown in Florida that currently rely on methyl bromide. A recent study (Spreen, et al.) indicates that winter production of these vegetables in Florida will fall $620 million in f.o.b. value and that the total economic impact on Floria will be a loss of more than $1 billion and 13,000 jobs. Because Mexico is currently identified as a developing country within the Montreal Protocol, Mexican growers will be given 10 additional years to use methyl bromide. As a result, Mexico will increase exports to the U.S. by $370 million. Mexican exports of tomatoes are expected to increase 80 percent, bell peppers 54 percent and eggplant 123 percent. The dilemma surrounding methyl bromide's removal from the market is real and will significantly enhance the position of Mexico in the international market.

International Competition

One of the few uncertainties surrounding the Mexican industry is the increasing international competition that is expected over the next decade. The Enterprise for the Americas Initiative will increase competition in the international market for fresh produce. Mexico still has the advantage, however, because of its proximity to the largest and wealthiest market in the western hemisphere, a common border to the U.S. Increasing transparencies in borders will intensify the competition from other Central and South American countries, but no other country enjoys the advantage of the common border that will allow Mexico to capitalize on lower marketing costs. The largest threat to Mexico in the international arena is likely to come from Cuba which has been kept out of most western hemisphere markets by the 1962 embargo. Loss of support from the former Soviet Union and Eastern European Alliance now restricts the acquisition of necessary resources for production of quality products required in the international market. Should conditions change so that Cuba is welcomed into the international community for international trade, then Cuban growers may be able to compete with Mexico in some fresh produce trade. That increased competition will also impact Florida growers who compete in the same markets that Cuban produce will likely enter. The likely result will be that Mexico will face increased competition in our markets, but Florida growers will be even more pressured because of the direct competition Cuba will be with Florida.

Mexican Macroeconomic Environment

The macroeconomic environment has created great uncertainty for growers, shippers and investors in the Mexican produce market. Policies of the Madrid and Salinas Administrations improved the economic environment within Mexico and enhanced the investment climate. The recovery of the Mexican economy appeared to be in full swing when the rapid devaluation of the peso began late in 1994 and continued into 1995. That devaluation shook the markets within Mexico and eroded the confidence of foreign investors in Mexico. It also devastated the U.S. winter fresh tomato market as Mexico redirected product normally sold in Mexico into U.S. markets.

The conventional wisdom for devaluing a currency is that it makes imports more expensive and exports cheaper, thus improving the trade balance by reducing imports and expanding exports.

The fruit and vegetable industry in Mexico is significantly responsive to export conditions. This is due to the fact that the industry is dominated by farmer-entrepenuers and was developed and continues to cater primarily to export markets. The Mexican produce industry will benefit through expansion of exports and export revenues. These gains in export revenues will be offset to some extent by increases in the cost of raw materials used in the production process, but this increase should be minimal in the produce industry for 2 reasons. First, beyond labor most inputs required for production of fruits and vegetables are used in the pre-harvest phase of production and the inputs were already purchased before the devaluation took place. Second, most of the inputs required for production of fruits and vegetables are available in Mexico, thereby not increasing their relative cost. Therefore, higher import prices did not affect input prices Mexican growers paid during the 1994/95 production season. The result is that Mexican growers benefitted from the devaluation with higher profits than otherwise could be expected. They paid for inputs before the devaluation and received much higher prices in the export market after the devaluation took place.

An additional result of the devaluation is that Mexican growers directed more of their product to the export market. They received higher returns in the export market than were possible in their domestic market. They received higher profits with increased exports and contributed to lower returns received by Florida growers. They are now in a position to invest more of their resources in export production for following seasons.

From the standpoint of investment, the Mexican growers and shippers are often provided capital by U.S. distributors which is repaid when sales are realized. Devaluation does not hold negative implications for these investors as sales of products funneled through them are encouraged and increase. Investments in Mexican export operations should not suffer from the devaluation. Because foreign investment in Mexican produce operations has initially concentrated on production of products to be sold in the U.S., investors have realized increased profits and the devaluation should not shake their confidence.

Summary

The Mexican produce industry will likely continue its growth in market share of the U.S. produce market. NAFTA, government regulations and the Mexican economy all stand to position Mexico to become an even larger supplier of fresh produce in the U.S. The environment exists for Mexico to expand exports to new records as they participate in the increasing demand for fresh produce. New relationships are being formed as growers and shippers from the U.S. extend their role in this dynamic industry. Expansion of exports of fresh produce from Mexico to the U.S. over the last 3 years signals a new arena where competition between Florida and Mexican growers will intensify. Florida growers will need to be agressive in becoming more efficient in production and marketing, and in protecting their markets from the more intense competition that results from foreign government policies that intentionally change the competitive advantage toward their products. The 1994/95 season is an example of the impact foreign policies can have on our growers and shippers.

Florida growers also need to position themselves to produce and market high quality product in the most efficient production and marketing systems possible, or sacrifice the leadership they currently have in the winter fresh vegetable industry. The status quo no longer exists for Florida growers. Rules have and are continuing to change. Leaders will be the survivors, and Florida growers and shippers may be in the best position of the last decade to advance their interest in advancing technology and influencing policy. Good defense has been promoted by many football coaches as the best game plan, until you have been scored on. Florida's defense has been porous over the last 5 years. An offensive plan needs to be developed and that plan must include plans to become more efficient and to become the premium supplier of fresh produce in the winter market.

Table 1. Monthly shipments and market shares of Florida and Mexico tomatoes, and total U.S shipments, 1994.

Month	Florida Shipments	Florida Share	Mexico shipments	Mexico share	Total U.S. shipments
	(1,000 cwt)	(%)	(1,000cwt)	(%)	(1,000 cwt)
January	824	74.0	267	24.0	1,113
February	749	65.4	388	33.9	1,146
March	743	56.4	565	42.9	1,318
April	928	69.9	388	29.2	1,328
May	1,181	79.9	260	17.6	1,479
June	717	45.8	199	12.7	1,566
July	81	5.9	91	6.6	1,371
August	--	-	117	8.5	1,380
September	5	0.4	103	8.3	1,243
October	252	21.5	93	7.9	1,171
November	591	52.7	98	8.7	1,122
December	783	76.2	151	14.7	1,028

Source:U.S. International Trade Commission, pp. D-12 to D-13.

Table 2. U.S. tomato imports from Mexico and Cuba, and Florida production and value, 150 to 1991.

Year	Imports from Cuba	Imports from Mexico	Florida production Quantity	Florida production Value
	(------ 1,000,000 pounds		---------)	$1,000,000
1951-54	19.0	216	434	31.9
1955-59	21.7	203	527	46.5
1960-64	10.0	316	637	55.4
1965-69	0	522	709	79.0
1970-74	0	775	616	95.4
1975-79	0	636	854	173.8
1980-84	0	557	1,249	305.1
1985-89	0	686	1,668	506.2
1990	0	730	1,580	440.4
1991	0	686	1,560	577.3

Note: Shipments and values are the average values for the periods listed in the years.

Table 3. Total shipments and Mexican imports of green beans, cucumbers, eggplant, bell peppers, squash and tomatoes, and Mexican market share for the years 1981 to 1991 in the December to April market window.

Year	U.S. shipments	Mexican imports	Mexican share
1981	179,144	88,449	49.4
1985	233,744	120,669	51.6
1990	261,915	135,859	51.8
1991	276,402	130,167	47.1

Source: VanSickle et al.

Table 4. Potential savings Mexican growers may realize from NAFTA as a result of savings in tariffs and selling fees.

Vegetable	Current Cost	Tariff	Selling Average Savings	Cost Savings	Total percent of cost
	(--------		($/ carton)	----------)	(%)
Tomatoes	$7.16	$0.46	$0.49	$0.95	13.7
Bell peppers	8.15	0.70	0.21	0.91	11.1
Cucumbers	9.62	1.39	0.49	1.88	19.5
Eggplant	6.45	0.40	0.11	0.51	7.9
Squash	11.08	0.46	0.80	1.26	11.4

Source: VanSickle et al.

Table 5. Savings Mexican growers may realize from increased productivity in production to equal productivity in Florida in 1990/91.

Vegetable	Total Cost	Preharvest Cost	Mexican Yield	Florida Yield	Potential savings
	($/carton)	($/acre)	(--Cartons/acre--)		($/ctn)
Tomatoes	$7.16	$2,511	880	1,300	$0.93
Bell peppers	8.15	2,860	756	1,000	0.93
Cucumbers	9.62	1,911	553	600	0.28
Eggplant	6.45	2,881	1,226	1,700	0.66
Squash	11.08	722	209	275	0.84

Note: Potential savings were calculated as the savings that would be realized if Mexico increased yields to equal those in Florida without increasing preharvest costs.

Source: VanSickle et al., p. 65.

Table 6. Total savings Mexican growers may realize post-NAFTA

	Savings from			
Vegetable	Tariff Reduction	Transportation Reform	Increased Yield	Total Savings
	(----------------$/ctn------------------------)			
Tomatoes	$0.46	$0.48	$0.93	$1.97
Bell peppers	0.70	0.21	0.93	1.84
Cucumbers	1.39	0.49	0.28	2.16
Eggplant	0.40	0.11	0.66	1.17
Squash	0.46	0.80	0.84	2.10

Note: Potential savings were calculated as the savings that would be realized if Mexico increased yields to equal those in Florida without increasing preharvest costs.

Source: VanSickle et al., p. 65.

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CHANGES IN TOMATO SPRAY SCHEDULES-- LONG OR SHORT TERM SOLUTIONS?

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INTRODUCTION

The tomato season of 1994-95 was the first to be affected by the Federal Worker Protection Standard (WPS) for Agricultural Pesticides (Code of Federal Regulations, Title 40k Part 170) (1). It was also the first season the insecticide imidacloprid (Admire™) was registered for use on all plantings of tomatoes.

Last year a paper at this Institute examined the potential impact of the WPS on hand labor tasks in tomato production (2). This paper is a follow up to that effort, with the aim of determining which, if any, changes were the result of the Worker Protection Standard taking full effect and which might be attributed to the availability of imidacloprid (Admire™).

METHODS

Two commercial vegetable agents from southern Florida had obtained spray schedules from tomato growers for the 1993-94 season. These same growers were asked for comparable spray schedules for the 1994-95 season. These were compared to determine changes between the two seasons. A timeline was used for each year, with the type of crop protection chemical (fumigant, fungicide, herbicide, or insecticide) plus the duration of the Restricted-Entry Interval (R.E.I.) (3, 4) listed for each of the three growers. Additional columns were used to record the number of fungicide and insecticide sprays per specific application. This allowed the authors to calculate both seasonal and weekly totals for both types of products for each grower and for each year. These data have been summarized in Figures 1 and 2 and are not presented as a table.

A second chart (Table 1) was complied to determine the number of applications of individual insecticides by grower and season. This table facilitated comparisons of the families of insecticides to see if there had been any changes as a result of the use of imidacloprid (Admire™). The common names and Restricted Entry Intervals of all products used during the 2 seasons are summarized in Table 2.

A fourth chart (Table 3) was developed to determine the number of days for possible re-entry for each grower for both seasons.

RESULTS

Crop Protection Chemical Use

As can be seen in Figure 1 and Table 1, the number of insecticides decreased for Growers 1 and 3 from the 1993-94 season to the 1994-95 season. The opposite was true for Grower 2. Silverleaf whitefly pressure was high in 1993-94 and much lower in 1994-95. Conversely, leafminers and worms were low in 1993-94, but high in 1994-95. These trends are reflected in the fact that the number of uses of organochlorines, organophosphates, and pyrethroids decreased from 1993-94 to 1995-94, while the number of uses of abamectin, *Bacillus thuringiensis*, carbamates, and oil increased from 1994-95 as compared to 1993-94 (Table 1).

Another very striking difference between the 1993-94 season and the 1994-95 season was the amount of rainfall experienced in the latter season. This is reflected in fungicide use, which increased significantly in 1994-95 as compared to 1993-94 (Fig. 2).

Potential Problems with Restricted Entry Intervals

Potential re-entry problems that might be caused by the new WPS were discussed in last year's paper (2). For two growers, there were potential severe problems with re-entry if the same schedule that had been used in 1993-94 were to be used in 1994-95. Table 3 shows the number of days per week without a Restricted Entry Interval (R.E.I.) for each of the growers for both seasons. In reviewing actual spray and hand labor schedules for 1994-95, which were available for Growers 1 and 2, it was found that, although there were actually fewer days without an R.E.I. in 1994-95 than in 1993-94, simple modifications allowed hand labor tasks to be performed with no problems. In the case of Grower 1, hand labor tasks were completed in the morning, with sprays applied in the afternoon. Grower 2 accomplished the same objective by scheduling hand labor tasks 1 to 2 days before sprays. The authors were unable to obtain a record of hand labor activities from Grower 3.

CONCLUSIONS

Based on the optimistic outlook of growers with respect to insect control and concerns expressed about the potential effects of the Worker Protection Standard, the authors had expected to see a significant increase in the number of days without a Restricted Entry Interval when hand labor tasks could be performed. While these projections have held true for insecticides during the 1994-95 season, heavy rains in tomato growing areas of southern Florida necessitated a much greater use of fungicides, which adversely affected days for re-entry. When resistance to the insecticide imidacloprid (Admire™) develops and as insect pressures change, this issue will need to be revisited.

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Table 1. Total Uses of Different Insecticides during the 1993-94 and 1994-95 Growing Seasons.

		1993-94			1994-95		
Family (3)	**Trade Name**	**Grower 1**	**Grower 2**	**Grower 3**	**Grower 1**	**Grower 2**	**Grower 3**
avermectin	Agrimek™	4	3	3	5	6	6
biorational	BT			5	6	3	13
carbamate	Lannate™	2		2	5	1	7
chloronicotinyle	Admire™				1	1	1
oil	stylet oil						6
organochlorine	Thiodan™	4	1	6			2
organophosphate	Lorsban™	10		7	3		4
organophosphate	Monitor™	6		11			
pyrethrin	Pipernyl butoxide			13			
pyrethroid	Ambush™	1		17			
pyrethroid	Asana XL™	6	6	14		4	10
pyrethroid	Danitol™	5					
pyrethroid	Pounce™		8			9	.
	TOTAL	38	18	78	20	23	49

Figure 1.
Insecticide Use on Tomatoes by Three Different Growers: 1993-94 & 1994-95

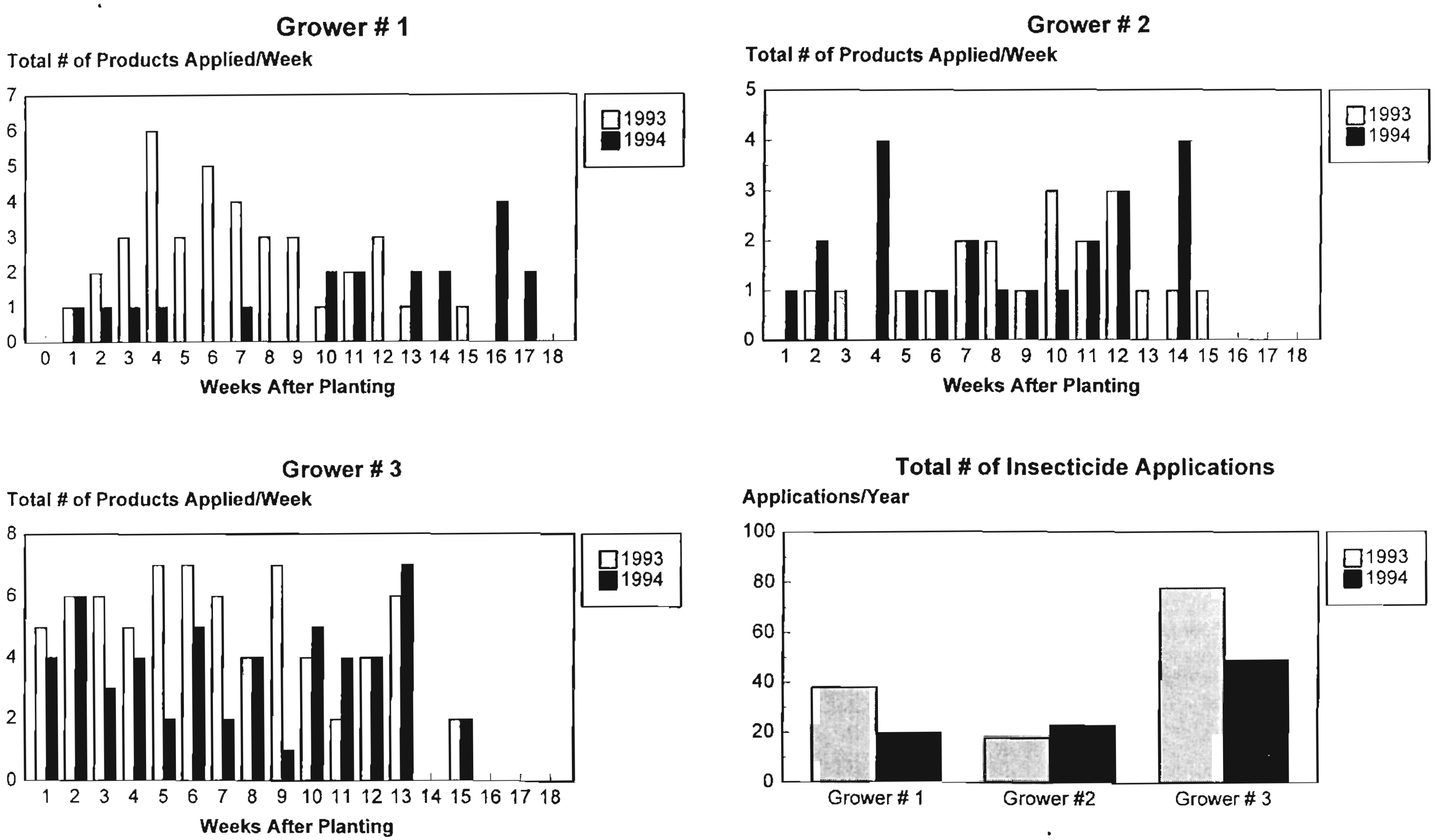

Figure 2.
Fungicide Use on Tomatoes by Three Different Growers: 1993-94 & 1994-95

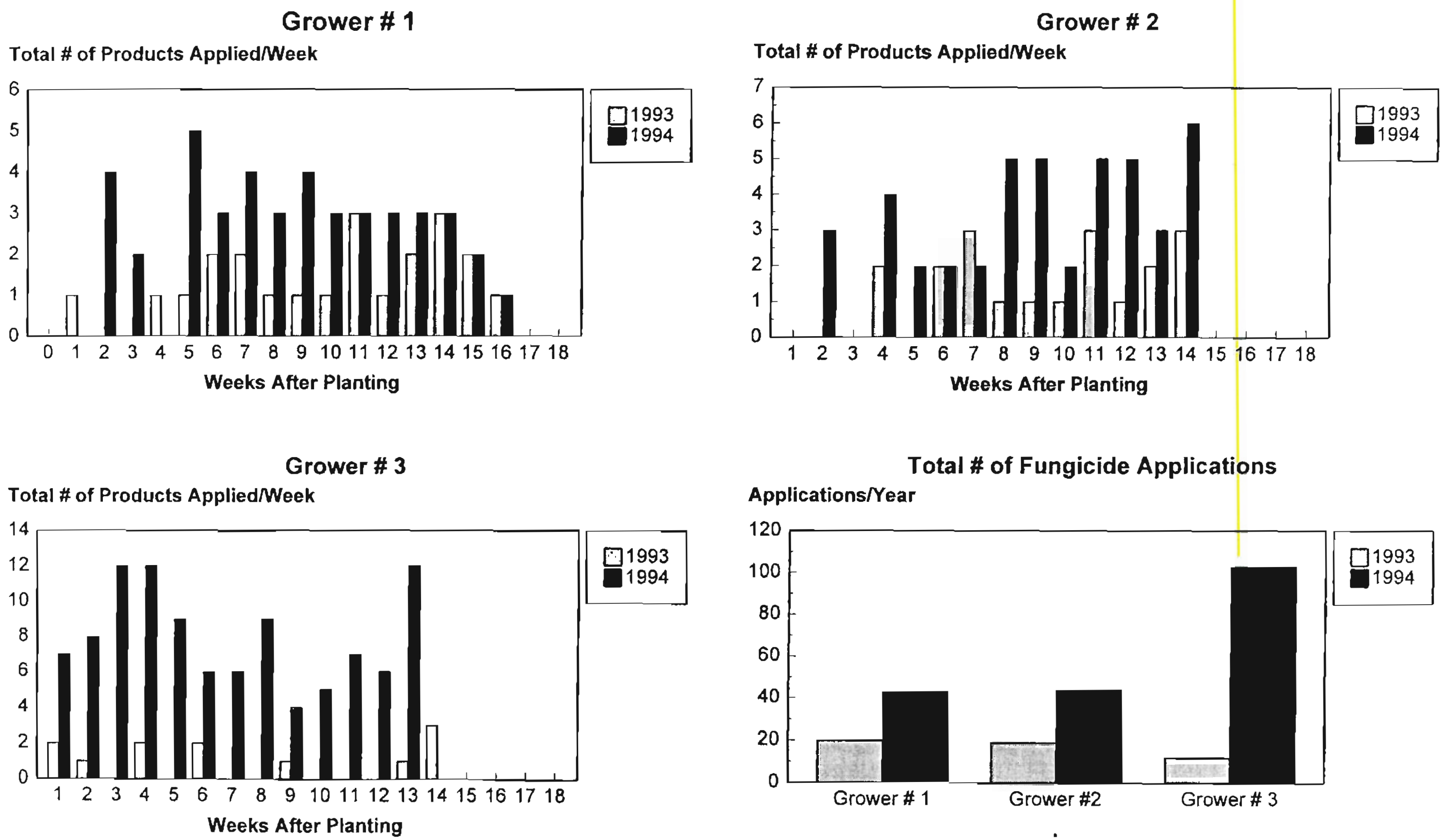

Table 2. Trade and Common Names and Restricted-Entry Intervals of Crop Protection Chemicals Used on Tomatoes

Trade Name	**Common Name(4)**	**Restricted Entry Interval (hrs.)[1]**
Fungicides		
Benlate™	benomyl	24
Blue-Shield™	copper hydroxide	48
Bravo™	chlorothalonil	48
Champ™	copper hydroxide	48
Dithane M45™	mancozeb	24
Kocide™	copper hydroxide	48
Manex	maneb	24
Manzate 200™	mancozeb	24
Herbicides		
Cobra™	lactofen	12
Gramoxone™	paraquat	48
Sencor™	metribuzin	12
Insecticides		
Admire™	imidacloprid	12
Agrimek™	abamectin	12
Ambush™	permethrin	24
Asana XL™	esfenvalerate	12
BT (generic)	*Bacillus thuringiensis*	12
Danitol™	fenpropathrin	24
Lannate™	methomyl	48
Lorsban™	chlorpyrifos	24
Monitor™	methamidophos	48
Pounce™	permethrin	24
PBO	piperonyl butoxide	24

Trade Name	**Common Name(4)**	**Restricted Entry Interval (hrs.)**[1]
Stylet Oil	oil	12
Thiodan™	endosulfan	24

[1]Restricted Entry Intervals as of early 1995 (4).

Table 3. Effect of 3 Different Spray Schedules and 2 Seasons on the Total Number of Days/Week without a Restricted Entry Interval.

	# Days/week without an R.E. I.: 1993-94			# Days/week without an R.E. I.:1994-95		
Week	**Gr. 1**	**Gr. 2**	**Gr. 3**	**Gr. 1**	**Gr. 2**	**Gr. 3**
1	5	7	5	3	6	0
2	5	5	1	4	2-4	0-1
3	4	3	3	2-3	7	0
4	1	3	0	4-5	3-4	0
5	0	6	2	2-3	4-5	0
6	2	1	0	1-2	2	0
7	2	5	2	1-2	3-4	0-1
8	2	1	1	2-3	4-5	0
9	1	4	2	1-2	1-3	1
10	4	3	3	1-2	1-3	0
11	3	4	3	1-2	1-3	0
12	1	3	3	1-2	2-3	0
13	4	2	2	1-2	4-5	0
14	1	2	1	2-3	3-4	0
15	1	5	6	1-3	6	5
16	3	7	2	4-5	n.a.	3
17	3	7	4	5-6	n.a.	5
18	7	4	4	n.a.	n.a.	n.a.
Total	49	72	44	36-52	49-67	14-16

WPS Grower Compliance Strategies

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The Worker Protection Standard (WPS) was issued by the U. S. Environmental Protection Agency (EPA) in an effort to reduce the risk of pesticide-related illness and injury to employers and employees who work with or may be exposed to pesticides. This regulation went into full effect on January 1, 1995. In Florida, the state lead agency with enforcement responsibility is the Florida Department of Agriculture and Consumer Services (FDACS). Florida growers have now had about a two-year learning curve since we first started hearing about this new EPA regulation. Growers have been trained, retrained and inundated with information on changes they must make in their day-to-day operations in order to maintain compliance with these new rules. Some view these rules as a necessary check-and-balance system to insure the safety of pesticide workers and handlers, while others look upon them as one more layer of bureaucracy in an industry already becoming overloaded with governmental good intentions.

In talking with vegetable growers around the state, we find that some jumped on the regulatory wagon immediately and thus are in good shape, many with a successful inspection already under their belts. It seems that others are just now waking up to the reality of the WPS and the fact that, like it or not, these regulations are now a part of day-to-day farming activities. This presentation will give a pictorial tour of Central and South Florida, to show how growers in various parts of the state are dealing with WPS compliance. Although I'm sure most of you have your programs in place, we can all usually learn something from the ideas and resourcefulness of others.

Based on the observations of the extension agents in South Florida last season, a number of potential problem areas seemed to keep surfacing. At the beginning of last season, we were still seeing the WPS posters at the entrance to farms. This would indicate that the entire farm was under an REI which would severely limit activity. Most growers are now posting individual fields or blocks and have worked out logical ways to designate or number posted units, including splitting very large blocks into more than one unit to avoid limiting activity in one end while spraying the other end which could be a mile away. For those chemicals which do not require posting, some farms, especially larger ones, are choosing to orally notify workers as timely field posting and removal could become a huge task. Typically, a group of workers will be working together in one area; thus, a timely oral warning about pesticide applications in that area may suffice.

Several problems were seen with the central location designations and information. Your pickup truck is not a suitable central location site unless it is always on the farm whenever workers are present. In one case, the WPS safety poster was mounted on a large wooden sign board in an appropriate area, but the application information was kept in a locked pesticide storage building. This is not accessible to workers. These two items should be located together in an area that is accessible to workers and handlers. The application information can be on a clipboard inside a protected box, in a piece of capped PVC, or even in a mailbox. It must be available for 30 days after the REI or the end of the application. This also applies to records on chemical applications for crop destruction at the end of the season, so don't get in too big a hurry to take the information down. Fading of the posters has been a problem that many growers mentioned. One of the WPS inspectors noted that the laminated posters that many were using seemed to be fading worse than the heavy paper ones distributed by EPA through the Extension offices.

Training has presented a few problems. One comment that was heard many times was simply the lack of interest of the workers being trained. The old saying "You can lead a horse to water, but you can't make him drink" also applies here. Unfortunately, in this case the consequences can be slightly more serious. Liability is always a concern for growers, but all you can do is make a reasonable effort and document, document, document! Some farms scheduled their training based on a 5-day or weekly grace period instead of the 15 day grace period, partly due to high turnover and continual influx of new workers. Smaller operations find they can get by with less frequent training, whereas larger farms sometimes find it necessary to train more frequently, often every day, depending on the time of season, i.e. production or harvest. If you are inspected, they are going to want to know what procedures you follow. They are also very interested in what questions you ask during training and what questions workers ask.

One decision has been whether to utilize the EPA verification card program. The purpose of this program was to reduce training duplication; however, some growers are not accepting cards that were issued during training conducted by other farms. They do not know precisely what type of training was provided and they are concerned about potential liability problems in the event of a pesticide mishap. Some farms have chosen to develop their own cards, especially when workers move from one production area to another within the company. Others farms have organized into groups where each member farm will accept cards issued by other farms in that group. Since this is a voluntary program, any system which works for your organization should be acceptable.

One relatively easy step in the compliance picture is to make sure that restricted pesticide applicator licenses are kept updated and that all pesticide handlers are either licensed or are working under the supervision of a licensed pesticide applicator. If you are inspected, remember that you do not have to know all the answers immediately. There is nothing wrong with replying that you followed the information on the label and would have to check the label to be sure of a rate, the PPE required, etc. In some cases, growers have been asked during an inspection to trace the path of a particular chemical from the time it was delivered until the container was disposed of. This may not seem like a big task until you start considering all the steps involved - who signed for it, where it was stored, PPE for mixing/loading, amounts and procedures for application, PPE for application, records kept, was area posted, disposal of container, etc. Make sure you can track the path of any pesticide in your operation without hitting "potholes".

There have been a number of changes since the WPS was first implemented. This spring, EPA amended the WPS in five major areas. This was done in an attempt to address the concerns of various grower organizations about the wording, interpretation and intent of the WPS. Some of the changes are positive for growers, while others seem more stringent than the original document and may require modification of the compliance programs of some farms.

Training Requirements: Beginning January 1, 1996, employers must provide brief pesticide safety information to untrained agricultural workers before they enter pesticide treated areas. The minimum effort that will be accepted by EPA is to show new workers the WPS poster and briefly explain the components. It is probably a good idea to also inform them of the central location and the decontamination sites. EPA will be developing handouts based on the poster, but growers have indicated that they would prefer to use the poster rather than rely on yet another handout which will probably not be read.

In addition, after January 1, 1996, you will only have five days in which to train workers who have not been previously trained. The current requirement is still 15 days. Originally, this would have been reduced in October, 1997. In light of the early reduction in the grace period and the new safety information requirement, it would seem that the grower might as well go ahead and provide training before they begin work in order to save time and duplication of efforts, since the information you must provide in the brief safety training is also required in the regular WPS training.

Exemption for Crop Advisors: Certified or licensed crop advisors and persons under their direct supervision are exempt from the restrictions on entering areas where pesticides have been applied (if they have received pesticide safety training), while they are performing crop advisory tasks. A temporary grace period was established until May 1, 1996, to allow time for crop advisors to acquire certification or licensing. According to EPA, if a crop advisor (i.e. scouts, etc.) is not licensed or certified through a program approved by EPA or a State pesticide enforcement agency, then they will still have to follow the provisions designated for handlers. Florida currently has no certification program and it is unclear how they will address certification of crop advisors. FDACS has been given the responsibility of developing a certification program for Florida. They anticipate a draft document will be submitted in October 1995 for EPA approval, with a goal of having a certification program available by the May 1996 deadline.

Exemption for Limited Contact Activity: This exception (which became effective May 3, 1995) allows workers flexibility during an REI to perform limited contact tasks that could not have been foreseen and which, if delayed, would cause significant economic loss. At the same time, the exception includes significant provisions to limit pesticide exposure and risk to employees performing limited contact tasks. Workers may not enter during the first 4 hours. Time in a treated area under an REI may not exceed 8 hours in a 24-hour period, and contact is limited to feet, lower legs, hands and forearms. Other restrictions also apply. Examples may include moving or repairing weather equipment, heating or ventilation equipment, repair of nonapplication field equipment, and moving of bee hives.

Exemption for Irrigation Activities: Allows workers the flexibility during an REI to perform irrigation tasks that could not have been foreseen and which, if delayed, would cause significant economic loss. Restrictions are very similar to the limited contact summary. This exemption also became effective May 3, 1995.

REI Revisions for Low Risk Pesticides: EPA has identified 114 low risk pesticide active ingredients as candidates for a reduction in REIs. This would reduce the REI from 12 hours to 4 hours for certain pesticides. Additions to the candidate list may be proposed until December 1995. Currently proposed materials include B.t. products, growth regulators, various oils, etc.

The good news is that Florida growers have done a reasonably good job in complying this first year. In surveys by FDACS to determine the frequency and nature of WPS violations, of the 256 establishments inspected, 129 violations were reported. This included 61 at farms and 58 at nurseries. Typical violations (and number) occurred in five categories: Inadequate information at central locations (22), PPE violations (20), employer requirements (14) including decontamination site problems, safety training (4), and REI violations (1). Where improvements can be made are in the areas of central location (safety posters, application information and accessibility) , closer attention to PPE requirements (inspecting and replacing, proper fit and storage, not taking contaminated PPE home) and decontamination sites (proper location, necessary items).

An estimate of the cost to growers to date is very hard to determine. Farms have trained from as few as 10 to 3000 or more employees. Start-up costs to come into compliance ranged from an estimated $5000 for smaller operations to $150,000 for large companies. Annual costs will vary depending on changes in numbers of workers, replacement items needed and other potential changes in the rule. EPA already expects lawsuits to be filed by farmworker groups who are upset that the most recent changes have seriously weakened the rule. Many growers feel that the first few years will be the worst, and that after the initial wave of workers are trained, things will slow down until retraining is required. The challenge to the Florida vegetable grower will be to keep on top of these regulations to avoid even more problems down the road.

EFFECTS OF FERTIGATION SCHEDULES ON TOMATO YIELD AND LEAF TISSUE ANALYSES

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Drip irrigation is playing an increasing role in the improvement of water and nutrient management on tomato farms in Florida. Water conservation (Clark et al., 1991; Hochmuth, 1994c; Locascio et al. 1989a) and improved nutrient efficiency with improved yields (Cook and Sanders, 1991; Dangler and Locascio, 1990; Hochmuth, 1992; Hochmuth and Clark, 1991; Locascio et al., 1985; Locascio et al., 1989b) have been demonstrated. Although the advantage of application of preplant N and K for drip irrigated tomatoes has been demonstrated, evaluations of various fertigation schedules are limited.

Plant leaf and sap analysis can be an important tool for monitoring crop performance in relation to a nutrient management program (Coltman, 1987; Coltman and Riede, 1992; Hochmuth et al., 1991; Olson et al., 1994; Prasad and Spiers, 1985; Scaife and Stevens, 1983). Sufficiency ranges for nutrient content of whole leaves have been developed for tomato in Florida (Hochmuth et al., 1991). Although many growers use routine leaf analyses, they often complain about the cost and relatively long turn-around time for results. Beginning in the mid 1980s, research was begun to calibrate petiole fresh sap quick-test procedures for determining N and K status of Florida tomato plants in an economical and timely fashion. Published guidelines for petiole sap testing for tomato in Florida are based on results with crops grown with subsurface irrigation and all fertilizer applied preplant. Evaluations of petiole sap testing with drip irrigation and fertigation have not been conducted. With the increase in use of fertigation with drip irrigation in Florida tomato production, there is a need to develop sufficiency ranges for leaf and petiole sap testing for fertigated tomato.

This research was conducted to evaluate the effects of selected N and K fertigation programs on tomato yield and quality, and to determine the effects of fertigation on leaf and petiole sap N and K concentrations.

Materials and Methods

Three fertigation studies with tomato were conducted at Quincy (Springs 1993 and 1994) and at Gainesville, FL (Spring, 1994). The Quincy sites were on Orangeburg fine sandy loam soils at the North Florida Research and Education Center and on an Arrendondo fine sand at the Horticultural Research Unit of the University of Florida at Gainesville, FL.

There were six treatments in 1993 and eight treatments in 1994 (Table 1). Treatments no. 3 and 6 were not used in 1993. The soil tested high in phosphorus at both locations and tested high in potassium at Quincy but medium at Gainesville. No potassium was applied at Quincy and 120 lb K_2O was applied at Gainesville. Total nitrogen was 175 lb per acre at both sites. Potassium was applied with nitrogen in proportion to the N application used for each treatment at Gainesville. The sources of N and K nutrients were ammonium nitrate and potassium chloride, respectively.

Tomato plants were planted in single rows on polyethylene mulched and fumigated (methyl bromide) beds. Beds were six feet apart on centers and beds were 36 inches across the top. Plants were spaced 20 inches apart at Quincy and 18 inches apart at Gainesville. Drip irrigation tubing was positioned in the center of the bed and one inch deep. Tomatoes were staked, pruned, tied, and pests were controlled with applications of labeled pesticides. Irrigation was operated to maintain tensiometers at -10 cb at the six-inch depth in the soil with 0.75 Pan evaporation water quanity applied at each irrigation.

On weeks (after planting) 4, 6, 8, 10, (Gainesville, 1994) with additional wk 12 (Quincy, 1994) and wk 14 (Quincy, 1993), leaf samples were taken for N and K analyses. Samples of most-recently-matured whole leaves were analyzed for total N and for K and petiole sap was analyzed for nitrate-N and for K.

Tomatoes were harvested twice each season and graded into extra large, large, medium, and cull categories. Experiments were in randomized complete-block design with four replicates. Data were analyzed by analysis of variance and regression analysis.

Results

Results were summarized according to three major treatment groups within which specific treatment contrasts were made. The three treatment groups were 1. Preplant fertilizer amount (0, 40, and 100%), 2. Fertilizer schedule of weekly injections (for 12 or 6-week periods) or injections for 12 weeks with each week proportional to crop growth curve (Hochmuth and Clark, 1991), and 3. Contrasts of fertilizer (treatments 1 through 7) versus no fertilizer were also made.

Yield

Fertilization. Tomato yield was highly responsive to N (and) K fertilization in all experiments (Table 2). Only 52%, 24%, and 24% total marketable seasonal yields were obtained at the Quincy 1993, 1994, and Gainesville, 1994 sites, respectively with no fertilizer.

Preplant fertilizer. Yield from harvest 1 at Quincy was not affected by the amount of preplant fertilizer applied but, at Gainesville on a sandy soil, 40% and 100% preplant resulted in greater yields of early extra large and total early marketable fruit compared with no preplant fertilizer applied (Table 2). Total season extra large fruit was not affected by treatment at Quincy, but, at Gainesville, yield of total extra large fruit was better with 40 or 100% fertilizer applied preplant than with no preplant fertilizer and yields with 40% preplant were better than with 100%. At Quincy in 1993, total seasonal marketable yields were better with 100% preplant compared with no preplant or 40% preplant (Table 2). Treatment had no effect on total seasonal marketable yield at Quincy in 1994. Total seasonal extra large and marketable fruit at Gainesville were affected by treatment in the following order: 40% > 100% > 0%.

These yield data showed that, on sandy soils, yields would be improved with some fertilizer applied preplant. However, with application of 100% N and K preplant, reduced yields occur due possibly to soluble salt burn of plants early in the season and possibly due to leaching losses of a portion of the fertilizer later in the season. On heavier soils, proportion of preplant fertilizer is not as critical although, in one season, better yields resulted when all fertilizer was applied preplant.

Fertilizer schedule. Injection schedule for application of N (and) K had little effect on any tomato fruit category in any experiment (Table 2). These data viewed with the results on preplant fertilizer indicate that injection frequency or schedule has less effect on yield than does ensuring that at least some (N (and) K is applied preplant, especially for sandy soils.

Leaf Nutrients

Fertilization. Leaf N and K concentrations responded dramatically to N (and) K fertilization (Tables 3 and 4). Concentrations of N in leaves reached deficiency status in unfertilized plants by week 6 in all three experiments (Table 3). Leaf-N concentrations of less than 2.8% at first flower (after week 4) is representative of N deficiency (Hochmuth et al., 1991a). Leaf-K concentrations were increased by fertilization at several sampling periods in both Quincy seasons (Table 4). When no K was applied at Quincy, fertilization (with N only) resulted in an increase in K in tomato leaves presumably because severely N deficient plants were limited in their ability to grow and K accumulated. Leaf K concentrations of N fertilized plants remained above sufficiency levels all season in both Quincy experiments. Even though plants were fertilized with K at Gainesville, leaf-K fell to deficiency concentrations by week 10 (Table 4). It is possible that not enough K was applied (120 lb K_2O per acre) at Gainesville. Recent research showed responses to more K at some sites (Hochmuth et al., 1991b; Locascio et al., 1994). Leaf K was higher at Gainesville for plants receiving no fertilizer because, for those plants, only N was omitted and K was still applied. Leaf analyses showed that, in these experiments, N nutrition was the major limiting factor related to treatments at the three sites.

Preplant fertilizer. Amount of preplant fertilizer had little effect on leaf N or K in both Quincy experiments (Tables 3 and 4). Where there were slight differences between treatments, the leaf N and K concentrations were above sufficiency levels. Only at

Quincy, 1993 did a significant difference for N concentration show up where leaf N was increased for plants with 100% N applied preplant and this could be responsible for the increase in total yield with this treatment. At Gainesville, N concentrations remained above sufficiency levels for the season with the 0 and 40% preplant treatments. Leaf N fell to deficiency levels after week 8 when all N was applied preplant. Leaf K was likewise rarely affected by preplant N treatment at Quincy and all values were in the sufficiency range, but at Gainesville leaf K fell to deficiency levels with all treatments after week 8. Leaf K at Gainesville fell uniformly to deficient levels so that N nutrition was probably still the controlling factor for yield response to treatment.

Fertilizer schedule. Injection schedule or timing had little effect on leaf N or K in any experiment (Tables 3 and 4). Leaf N remained above sufficiency levels with all treatments for the season in all experiments except for wk 14 at Quincy, 1993. Leaf K fell to deficiency levels with all treatments after wk 12 at Quincy, 1993, and after wk 8 at Gainesville.

Leaf tissue data showed that the most likely controlling factor for yields in these experiments was N nutrition. Treatments that had higher leaf N at the beginning of the season and which maintained adequate N through week 8 resulted in greater yield. Potassium nutrition had little relation to yield responses in these experiments, although at Gainesville, leaf K was extremely low by week 10. This low K could be a factor in the reduced yields for the Gainesville location compared to the Quincy experiments.

Petiole Sap Nutrients

Fertilization. Nitrate-N concentrations of fresh petiole sap responded dramatically to fertilization (Table 5). Petiole K concentrations did not respond as greatly to N fertilization (Table 6). Without N fertilization, petiole sap fell to extremely low levels by week 6 in all experiments. Concentrations of petiole sap N below 1000 by week 6 (first open flowers) is considered deficient (Hochmuth, 1994 a,b). Petiole sap K remained above sufficiency levels all season at all locations except for fertilized plants after week 8 at Gainesville (Table 6). Petiole K concentration below 3000 ppm after week 8 would indicate K deficiency (Hochmuth, 1994 a, b).

Preplant fertilizer. Petiole sap N concentrations were affected by preplant fertilizer treatment at Quincy in 1993 and at Gainesville. At Quincy, 1993, petiole sap N concentrations fell during the season with all treatments but fell to lower levels for the 0% treatment than the 40% treatment which fell to lower levels than the 100% treatment (Table 5). These data showed that, when preplant N amount is reduced from 100%, the plant contained less nitrate-N and injection of N did not increase the nitrate-N concentrations. It is possible that nitrate N is rapidly reduced in plants receiving N only from small amounts of injected N so that little nitrate-N accumulates in these plants, or that fertilizer amounts are never high enough at any one injection to maintain a high nitrate-N concentration in the petiole sap. A combination of these reasons may be responsible for the yield responses observed at Quincy, 1993, where yield was reduced in the zero preplant treatment because nitrate-N level fell too soon and could not be recovered by fertigation. Leaf-N also fell by week 8 to concentrations lower than those of plants with 40 or 100% N preplant (Table 3).

Petiole sap N at Gainesville fell with all treatments by week 8 although decreases were greatest for plants with all preplant N and K (Table 5). Currently published sap nitrate-N sufficiency ranges (Hochmuth et al., 1988; Hochmuth, 1994 a,b) appear to be adequate for the early and late-season values based on a comparison with sap-N profiles of the better performing treatments in these experiments. Values for mid-season, week 6 through 10, in these experiments with the better treatments are 10 to 15% higher than those values published.

Preplant fertilizer treatments had little effect on petiole sap K concentrations (Table 6). All petiole sap K concentrations remained above sufficiency levels all season at all locations except at Gainesville where petiole sap K fell to deficiency levels (below 3000 ppm) after week 8 (Table 6).

Fertilizer schedule. Timing and scheduling of injected fertilizer had little influence on petiole sap N (Table 5) or on petiole sap K (Table 6) concentrations. Although, at certain times in the season, statistical differences were observed, e.g. weeks 6 and 8 at Quincy, 1994, and weeks 6 and 10 at Gainesville, concentrations with all three treatments would have been placed in the same sufficiency (or deficiency) category according to published sufficiency ranges (Hochmuth, 1994 a,b).

Nutrient injection schedule had no effect on petiole sap K concentrations (Table 6). Petiole sap K remained above sufficiency levels all season except for the last sampling at Quincy, 1993 and 1994, and except for the last two samplings at Gainesville.

Summary

Fertilizer N management with drip irrigated, fertigated tomatoes is important for highest yields. Our results showed that tomatoes responded best when 40% of the N was applied preplant, especially on sandy soils. This result is similar to previous research where N applied with the drip resulted in better yield than with all N preplant. Response is not always great to preplant N on heavier soils, a result shown in previous research (Locascio et al., 1985; Locascio et al., 1989a).

Injection schedule and N timing had little effect on yield or leaf tissue N concentrations. As long as 40% N was applied preplant, then schedule of injected N was of little concern. N can be applied in as few as six weekly injections or in 12 weekly injection.

Leaf N and petiole sap N were both responsive to fertilization treatments in these experiments. Petiole sap N was a good indicator of plant N status and a good predictor of yield potential. Petiole sap analysis was easy and quick and would be a useful tool for in-field use on tomato farms.

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Table 1. Treatments used in tomato fertigation studies at Quincy and Gainesville.

Treatment number	Preplant N (lb/acre)	Fertigate N (lb/acre)	Fertigate N (lb/wk-wks)
1	0	175	14.6/wk-12 wks
2	0[z]	175	29.2/wk-6 wks
3	0	175	variable - 12 wk[y]
4	70	105	8.8/wk-12 wks
5	70[z]	105	17.6/wk-6 wks
6	70	105	variable-12 wks[x]
7	175	175	-
8	0	0	-

[z]Not included in 1993 study.

[y]Growth curve: 2 wks at 8.8 lb/wk, 2 wks at 13.1 lb/wk, 6 wks at 17.5 lb/wk, last 2 wks at 13.1 lb/wk.

[x]Growth curve: 2 wks at 5.3 lb/wk, 2 wks at 7.9 lb/wk, 6 wks at 10.5 lbs/wk, and last 2 wks at 7.9 lb/wk.

Table 2. Effects of fertigation programs on tomato yield in three seasons at two sites in Florida.

Treatment	Quincy, Spring, 1993				Quincy, Spring, 1994				Gainesville, Spring, 1994			
	Harvest 1		Total season		Harvest 1		Total season		Harvest 1		Total season	
	Ex. lg.	Total mkt.	Ex. lg.	Total mkt.	Ex. lg.	Total mkt.	Ex. lg.	Total mkt.	Ex. lg.	Total mkt.	Ex. lg.	Total mkt.
	Yield (25-lb cartons per acre)											
Preplant fertilizer (%)[w]:												
0	470	540	1260	1550	580	700	1220	1860	200	360	510	1250
40	520	600	1390	1740	620	770	1250	1960	340	540	740	1540
100	560	660	1560	2030	540	630	1140	1810	310	530	540	1330
Significance[x]:				40vs.100**					0vs.40**	0vs.40**	0vs.40**	0vs.40**
											40vs.100**	40vs.100*
Fertilizer schedule[y]:												
12 wk	470	550	1270	1620	550	670	1230	1880	320	530	680	1470
6 wk	N/A	N/A	N/A	N/A	660	820	1330	2060	250	420	590	1390
Curve	510	600	1370	1670	600	710	1150	1780	240	410	600	1330
Significance[x]:												
Fertilization[z]												
With	510	590	1370	1720	590	720	1220	1890	280	460	600	1390
Without	330	420	640	890	220	280	250	460	60	170	80	330
Significance[x]:	*	*	**	**	**	**	**	**	**	**	**	**

[z]Fertilization comparison involves treatments 1 through 7 vs. 8.
[y]Fertilizer schedule is contrasts of main effects of injection over 6 or 12-week period of same amount of fertilizer each week or injection of fertilizer proportional to crop growth.
[x]Contrasts significant at 5% (*) or 1% (**) probability level. All other contrasts not significant.
[w]Preplant fertilizer at 0, 40, or 100% of total N and (or) K applied preplant incorporated in the bed. Remainder of fertilizer injected through drip system.

Table 3. Effects of fertigation programs on tomato leaf N concentrations in three seasons at two sites in Florida.

	Quincy, Spring, 1993 Sampling date (wk)						Quincy, Spring, 1994 Sampling date (wk)					Gainesville, Spring, 1994 Sampling date (wk)			
Treatment	4	6	8	10	12	14	4	6	8	10	12	4	6	8	10
	Leaf N conc. (%)														
Preplant fertilizer (%)[w]:															
0	4.8	4.4	3.0	2.8	2.4	1.8	4.7	4.9	3.9	3.4	3.0	5.7	3.9	3.9	3.2
40	4.2	4.3	3.1	2.8	2.5	1.9	4.8	4.9	4.1	3.5	3.0	6.0	3.5	3.5	2.7
100	4.9	4.7	3.5	3.1	2.5	1.9	4.3	5.1	4.3	3.5	2.9	4.5	4.5	2.4	2.1
Significance[x]:			40vs.100*									0vs.40* 40vs. 100**	0vs.40** 40vs. 100**	0vs.40** 40vs. 100**	0vs.40** 40vs. 100**
Fertilizer schedule[y]:															
12 wk	4.6	4.4	2.9	2.8	2.4	1.9	4.7	4.8	3.9	3.3	3.2	5.9	3.6	3.6	3.1
6 wk	N/A	N/A	N/A	N/A	N/A	N/A	4.9	5.1	4.1	3.5	2.9	6.0	3.8	3.8	2.7
Curve	4.5	4.3	3.2	2.8	2.5	1.8	4.6	4.9	4.0	3.6	3.0	5.6	3.8	3.8	3.2
Significance[x]:								T1 vs.2**				T1,2 vs.3*			T1,3 vs. 2** PXT**[v]
Fertilization[z]:															
With	4.6	4.4	3.1	2.9	2.5	1.9	4.7	4.9	4.0	3.5	3.0	5.7	3.9	3.5	2.8
Without	4.1	2.1	2.1	2.3	2.2	1.6	3.4	2.6	2.5	2.5	2.3	5.1	2.2	2.2	2.1
Significance[x]:		**	**	*		*	**	**	**	**	**	**	**	**	**

[z]Fertilization comparison involves treatments 1 through 7 vs. 8.
[y]Fertilizer schedule is contrasts of main effects of injection over 6 or 12-week period of same amount of fertilizer each week or injection of fertilizer proportional to crop growth.
[x]Contrasts significant at 5% (*) or 1% (**) probability level. All other contrasts not significant.
[w]Preplant fertilizer at 0, 40, or 100% of total N and (or) K applied preplant incorporated in the bed. Remainder of fertilizer injected through drip system.
[v]PXT = significant interaction of preplant fertilizer and fertilization schedule.

Table 4. Effects of fertigation programs on tomato leaf K concentrations in three seasons at two sites in Florida.

Treatment	Quincy, Spring, 1993 Sampling date (wk)						Quincy, Spring, 1994 Sampling date (wk)					Gainesville, Spring, 1994 Sampling date (wk)			
	4	6	8	10	12	14	4	6	8	10	12	4	6	8	10
	Leaf K conc. (%)														
Preplant fertilizer (%)[w]:															
0	3.6	3.8	3.8	3.6	2.7	1.4	3.8	4.6	4.3	3.4	2.5	4.2	4.1	2.7	1.1
40	4.0	3.7	3.5	3.3	2.9	1.7	3.8	5.1	4.2	3.4	2.4	4.3	3.9	2.5	1.1
100	3.8	4.1	3.7	3.8	2.9	1.7	3.5	4.6	4.2	3.4	2.6	4.1	3.7	2.1	1.1
Significance[x]:	0vs. 40*							0vs. 40*						40vs. 100*	
Fertilizer schedule[y]:															
12 wk	4.0	3.9	3.7	3.6	2.8	1.7	3.7	4.8	4.2	3.4	2.4	4.2	4.1	2.6	1.2
6 wk	N/A	N/A	N/A	N/A	N/A	N/A	4.0	4.8	4.3	3.6	2.8	4.3	4.1	2.7	1.0
Curve	3.6	3.6	3.6	3.3	2.7	1.3	3.8	4.9	4.2	3.3	2.2	4.1	3.8	2.6	1.2
Significance[x]:	*					*					T1,2 vs.3*				
Fertilization[z]:															
With	3.8	3.8	3.7	3.5	2.8	1.6	3.8	4.8	4.3	3.4	2.5	4.2	3.9	2.5	1.1
Without	3.3	2.7	2.4	2.9	2.4	1.5	3.7	3.5	3.0	3.0	2.4	3.9	4.0	3.0	2.2
Significance[x]:	**	**	**					**	**	**				**	**

[z]Fertilization comparison involves treatments 1 through 7 vs 8.
[y]Fertilizer schedule is contrasts of main effects of injection over 6 or 12-week period of same amount of fertilizer each week or injection of fertilizer proportional to crop growth.
[x]Contrasts significant at 5% (*) or 1%(**) probability level. All other contrasts not significant.
[w]Preplant fertilizer at 0,40, or 100% of total N and (or) K applied preplant incorporated in the bed. Remainder of fertilizer injected through drip system.

Table 5. Effects of fertigation programs on tomato petiole sap nitrate-N concentrations in three seasons at two sites in Florida.

Treatment	Quincy, Spring, 1993 Sampling date (wk)						Quincy, Spring, 1994 Sampling date (wk)					Gainesville, Spring, 1994 Sampling date (wk)			
	4	6	8	10	12	14	4	6	8	10	12	4	6	8	10
	Petiole nitrate-N conc. (ppm)														
Preplant fertilizer (%)[w]:															
0	1220	860	380	280	140	90	1390	1380	900	620	470	900	1160	840	330
40	1310	810	730	840	170	95	1360	1400	890	680	320	910	1110	400	230
100	1160	950	1030	1030	240	130	1110	1310	1020	610	380	940	1070	240	310
Significance[x]:			0vs.40** 40vs.100**	0vs.40** 40vs.100**										0vs. 40**	
Fertilizer schedule[y]:															
12 wk	1300	840	580	580	170	100	1360	1400	830	560	440	940	1060	580	210
6 wk	N/A	N/A	N/A	N/A	N/A	N/A	1460	1480	980	590	410	930	1310	660	220
Curve	1240	830	540	530	140	90	1300	1290	880	800	330	850	1040	620	400
Significance[x]:								T1,2vs. 3*	T1,vs.3* PXT[v]				T1vs.2*		T1,2 vs.3**
Fertilization[z]:															
With	1240	860	650	650	170	100	1340	1380	910	650	390	910	1130	570	280
Without	1070	110	170	340	260	130	800	90	200	330	300	760	360	280	440
Significance[x]:	**	**	**	*			**	**	**			*	**	*	*

[z]Fertilization comparison involves treatments 1 through 7 vs. 8.
[y]Fertilizer schedule is contrasts of main effects of injection over 6 or 12-week period of same amount of fertilizer each week or injection of fertilizer proportional to crop growth.
[x]Contrasts significant at 5% (*) or 1% (**) probability level. All other contrasts not significant.
[w]Preplant fertilizer at 0, 40, or 100% of total N and (or) K applied preplant incorporated in the bed. Remainder of fertilizer injected through drip system.
[v]PXT = significant interaction of preplant fertilizer and fertilizer schedule.

Table 6. Effects of fertigation programs on tomato petiole sap K concentrations in three seasons at two sites in Florida.

Treatment	Quincy, Spring, 1993 Sampling date (wk) 4	6	8	10	12	14	Quincy, Spring, 1994 Sampling date (wk) 4	6	8	10	12	Gainesville, Spring, 1994 Sampling date (wk) 4	6	8	10
	Petiole K conc. (ppm)														
Preplant fertilizer (%)[w]:															
0	3500	3260	3550	3240	3040	1910	4080	3380	3650	3260	2960	3690	3560	2970	1310
40	3550	3100	3680	3410	3210	2180	3790	3180	3360	3280	2620	3750	3460	2940	1480
100	3600	3200	3730	3680	3480	2080	3880	3380	3480	3000	2550	3980	3550	2500	1130
Significance[x]:														40vs. 100*	
Fertilizer schedule[y]:															
12 wk	3430	3250	3750	3490	3060	2130	3680	3350	3500	3200	2860	3660	3360	3040	1310
6 wk	N/A	N/A	N/A	N/A	N/A	N/A	4030	3250	3600	3480	2410	3750	3530	2860	1450
Curve	3630	3110	3480	3160	3190	1950	4110	3240	3410	3140	3120	3750	3490	2960	1420
Significance[x]:															
Fertilization[z]															
With	3540	3190	3640	3400	3200	2050	3930	3290	3500	3230	2710	3760	3470	2890	1360
Without	3470	3500	3350	3150	3250	2080	3230	3780	3700	3200	2380	3930	4030	3500	2450
Significance[x]:		*						*					**	**	**

[z]Fertilization comparison involves treatments 1 through 7 vs. 8.
[y]Fertilizer schedule is contrasts of main effects of injection over 6 or 12-week period of same amount of fertilizer each week or injection of fertilizer proportional to crop growth.
[x]Contrasts significant at 5% (*) or 1% (**) probability level. All other contrasts not significant.
[w]Preplant fertilizer at 0, 40, or 100% of total N and (or) K applied preplant incorporated in the bed. Remainder of fertilizer injected through drip system.

Bacterial Wilt of Tomato

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INTRODUCTION

For nearly 100 years, Florida tomato growers have had to abandon tomato fields because of the devastating effects of bacterial wilt. Despite the efforts of many qualified scientists, as well as determined growers, a practical and reliable disease control recommendation is still not available. A brief overview of the disease and it's causal agent is presented to illustrate the difficulties encountered when working with this disease. New developments in research on bacterial wilt, prospects for control and how they apply to Florida tomato growers will also be discussed.

Bacterial wilt of tomato is caused by the bacterium *Pseudomonas solanacearum*. This wilt-inducing bacterial pathogen affects a wide range of plants in tropical, subtropical and temperate climates throughout the world. In the United States, bacterial wilt occurs primarily in the southeast, where it is considered indigenous to the region and can persist indefinitely in the soil. There are many examples of severe epidemics of bacterial wilt occurring in fields with no prior history of vegetable production (Jaworski and Morton, 1964; Dukes et al., 1965; D. Chellemi, personal observation). Within Florida, bacterial wilt occurs in all tomato production regions except Homestead.

One of the major stumbling blocks to developing effective control measures has been the high degree of variability associated with the bacterium and the disease. *Pseudomonas solanacearum* differs from region to region in almost every aspect of it's ecology, including the range of host plants affected, survival in soil, response to environmental conditions, sensitivity to antibiosis and competition by other soil microbes and nutritional requirements. For example, in China, Indonesia, and Vietnam, bacterial wilt is a major limiting constraint in the production of peanuts (Mehan et al., 1994) where as Florida strains of the bacterium do not infect peanut (Kelman and Person, 1961; Velupillai and Stall, 1984). In Florida, bacterial wilt has been observed on most members of the solanaceous family including tomato, potato, eggplant, tomatillo, black nightshade and cutleaf ground cherry. Bacterial wilt has also been observed in the field on sesame (Velupillai and Stall, 1984).

RESISTANCE

Resistance in tomato genotypes to bacterial wilt of has been variable. Cultivars such as 'Venus', 'Saturn', 'Kewalo', 'Rodade' and 'Capitan' are resistant to bacterial wilt in other locations (Henderson and Jenkins, 1972; Gilbert et al. 1974; Bosch et al. 1985) but were susceptible when evaluated under Florida field conditions (Sonoda and Augustine, 1978; Scott et al, 1993; Chellemi et al, 1994). Of the genotypes that have been evaluated under Florida field conditions, Hawaii 7997, Hawaii 7998 and CRA 66 have demonstrated high levels of resistance (Sonoda and Augustine, 1978; Scott et al., 1993). When tested against a number of Florida strains, the resistance appears to be stable (Chellemi et al. 1994A). The problem with developing a commercially acceptable cultivar is that genes for resistance are located on at least three of the 12 chromosomes present in tomato (Danesh et al. 1994), are linked to small fruit size and are moderated by environmental factors such as temperature (Acosta et al. 1964). Thus, breaking the linkage with small fruit size often results in a decline in resistance. Also, with at least three genes responsible for conferring resistance, additional dilution of resistance can occur each time a backcross is made. Field evaluation of resistance is further hindered by fluctuating environmental conditions which can modify resistance.

Despite all of the obstacles, 'Neptune', an open-pollinated, determinate, heat-tolerant, cultivar with moderate resistance was developed for the Florida fresh fruit market using Hawaii 7997 as the resistant parent (Scott et al. 1995). Marketable yield and fruit quality of 'Neptune' are similar to 'Solar Set' and Sunny. Disease resistance is intermediate between 'Solar Set' and Hawaii 7997. In situations where disease pressure is low, 'Neptune' will result in acceptable levels of disease control. For example, in a 1992 field experiment conducted in a bacterial wilt infested field, the incidence of bacterial wilt was reduced from 36% in plots planted with 'Solar Set' to 6% in plots planted with Neptune (Chellemi et al. 1993). However, in a 1993 field experiment in naturally infested field, the incidence of bacterial wilt was reduced from 83% in plots plant with Solar Set to 22% in plots planted with Neptune (Chellemi et al. 1994B). Thus, 'Neptune' will not provide acceptable levels of control when disease pressure is high. The major limiting factor against acceptance of 'Neptune' is the fruit size, which is in the medium to large range. In an effort to increase fruit size, Neptune was back crossed with several breeding lines and evaluated in the field. The results were encouraging as additional dilution of resistance did not occur (Chellemi et al. 1994). Several hybrids will be evaluated in 1995 in North Florida.

Although time consuming and regarded as an out-of-date method, grafting a susceptible tomato cultivar with horticulturally acceptable characteristics onto a rootstock with resistance to bacterial wilt, such as Hawaii 7997, has been used to develop disease resistant transplants (Grimault et al., 1993; Lee, 1994). In Japan, grafting is used to such a large extent that robots have been developed to make the process economically feasible (Kurata, 1994).

FUMIGATION

Fumigation with methyl bromide can result in an initial decrease in bacterial populations in soil (Ladd et al. 1976; Ridge, 1976) but does not provide season-long control of bacterial wilt of tomato (Enfinger et al. 1979). Chloropicrin can significantly reduce bacterial populations in the soil (Ladd et al. 1976; Ridge, 1976), but the effect on bacterial wilt is erratic. Season-long control was obtained in some studies (Enfinger et al. 1979; Kelman, 1953) but not in others (Enfinger et al., 1979; Melton and Powell, 1991). In fumigation studies conducted in Quincy, Florida, it took twice the recommended rate of fumigation with a 66:33 formulation of methyl bromide:chloropicrin (700 lbs/A on a broadcast basis) to significantly reduce populations of *Pseudomonas solanacearum* (Chellemi et al., 1993). Metham sodium (Vapam) has no effect on the incidence of bacterial wilt (Enfinger et al., 1979). The major obstacle confronting the use of broad spectrum soil fumigants to control bacterial wilt is that populations of the bacterium in fumigated soil rapidly rise to levels higher than before treatments were applied. Thus, reductions in the population density of the bacterium approaching 100% are necessary to reduce the incidence of disease.

CULTURAL PRACTICES

Bacterial wilt is favored by conditions of high soil moisture (Kelman, 1953; Moffet et al., 1983). Thus, over irrigation, poor drainage, extended periods of rainfall can increase the incidence of disease. In general, onset and development of bacterial wilt occurs when air temperatures exceed 86 F (Hayward, 1991). In the southeast coast of Florida, Sonoda (1978) showed a direct relationship between time of transplanting and incidence of disease. Incidence of bacterial wilt decreased from 93% in fields transplanted on September 28 to 17% in fields transplanted on November 9. This explains why bacterial wilt is only sporadically observed during winter production in South Florida even though the bacterium is present in all locations except Homestead. Soil solarization does not result in significant reductions in populations of *Pseudomonas solanacearum* in Florida (Chellemi et al. 1994) and when performed alone, is not recommended for control of bacterial wilt. However, when solarization was combined with 350 lbs/A of a 66:33 formulation of methyl bromide:chloropicrin, populations of *Pseudomonas solanacearum* were dramatically reduced (Chellemi et al, 1994) and disease incidence was reduced from 37% in control plots to 7% in treated plots (Chellemi et al., 1993). Apparently, fumigation predisposes populations of the bacterium making them more sensitive to the effects of soil solarization.

SOIL AMENDMENTS

There are numerous examples of soils suppressive to bacterial wilt of tomato including some from the southeastern United States (Bereau and Messiaen, 1975; Nesmith and Jenkins, 1988; Ho et al., 1988; Hopkins and McCarter, 1988). The mechanism which leads to suppression is not fully understood although in many cases it appears to be biological. Biological control of bacterial wilt using avirulent mutants of *Pseudomonas solanacearum* and strains of other antagonistic soilborne bacteria has demonstrated potential in laboratory and field experiments (McLaughlin and Sequeira, 1988; Ciampi-Panno et al, 1989; Anuratha and Gnanamanickam, 1990; Phae et al, 1992). However, when evaluated under Florida field conditions, neither the avirulent mutant strains nor antagonistic soilborne bacteria provided acceptable levels of control (McLaughlin et al, 1990; D. Chellemi, unpublished data). Evidently, fluctuating environmental conditions, inadequate delivery systems for the biocontrol agents, and interactions with other soilborne plant pests, make biological control unfeasible as a singularly applied tactic for controlling bacterial wilt. Biological control may offer some potential when used in conjunction with other control tactics such as soil solarization, soil amendments, and resistant cultivars. Incorporation of various organic and inorganic materials into soil has led to the suppression of bacterial wilt in China (Sun and Huang, 1985; Taiwan (Hartman and Yang, 1990) and Guadeloupe (Prior and Beramis, 1990). In Florida, suppression of bacterial wilt by various composted organic amendments was found to be variable (Chellemi et al. 1992). Addition of composted sewage sludge increased disease while addition of spent mushroom compost decreased disease. The effect of composted organic amendments varied from farm to farm and appears to dependent upon soil type, strains of the bacterium present, and the presence of other soil microorganisms.

There is evidence that calcium nutrition and/or soil pH affects the resistance of tomato to bacterial wilt. Greenhouse and laboratory studies have shown that increased calcium concentration in the nutrient solution reduced disease severity (Kelman, 1950; Ssonkko, 1993; Yamazaki and Hoshina, 1995). In field experiments conducted in Florida, lime ($CaCO_3$) applied at the rate of 1 ton/A and roto-tilled into the soil one month prior to planting resulted in a slight reduction in the incidence of bacterial wilt (Locascio et al., 1988). When a rate of 7.2 tons/A was uniformly incorporated to a depth of 24 inches, the incidence of bacterial wilt was significantly reduced for up to two years (Ssonkko, 1993). It is interesting to note that the only tomato production region in the state where bacterial wilt does not occur on a regular basis is Homestead, where the soils are calcareous with a high pH.

SUMMARY AND PRESENT RESEARCH

Development of resistant cultivars is the most ecologically sound strategy for managing bacterial wilt of tomato. However, due to the complexity of inheritance of resistance, it is doubtful that a horticulturally acceptable cultivar with complete resistance can be obtained. The use of molecular biology will facilitate the identification of all of the genes responsible for conferring resistance and will facilitate backcrossing programs by identifying linkage drag and dilution of resistance genes without costly and time consuming field trials. At present, the best that can be hoped for using conventional plant breeding is the development of a horticulturally acceptable cultivar with a moderate level of resistance. Field trials are currently underway in Bradenton and Quincy evaluating the performance of hybrids using Neptune and other resistant open-pollinated cultivars as the resistant parent.

The effects of calcium nutrition and soil pH is being investigated further at the North Florida Research and Education Center in Quincy. Preliminary results indicate that a moderate level of suppression can be obtained by combining economically feasible applications of lime with an altered nutritional program. In conclusion, is anticipated that any bacterial wilt management program developed in the near future will require the combined use of several tactics including cultivars with moderate levels of resistance fertility programs that increase soil pH and calcium uptake in the plants.

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European Tomato Industry

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Tomato is the main vegetable grown in Europe, with a production of 16.7 metric tons, as well as in the European Community, with a production above 13.6 metric tons, including both fresh market and canning industry tomatoes.

Italy, Spain and Greece represent 79% of the European Community production, being Italy the leader with 44% of the EC production. Exports in the EC are leaded by The Netherlands and Spain, and imports are leaded by Germany, France and United Kingdom. In Spain and Italy, canning industry is increasing, which takes a large part of the tomato production. Thus, both countries are actually importing tomatoes despite their higher productions.

The Netherlands, with their particular veiling system of trading, can be considered as the main market for European horticultural products. Veilings control in The Netherlands 99% of the legumes that are produced under greenhouses, although now direct trade between producer and exporter is increasing at the same rate as veilings group together to control better the markets. The Netherlands import during winter mostly for export, and sometimes one can buy in the South of Europe Dutch tomatoes during the southern growing season and even, because of their trade networks, "Dutch" tomatoes that were actually grown in the South.

Main importers in northern European countries have a year-round calendar for tomato, coming in October from Murcia and Almería in Spain, followed at the end of October by tomatoes from the Canary Islands, also in Spain, starting at the end of November and December with tomatoes from Morocco (and even sometimes also from Florida) and ending in March to May with tomatoes grown in Belgium and in The Netherlands.

In the EC market, competition by eastern European countries is becoming important, for example, Albania, Rumania and Bulgaria are introducing high quality tomatoes that are available from mid spring to beginning of summer. In fact, seed producers are starting to develop varieties that adapt better to their growing conditions, like the Vemone tomato.

While the main producers of the EC are the Mediterranean countries, the higher yields are achieved in northern Europe. This is due to the fact that in northern European countries, most of the production is done under glass, while in the South, due to the particular climatic conditions, tomatoes can be grown for most part of the year in open fields or in very simple greenhouse or shade structures. Northern European countries are now starting to take advantage of the fact that heat excess in July and August in the southern countries can slow down the summer production of tomatoes, thus summer market is starting to be left to northern European producers. The technology in eastern Europe is very poor, most of the production is done in open fields and hydroponic systems are not yet used on a commercial scale, unlike northern Europe where most of the production is under glass.

The EC is a market with high buying power, and prefers to buy quality products that are more expensive than cheap products that are not well packaged. New aspects are being introduced in tomatoes: varieties that are flat and dented are more appreciated, as well as for flavor, aroma and vitamin content. As new varieties are better known by consumers, tomatoes with such qualities are more appreciated. The same trends apply to environmental conditions: growers tend to introduce biological control because consumers prefer environmentally friendly grown tomatoes. In some countries there are regulations in relation with pesticide residues and also in relation with growing techniques (recirculation, disposal of wastes, etc.). This implies a different way of growing: growing techniques should prevent entry of insects for virus transmission, that can be done only in protected horticulture. In northern Europe growers are more concerned about environmental restrictions while growing structures in the South of Europe are more open and do not account for this. In this sense an effort is being made now towards optimization of greenhouse structures in Mediterranean areas and introduction of hydroponic systems. One of the main problems in Europe regarding production of horticultural crops is due to the differences in regulations in the various countries, for example regarding environmental conditions.

Hydroponic systems under glass use coconut fiber, pumice, glasswool, wood chips, rockwool, peat, calcined clay, perlite, vermiculite or sand. These systems include automatic irrigation and application of nutrient solutions, with recirculation systems in northern Europe. Soilless culture aims to obtain higher productions by implementing an optimal air/water relation, preventing diseases and controlling nutrition. One of the main problems of these systems is the generation of high amounts of soilless media wastes. In some countries, like in The Netherlands, it is compulsory to use the hydroponic systems with recirculation of nutrient solutions and recycling of media.

Trends in consumption have changed over the past years, they started with the fashion of the big pale tomato, later the round tomato without flavor took over, later the beef tomato and now the grape tomato and the cherry tomato, more slowly, are starting to be the best sells. These last trends are being carefully introduced by growers due to the overproduction. Over the past years, market was getting de-localized because new varieties are widespread over all growing areas, causing changes in consumers preferences. Especially, with the introduction of new tomatoes, like the Long Shelf Life, that changed market trends and prices very fast. The problems to solve are that sometimes tomatoes that are good to sell are not good to eat. Long Shelf Life tomatoes have nice texture and color but they lack production and ease of culture. They do not like high heat and need a lot of light. This is why they are successful in the South of Europe and in the North-African countries. Long Life tomatoes will produce different effects over markets and consumers in relation with buying habits, for example, and over calendars and regions where they are grown. Now, European supermarkets are starting the strategy of innovating along the year with specialty tomatoes that are available over small periods of the year. Trademarks are starting to win the market, and high quality products have increased their sells due to the high quality standards that pay for higher prices. Grower's associations go for the local high quality marked products, like recently in the Maresme area in Spain where growers have associated to develop "green" red tomatoes. This implies a reorganization of the grower's associations.

Tomato production in Spain

In Spain there are around 60,000 hectares of tomato, being second only to Italy in European tomato production.

Production is Spain is mostly centered in the Mediterranean coast and in the Canary Islands. In new areas, they are grown extensively in flat, well mechanized fields, while in traditional areas, mechanization is difficult because fields are very small. Tomatoes are grown year-round in unheated polyethylene greenhouses.

Most of the production is for the Spanish market, especially for canning industry, and only around 13% of the production is exported. Spain used to be the main tomato producer in the EC, now it is Italy. The main competitors for the Spanish tomatoes are The Netherlands and Greece. Also Egypt and in a smaller scale, Algeria, Morocco and Tunisia are starting to compete with the Spanish tomatoes in the EC market, because of their lower cost of labor.

An important problem in Spain is leaching of nutrients, that has not been solved yet. New environmental campaigns for tomatoes in the Catalan area of the Maresme include control of leachates along with integrated pest management. Labor is the most expensive cost for tomato production, it takes approximately 60% of the cost, because of harvesting, pruning and staking. Crops is Spain are not well mechanized for these activities and an effort should be made to introduce carts, conveyor belts, small tractors and other facilities for tomato production.

Another important problem regarding tomato production is in relation with viruses. They are important mostly in the warm regions, like the Mediterranean area where vectors are more widespread. Some of the main viruses are the TSWV (Tomato Spotted Wilt Virus) and CMV (Cucumber Mosaic Virus) and also the TYLCV (Tomato Yellow Leaf Curl Virus) and the ToMV (Tomato Mosaic Virus) are starting to produce damages. Spanish researchers are working on gene introduction for resistances. In fact, new trends on tomato research are studies for long life and virus resistances. Long Shelf Life tomatoes have the problem of lack of flavor, and they are working on varieties that have more flavor.

The main production areas in Spain are the Southeast of Spain, in the provinces of Almería and Murcia, where there are more than 10,000 hectares of tomato, which is 16% of the total Spanish tomato growing area. Tomato is in these areas a fall crop, transplanting between July/August up to the 15th of September in open air, in the shade at the end of July and in greenhouses at end of August or September, until January. The most important varieties are: Royesta, Rambo, Ramy, Cobra, Marmande Raf, Bornia, Lorena. The Long Shelf Life varieties like Daniela are increasing.

The Canary Islands are also a main Spanish producer, with an increasing market and decreasing price, but also with low production costs. The Canary Islands have been able to maintain higher prices than the Spanish peninsula, and they export 180,000 mt per year (49% of the Spanish exports) to the EC. Long Shelf Life are 70% of the Canarian tomatoes. Main competitors are the Moroccan tomatoes. The Canary Islands can produce year-round because of their location, and they are nowadays taking over the Dutch market. New European regulations will force the Canary Islands to sell only from November to April. Paradoxically, technology in the Canary Islands comes mostly from The Netherlands.

In Spain there are 4 different production times:

Type	Sowing	Transplant	Harvest	Area
Extra-early	October	December	February	Southeast (Murcia, Almería)
Early	November	February	May	East
Mid-season	January	Spring	Summer	Inland
Late	June	July-September	September-February	Southeast (Murcia, Almería) Canary Islands

Late and extra-early tomatoes are grown mostly for export and they represent around 36% of the Spanish production. Summer productions are for local fresh market and for industry and they represent 64% of the production. Average productions are 40 mt per ha in fresh, open air, 70 mt per ha in semi-forced and hybrids and more than 100 mt per ha in greenhouses.

In Spain the production is now increasing by increasing productivity, not the area cultivated. This is achieved by introduction of hydroponic systems in greenhouses. Rockwool was introduced in Spain in 1984 and, because of cost, some substitutes were studied. They introduced sand, that had ecological problems because of extraction and in 1990, perlite was introduced as a medium for vegetables. Tomato was the first vegetable to be cultivated in Spain under these systems.

Notes

Figures have been adapted from 'Anuario de Producción FAO 1991' and from 'Estadística del Comercio Exterior de España', Dirección General de Aduanas. If not otherwise stated, figures represent data for 1991. Some information has been obtained from Horticultura trade magazine from Spain (various numbers), Fruit et Legume Distribution (various numbers) from France and 'La Horticultura Española en la CEE', SECH, 1991.

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Figure 1. Tomato production, in metric tons, in the European Community.

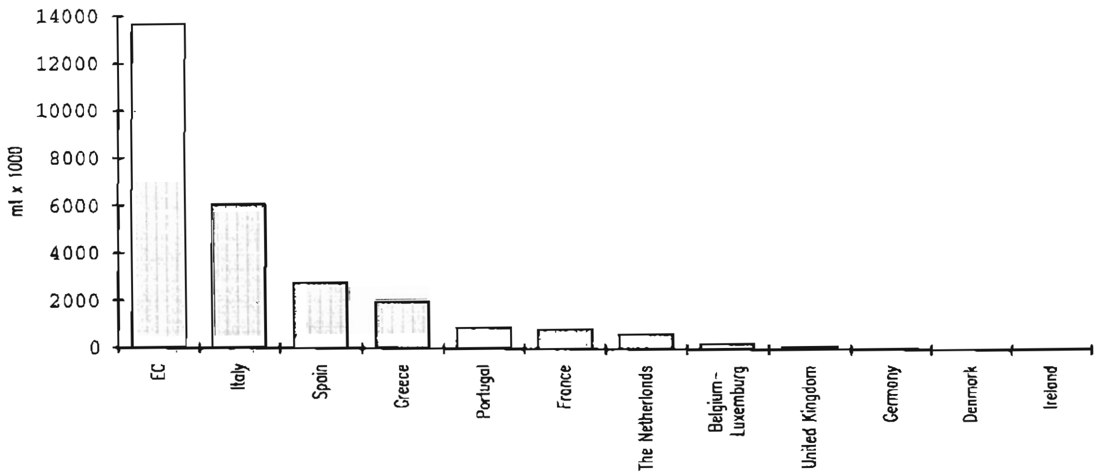


Figure 2. Percent production in EC countries.

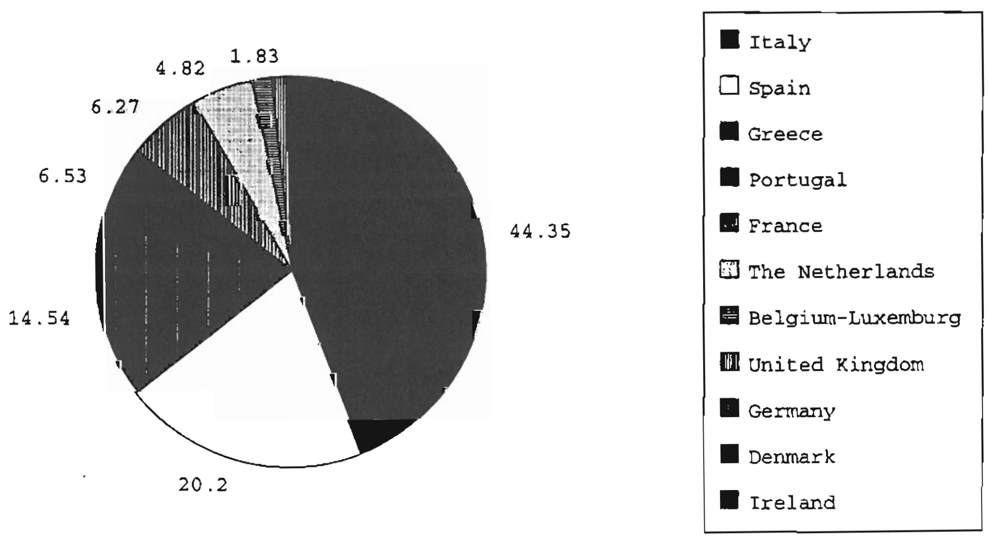


Figure 3. Tomato cultivated area in the EC (per one thousand hectares).

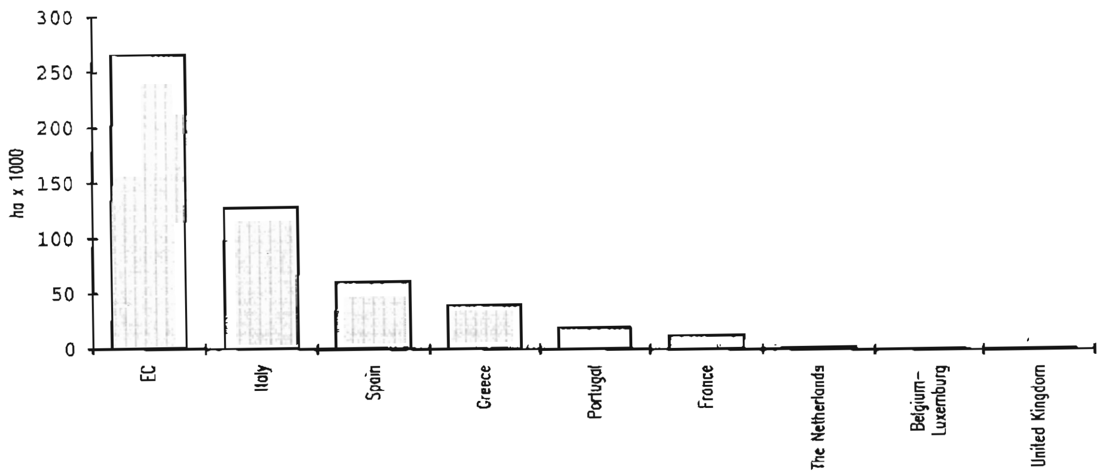


Figure 4. Tomato imports and exports in the EC market (per one thousand metric tons).

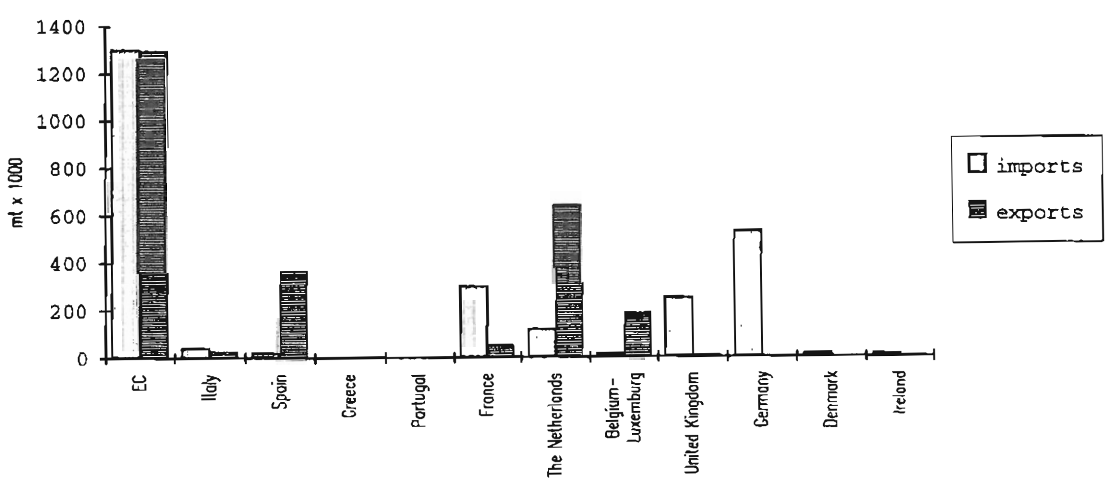


Figure 5. Average tomato production in EC countries (kg per hectare).

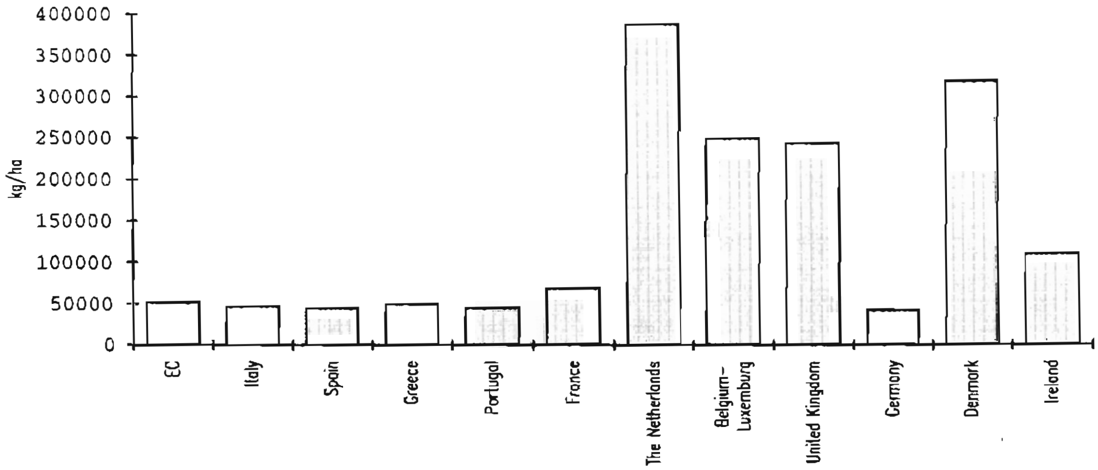


Figure 6. Average tomato production in non-EC countries (kg per hectare). Data from Poland, Rumania, Algeria, Tunisia and Israel are from FAO 1989).

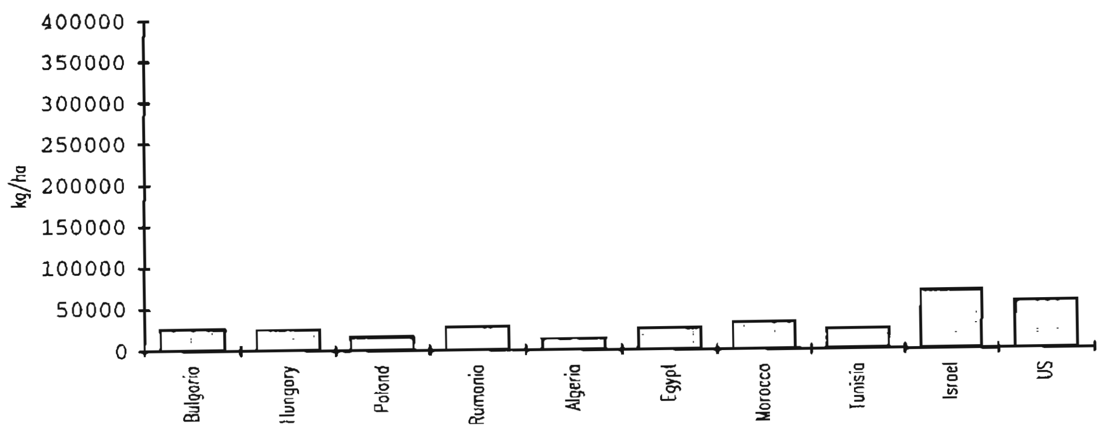


Figure 7. Tomato imports in Spain (metric tons).

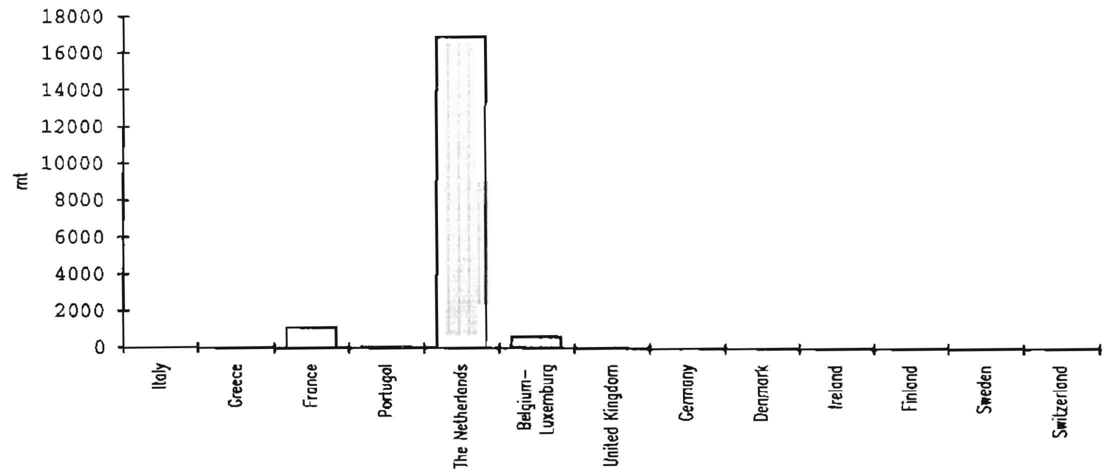
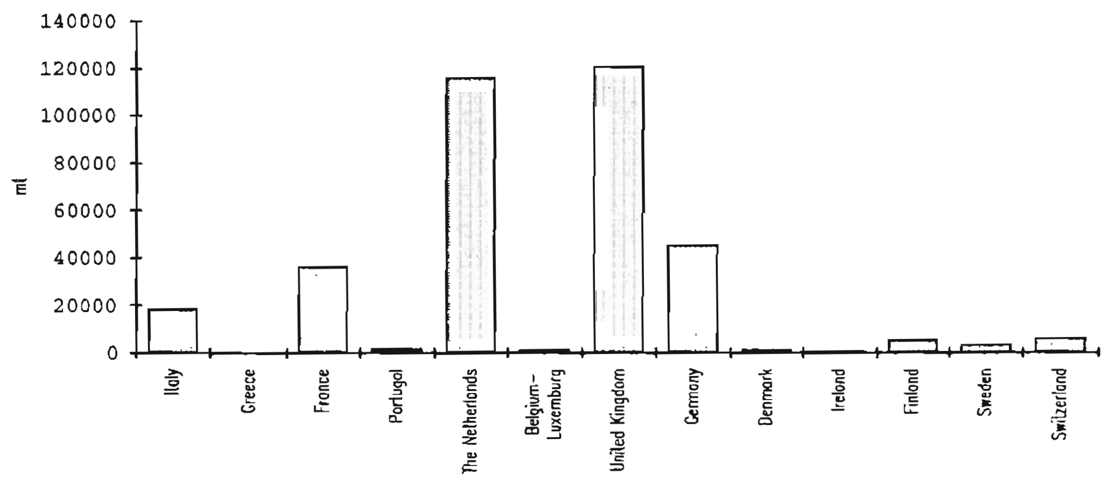


Figure 8. Tomato exports in Spain (metric tons).



The Use of Mating Disruption to Control Tomato Pinworm, *Keiferia lycopersicelle*.

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Abstract:

During the last three spring growing seasons in Southwest Florida, pheromone emitters were evaluated in commercial tomato production fields for the control of tomato pinworm (TPW). Treated and untreated plots ranging from 10 to 60 acres were monitored for TPW populations with pheromone baited wing traps. Plots were scouted for the presence of TPW mines. Trap counts in treated areas over all three seasons remained very low never exceeding over 5 moths/trap/night. In the untreated control plots trap counts increased as the seasons progressed and often reached levels over 50 moths/trap/night. Mating disruption with pheromone emitters appears to be an effective strategy for the control of TPW.

Introduction:

The tomato pinworm *Keiferia lycopersicelle* has become a serious pest of tomatoes in Florida(4). Its larvae are leaf miners in the early instars and then become leaf rollers, and may even bore into the fruit just below the calyx(1). Control of this pest can be difficult at best, because the larvae lives part of their life cycle feeding between the upper and lower surface of the leaf out of the reach of most pesticides which must contact the larvae in order to be toxic.

After the identification of the TPW pheromone and the description of the adult sex pheromone biology (3), development of a system using sex pheromone for control of the tomato pinworm was initiated and experimental trials were begun in Florida, California, and Mexico (2).

These successful trials resulted in a promising strategy, wherein, male tomato pinworm moths are inhibited from locating and mating with females, following the mass application of a synthetic female sex attractant. When their mating is disrupted there are no eggs to lay and no larvae to damage the leaves and fruit.

Several commercial formulations and application methods have become available to the growers. Two of these commercial formulations were tested in Florida in 1992(5).

The trials reported herein were initiated in order to test other formulations of TPW mating disruptants in on farm grower demonstrations.

Materials and Methods:

All trials were performed in commercial tomato fields in the Immokalee area.

In the spring of 1993, CheckMate™ TPW (Concep, Inc.) was evaluated for the control of tomato pinworm. Treatments consisted of a 10 acre plot treated with the mating disruptant, and an untreated control plot in the adjoining 60 acre field. The treated plot was bordered on three sides by woods and on the fourth side by the control plot. The two plots were separated by about 200 ft. Six pheromone baited wing traps were placed on a transect through each plot. The transect through the untreated control plot began 200 ft. away from the treated area, and extending for approx. 0.5 miles. The mating disruptant tags were stapled to 3.5 inch surveyors flags and applied to the center row of the three row beds of tomatoes at the rate of 200 tags per acre(9.6g a.i.). The tomatoes were planted on 1/3/93 (treated plot), and 12/28-30/92 (control plot). Tags and traps were set out on 2/5/93. Treatments were scouted every three to four weeks for the presence of tomato pinworm leaf mines. Wing traps were monitored for adult pinworm moths twice per week.

In the **spring of 1994**, CheckMate™ TPW was again evaluated for the control of tomato pinworm. Treatments consisted of a 13.3 acre plot treated with the mating disruptant, an adjacent (transition area) field which was 19.5 acres, and an untreated control plot of 22 acres, located 2 mile away from the treated plot. The mating disruptant tags were placed as high up as possible on the limbs of the plants at the rate of 200 tags per acre(9.6g a.i.). Six pheromone baited wing traps were placed on a transect through each treatment. The tomatoes were planted on 12/20/93 (treated plot), 12/25/93, (transition plot), and 12/13/93 (control plot). Tags were set out on 1/27/94 and pheromone traps were set out on 2/3/94. Treatments were scouted every three to four weeks for the presence of tomato pinworm leaf mines. Wing traps were monitored for adult pinworm moths twice per week.

In the **spring of 1995**, Decoy™ TPW mating disruptant was evaluated at two different rates. The treatments consisted of an untreated control on 25.5 ac, and Decoy TPW at rates of 300 clips per acre (26g a.i.) on 27.4 ac, and 400 clips per acre (35g a.i.) on 24.6 ac. The treatments were comprised of 77.5 acres of the youngest tomatoes in a 245 acre tomato production field, and were separated by non-crop areas approximately 500 feet in length. The tomatoes were planted between 1/17/95 and 1/20/95. The clips were applied to every other row of tomatoes on the string after the first tie was made on 3/16/95. Six pheromone baited wing traps were set out in a transect across each of the plots on 3/16/95. Treatments were monitored on 4/17, 5/9, and 5/22/95 for the presence of tomato pinworm leaf mines. Leaf mines were monitored by examining 33 feet of row, in 6 random locations in each plot. (Septae in the traps and trap bottoms were replaced on 4/19/95).

All treatments in 1993 and 1994 received biweekly applications of insecticides including members of the organophosphate, organochlorine, carbamate, and synthetic pyrethroid families. In 1995, all of the treatments were treated with Admire™, which allowed a 70% reduction in the use of pyrethroids, a 66 % reduction of organochlorines, and the elimination of organphosphates from the spray program.

Results:

Initial trap counts on all treatments in each of the three years were less than one moth per trap per night. Trap counts remained low in all treatments over all years for the first three to four weeks (figures 1,2, & 3). After this initial phase, trap counts in the untreated control began to rise steadily, while treated plots remained very low (< 1 moth/trap/night). Between 7 and 8 weeks after treatment, trap counts in the untreated control increased dramatically in each of the three years.

In 1993 trap counts in the two traps nearest the treated area (transition 1 = 200 ft. away, and transition 2 = 240 ft. away: See figure 1) mirrored the untreated control plot but were lower in a direct relationship to the distance from the treated area. Trap counts in the treated plot never exceeded 1 moths/trap/night. No pinworm mines were found in either treatment during the spring of 1993.

In 1994 trap counts in the field adjacent to the treated area showed a similar tendency to the untreated control 2 miles away, but at a much reduced level (figure 2). Trap counts in the treated plot never exceeded 1 moths/trap/night. No pinworm mines were found in any treatments during 1994.

In 1995 trap counts in both of the treated areas remained below 2 moths/trap/night, until 56 days after the treatments began, when counts in the 300 clips/ac treatment began to increase (figure 3). At the end of the trial, 64 days after treatment, trap counts in the untreated control were running around 35 moths/night, the 300 clips/ac treatment was averaging around 15 moths/night, and the high rate of 400 clips/ac had not exceeded 5 moths/night.

No pinworm mines were found in any treatments 54 days after treatment began. At 67 days after treatment the average pinworm mines observed on 33 feet of row were 50 in the untreated control, 49 in the 300 clips/ac treatment, and 35 in the 400 clips/ac treatment (figure 4).

Discussion:

The trap counts in the transition areas in 1993 (figure 1) and the adjacent field in 1994 (figure 2) indicate that the pheromone is capable of effecting surrounding areas. The lack of pinworm mines in all of the treatments in 1993 and 1994 is probably a function of high pinworm mortality due to the intense spray program that was being used in an effort to control the silverleaf whitefly.

In the spring of 1995 the advent of Admire for the control of the whitefly gave an opportunity to test mating disruption on a large scale in an environment with a much reduced insecticide usage. During 1995 moth trap counts in the treated areas remained very low throughout the trial. The lower rate of Decoy TPW began to lose effectiveness after 56 days, but the high rate was very effective to the end of the trial (figure 3).

Pinworm mines rose dramatically in only 13 days from none being found on 5/9/95 to a large number in every plot by 5/22/95. Although there were no significant differences between the plots, the 400 clips/ac plot had a tendency toward fewer pinworm mines than either the untreated control or the 300 clip/ac plot (figure 4). The rapid increase in mines may be a function of mated females moving into the treated areas from the surrounding production fields. Harvest started on the surrounding production fields 7 to 8 weeks before the last leaf mine samples were taken. Once the harvest began applications of insecticides were discontinued. Even under such pressure from the nearby tomato fields, the high rate of Decoy TPW showed less pinworm mines at the end of the trial.

Summary:

Several formulations exist that are efficacious against the tomato pinworm. Close attention should be paid to the proper distribution and recommended rates of pheromone emitters. Fields should be treated prior to the build up of large pinworm populations, and efficacy might be effected by the status of nearby tomato plantings. Mating disruption with pheromone emitters appears to be an effective strategy for the control of the tomato pinworm.

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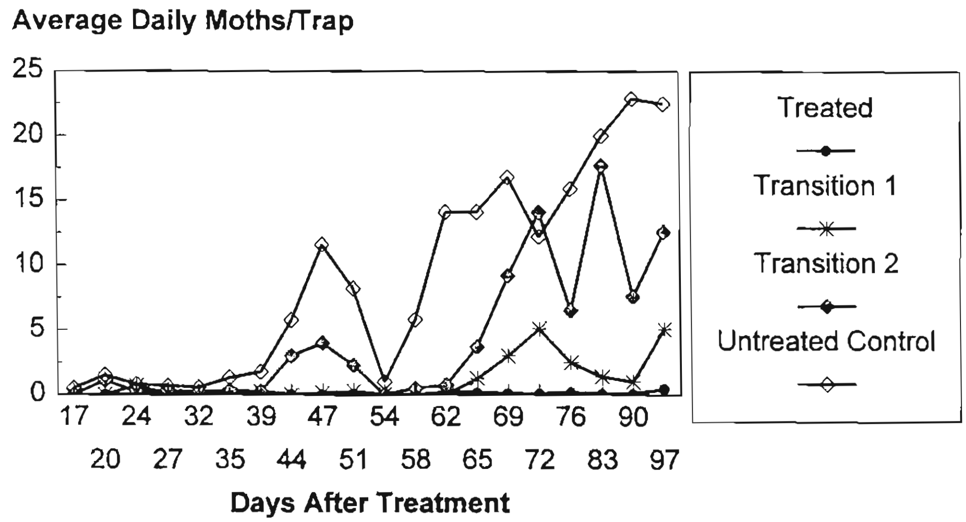
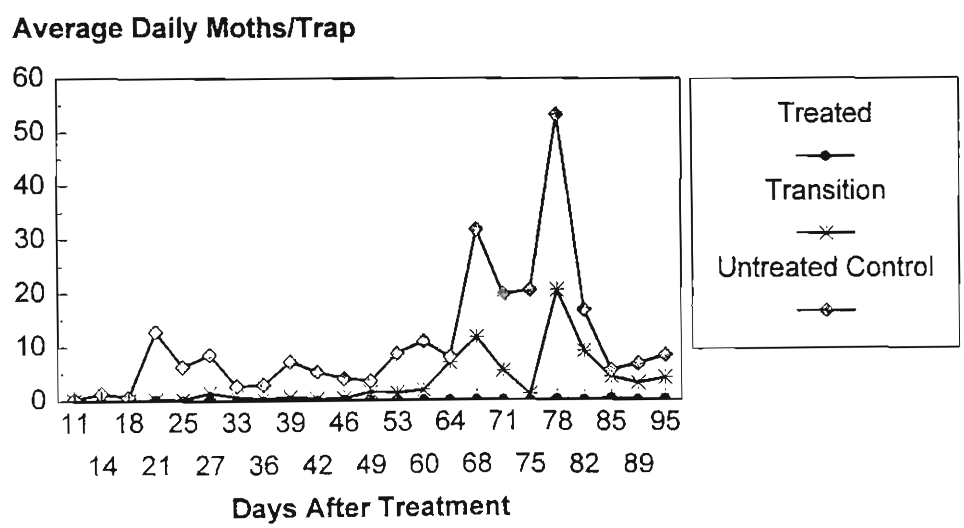
Figure 1.
Number of Moths Captured in Wing Traps
Spring 1993



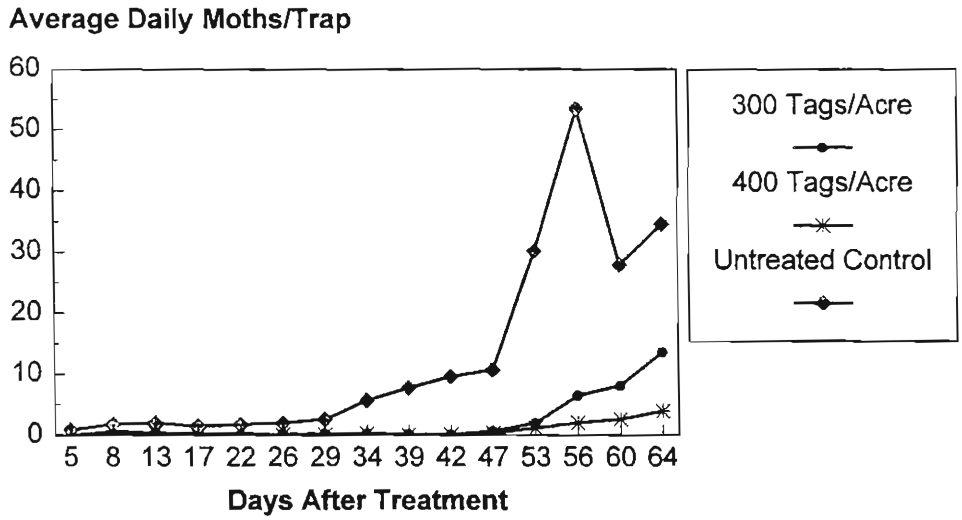
Mean of six traps per treatment

Figure 2:
Number of Moths Captured in Wing Traps
Spring 1994



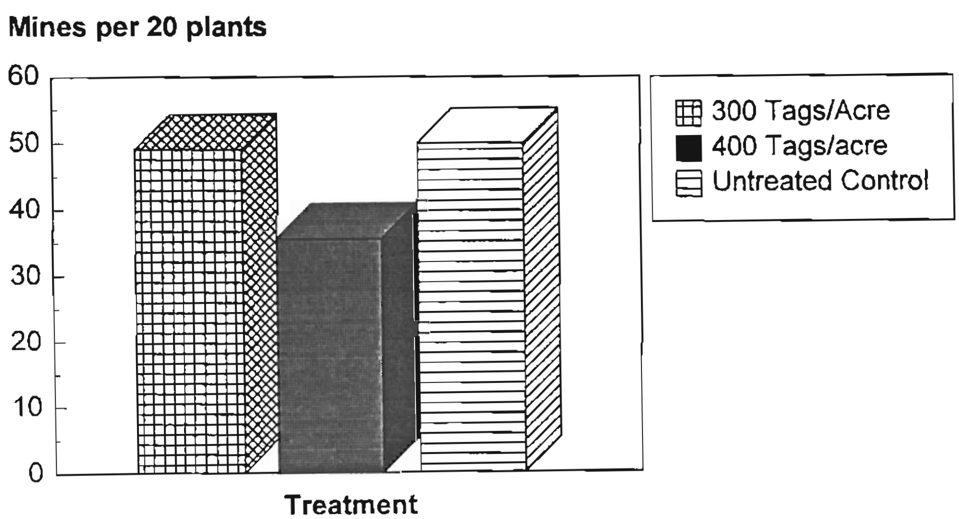
Mean of six traps per treatment

Figure 3.
Number of Moths Captured in Wing Traps
Spring 1995



Mean of six traps per treatment

Figure 4.
Pinworm Mines at Harvest
1995



Mean of 20 plants with 6 sampling locations per treatment

Management of Silverleaf Whitefly: Past, Present and Future

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The history of whitefly as a pest of Florida tomatoes goes back no further than 1987 when infestations in poinsettias spread to vegetables including tomato (Price et al. 1986, Hamon & Salguero 1987). The whitefly was identified as *Bemisia tabaci*, or "sweetpotato whitefly" a species known to have occurred in the state for at least 100 years but never previously recorded on tomato, cucurbits or even poinsettia according to DPI records. Why the sudden shift in host preferences? The explanation was that a new race, strain or biotype had been accidently introduced from somewhere, probably on poinsettias brought into the state for propagation or resale. The actual origin of the whitefly was anyone's guess.

One notable and easily distinguishable characteristic of the new whitefly was its ability to cause silvering or silverleaf of squash, now known to be a plant response to as yet unknown toxin(s) injected into the phloem by any of the four feeding immature stages known as nymphs (Jimenez et al. 1995). Squash silverleaf had been reported earlier from Israel, although water stress rather than whitefly had been implicated as the cause (Burger et al.1988, Paris et al. 1987). However whiteflies may have been present during these studies and thus may have been the actual cause of the reported silverleaf which is known to be exacerbated by plant stress (Paris et al. 1993). Whatever the origin, the new whitefly spread quickly throughout the tropics, subtropics, and further north and south in greenhouses, always identifiable by the silverleaf symptom on squash. In many of these areas it quickly became the number one pest on susceptible vegetable, broadleaf field crops and many ornamental crops. When closer scrutiny of the new pest revealed biological, physiological and even morphological differences between it and the previous *B. tabaci* from California, it was suggested that the new whitefly was actually a distinct species and the name *Bemisia argentifolii* or "silverleaf whitefly" was proposed (Perring et al., 1993, Bellows et al. 1994).

High populations of silverleaf whitefly can debilitate plants through sap removal and the sun-screening effects of sooty mold accumulation of secretions of honeydew. Moderate populations may be sufficient to induce plant disorders such as squash silverleaf and in tomato, irregular ripening (Schuster et al. 1995). Heavy infestations on Florida tomatoes in 1988 caused irregular ripening that at first caught growers unaware until after shipment so that losses included harvest and transport costs (Maynard & Cantliffe, 1989). Even low populations may quickly spread plant viruses through crops if high levels of inoculum are present. In fall of 1989 the previously unknown tomato mottle gemini virus (TMoV) swept through all Florida production areas except the North, causing widespread damage and economic loss.

Even more destructive that year was the Christmas freeze which totally destroyed the crop, taking whiteflies and virus with it. Although massive replanting in January proved financially disastrous due to low prices, the crop was free of whitefly and virus, providing a valuable lesson on the importance of a crop-free period to breaking the whitefly/virus cycle. Growers were urged to destroy all crop residues after the spring harvest and during the summer to maintain fields free of volunteers that could provide inoculum sources for the fall crop (Schuster et al. 1989, Stansly, 1990). Later, an exhaustive host range survey substantiated that tomato was the only significant source of TMoV in Florida tomato fields (Polston et al. 1993, McGovern et al. 1994). Tropical soda apple (*Solanum viarum*), the only susceptible weed host discovered and an introduced species from South America, is spread principally by cattle and wildlife (Mullahey et al. 1993) and occurred only rarely in conjunction with tomato production at the time. Common bean was also shown to be susceptible, but again, there was little correspondence between bean production and TMoV problems, except possibly the Homestead area. Furthermore, a significant role of beneficial insects in reducing whitefly populations during fallow periods was verified by observations of high rates of predation and parasitism in weed hosts (Schuster et al. 1992, Stansly & Schuster 1992, Stansly et al. 1993).

Grower response to the recommendation was good in the southwest production area, and rigorous summer cleanup was rewarded with low incidence of whitefly and virus in fall 1990. Unfortunately, whiteflies and virus built up sufficiently during the fall harvest to carry over into the spring crop. Shorter summer fallow in the south-central area probably contributed to early season problems there, and carryover into the spring crop may occurred from winter crops such cabbage (Schuster et al. 1992, Stansly & Schuster, 1992). These problems account for much of the $141 million in damage and control costs estimated for the 1990-91 season (Schuster et al. 1995). Crop rotation and spacial separation were recommended to separate overlapping fall and spring crops, and pressure the following spring was considerably reduced.

Unfortunately, economically feasible crop-free periods alone are not sufficient to maintain whiteflies and virus below damaging levels in tomato and suppression of whitefly populations within crops is still a necessity. This is accomplished with insecticides by comercial vegetable growers, although studies in an isolated organic farm on Pine Island have demonstrated the potential of biological control to provide sufficient suppression under these conditions (Stansly et al. 1993, Schuster 1995). A limited number of chemical alternatives were identified from screening over 45 products or product combinations in the laboratory, greenhouse, and field (Schuster et al. 1989, Stansly & Schuster 1990, Stansly et al. 1991). Chemical options prior to 1994 were limited to foliar applications of insecticides, generally conventional broad-spectrum types, although household detergents were also used (Butler et al. 1993, Stansly et al. 1995). Tank mixes of organo-phosphates and pyrethroids became increasingly popular as whitefly pressure increased over the season and over the years, possibly exacerbated by the breakdown of self-imposed restraints on planting dates and clean-up. All whitefly stages concentrate on lower (abaxial) leaf surfaces and up to 8 side-directed nozzles per row delivering spray at high pressure from diaphragm pumps were commonly used to attain maximum coverage. Still, twice a week applications were the norm. Air-assisted sprayers demonstrated some ability to achieve even better underleaf coverage and were increasingly used.

While this technology was adequate to control in-field populations, it did not proved effective in the face of large-scale immigration of whiteflies from adjacent crops, an increasingly common scenario as market temptations overrode pest control considerations (Schuster et al. 1993). Fortunately for many tomato growers, the systemic insecticide imidacloprid (Admire ®) was made available in spring 1994 (Swanson & Stansly 1994). Tests have shown that imidacloprid applied at transplanting can provide effective suppression of whitefly populations and virus movement for at least 60 days (Stansly & Cawley, 1994). Label restrictions allow for only 16 oz of 2 E product per acre per season, so that rotation to other classes of insecticide would be necessary in the event of late season infestations, hopefully delaying the onset of resistance.

Use of imidacloprid during the 1994-95 season was almost universal, and results were dramatic, although a wet fall and winter also contributed to whitefly demise. The formerly ubiquitous pest seemed non-existent in the southwest production area until late spring (Fig 1), and virus incidence was virtually zero. Imidacloprid is a powerful tool for whitefly control which must be used wisely to avoid development of resistant populations. The restriction to one application per crop is necessary to limit exposure of populations to only part of the crop cycle, preferably the early part when protection is most critical and imidacloprid most effective. Different chemistry should be used in the latter portion of the crop cycle if necessary to preserve the usefulness of all our presently available insecticides.

Ultimately, we hope to find economically viable, non-chemical means of managing whiteflies and other insect pests. Surveys of natural enemies attacking SLWF in Florida have identified 11 species of tiny parasitic wasps and 12 whitefly predators (Dean 1994). Biological control by this complex of natural enemies which is one of the major factors in reduction of whitefly populations during the crop-free period (Schuster et al. 1994), and have been shown to provide effective control in organically grown vegetable and unsprayed peanuts (McAuslane et al. 1994). We are seeking ways of realizing the potential of biological control in commercial tomato production through the use of habitat manipulation to provide refugia for natural whitefly enemies (Schuster et al. 1994). Perhaps imidacloprid and other new specifically targeted insecticides like such as growth regulators for whitefly and other tomato pests like armyworms and non-chemical controls such as mating disruption for tomato pinworm (Jenkins et al. 1990, Schuster et al. 1993) can provide a transition toward the goal of full biological control of silverleaf whitefly. Meanwhile, growers are urged to use their chemical tools judiciously and not forget the importance and utility of cultural practices for whitefly control such as fallow periods coupled with field sanitation and crop rotation to maintain whitefly populations at manageable levels.

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Efficacy and Phytotoxicity of Admire Application to Tomato Seedlings in the Plant House

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Introduction

With the advent of field use of Admire in January 1994, growers felt it was necessary to provide Silver Leaf Whitefly (SLWF) protection for plants while in residence in the greenhouse. Bayer (the parent company to Miles) does market a seed treatment of Admire called Gaucho, but this label is not available in the U.S. The purpose of this experiment was to determine rates, timing of application, and efficacy of Admire in the plant house.

Methods and Materials

'Colonial' tomato seeds were direct seeded into 392 unit containerized trays in Metro Mix 220 and grown under standard FL open sided greenhouse conditions in Feb. and Mar. of 1995. Overhead irrigation was used and the plants were fertilized weekly with 250 ppm N from Nutrileaf 20-20-20 (Miller Chemical Co. Hanover PA). To facilitate egg and nymph counts later in the trial, seedlings for replicates 1 and 2 were started 1 Feb 1995 and reps 3 and 4 were started later (24 Feb). Two trays were required for each replicate, with each tray containing 3 treatments and a control. Treatments within replications were assigned randomly to each tray. Each treatment consisted of 84 cells of seedlings separated from other plots by a blank row of cells.

Two rates of Admire, 0.01 ml and 0.005 ml per plant, (1/10 and 1/20 the field application rates respectively) were applied as a 5 ml soil drench into each individual tray cell at three separate timings: at seeding, 2 weeks, and 4 weeks after seeding. This gave 7 treatments:

1. No Admire
2. 0.01 ml at seeding
3. 0.005 ml at seeding
4. 0.01 ml at 2 weeks
5. 0.005 ml at 2 weeks
6. 0.01 ml at 4 weeks
7. 0.005 ml at 4 weeks

The plants were visually examined for symptoms of phytotoxicity as they developed following Admire application. Plants were grown the first four weeks in an open sided greenhouse and upon completion of the "at 4 weeks" treatment were immediately exposed to a vigorous colony of SLWF in an enclosed, air-conditioned glasshouse maintained at approximately 80° F. Trays were moved daily to counteract possible bias due to location. Five weeks after first exposure to whiteflies, 5 plants per plot from replicates 1 and 2 were transplanted into 4 inch pots for further evaluation.

Plants were evaluated for whitefly eggs and nymphs beginning 14 days after first exposure to whiteflies and at 7-day intervals thereafter. Ten plants were randomly selected from each treatment within each tray, cut off at the soil line and brought into the laboratory. Three cm^2/plant were examined under a stereoscopic microscope. Examined spaces were delineated by a cardboard template placed on each side of the midrib near the base of the leaflet.

After each plant was evaluated for whitefly nymphs all ten plants were placed in a paper bag and dried in a 175 degree F drying oven. Plant dry weigh per treatment was recorded.

Results

Phytotoxicity All Admire treatments, whether applied at seeding or to seedling plants, resulted in phytotoxicity. "Phyto" appeared within 3 days of application in 2 and 4 week old seedlings, but took about 2 weeks to develop when applied at seeding. The phyto appeared as necrosis on leaf tips and margins. More severe phytotoxicity was seen in response to the high (0.01 ml) rate than the 0.005 rate, regardless of time of application. Symptoms did not appear to impair plant development or be excessive by current plant house standards.

Plant dry weight (DW) Admire at the 0.01 ml rate reduced tomato dry matter accumulation in weeks 7, 8, 9, and over all (combined) sample dates when compared to the nontreated check (Table 1). The 0.005 ml rate did not effect dry matter accumulation.

Application time resulted in significant reductions in DW in week nine and over all (combined) weeks (Table 1). Thus the impact of Admire's plant DW reduction capacity was most severe when applied later in the transplant cycle. Apparently while Admire application tends to reduce plant DW whenever applied, a significant reduction in DW can only be noted when Admire is applied at week four in the transplant cycle.

Table 1. Plant dry weight as affected by Admire rate and timing on tomato seedlings for transplanting.

	Plant Dry Weight (g/plant)					
	Week 6	Week 7	Week 8	Week 9	Week 10	Average
Rate						
0	0.71	1.16 a	1.54 a	2.61 a	3.76	2.09 a
0.005	0.72	1.12 a	1.55 a	2.39 ab	3.71	2.00 a
0.01	0.69	0.98 b	1.34 b	2.17 b	3.17	1.75 b
Applic. Time						
None	0.71	1.16	1.54	2.61 a	3.76	2.09 a
At Seed	0.68	1.10	1.46	2.57 a	3.67	1.94 ab
2 Weeks	0.71	1.04	1.46	2.18 ab	3.52	1.90 ab
4 Weeks	0.72	1.02	1.42	2.09 b	3.18	1.79 b

Means followed by the same letter in the same column are not significantly different (LSD, $P < 0.05$)

Whitefly response Both rates of Admire provided significant protection from oviposition (egg laying) until plants were 8 weeks old. At 9 weeks, the number of eggs on plants treated at the high rate (0.01) was significantly lower than the control, but the low (0.005) rate appeared to have lost it's protective value (Table 2). This situation appeared to persist for an additional 2 weeks in 4 inch pots (Replicates 1 and 2) but could not be confirmed statistically. Both rates clearly reduced SLWF nymph development through 10 weeks after treatment.

Table 2. Numbers of eggs and live nymphs per 3 cm^2 leaf surface from 6 weekly samples as a function of rate of Admire.

	Plant Age (weeks)					
	Six		Seven		Eight	
	Eggs	Nymphs	Eggs	Nymphs	Eggs	Nymphs
Rate						
0	24.70 a	2.56 a	21.71 a	2.94 a	16.71 a	2.95 a
0.005	13.26 b	0.15 b	15.88 b	0.26 b	15.22 a	0.20 b
0.01	8.94 c	0.05 b	11.13 c	0.04 b	9.44 b	0.16 b

	Plant Age (Weeks)					
	Nine		Ten*		Eleven*	
	Eggs	Nymphs	Eggs	Nymphs	Eggs	Nymphs
Rate						
0	16.45 a	2.04 a	82.00	5.33 a	51.50	89.25
0.01	10.45 ab	0.17 b	64.56	1.22 b	16.83	52.58
0.005	14.63 b	0.76 c	98.89	1.78 b	44.25	29.83

* Replicates 1 and 2 only.
Means followed by the same letter in the same column are not significantly different (LSD, $P < 0.05$)

The oviposition and nymph development response of SLWF to plant age at time of Admire application was considerably weaker than the rate response noted above. Only at the 6 and 7 week evaluation was there a significant reduction in egg numbers observed between the at seeding and 4 week applications (Table 3). All timings reduced nymph survival effectively in weeks 6 and 7 as no differences were observed in nymph counts between the at seeding, 2-week or 4-week applications. No significant interactions between rate and time of application were seen.

Table 3. Numbers of eggs and live nymphs per 3 cm^2 leaf surface from 6 weekly samples as a function of plant age at application of Admire.

	Plant Age (Weeks)					
	Six		Seven		Eight	
	Eggs	Nymphs	Eggs	Nymphs	Eggs	Nymphs
Applic. Time						
None	24.70 a	2.56 a	21.71 a	2.94 a	16.71	2.95
Seed	13.10 b	0.11 b	16.12 b	0.20 b	13.15	0.33
2 Week	10.20 bc	0.09 b	14.85 b	0.15 b	10.29	0.14
4 Week	10.00 c	0.10 b	9.53 c	0.10 b	13.55	0.08

	Plant Age (Weeks)					
	Nine		Ten*		Eleven*	
	Eggs	Nymphs	Eggs	Nymphs	Eggs	Nymphs
Applic. Time						
None	16.45 a	2.04	82.00	5.33	51.50	89.25
Seed	15.95 a	0.63	91.33	2.17	20.75	21.62
2 Week	9.19 b	0.35	60.17	0.00	34.50	56.75
4 Week	12.49 ab	0.42	93.67	2.33	36.38	45.25

* Replicates 1 and 2 only.
Means followed by the same letter in the same column are not significantly different (LSD, $P < 0.05$)

Conclusions

Time of application had little effect on level of protection from whitefly achieved, while significant rate responses were evident. The 0.01 rate provided short-term protection from oviposition by whiteflies and maintained plants almost free of nymphs under intense population pressure through at least 9 weeks from seeding. Although significantly more nymphs were seen 9 weeks from seeding on plants treated with the 0.005 ml rate, the actual number was low given the intense pressure within the whitefly colony. Furthermore, there were no differences between rates at 8 weeks. Therefore, the 0.005 rate would probably provide adequate protection in the planthouse under most conditions.

The impact of a reduction in transplant dry matter accumulation resulting from Admire application on yield was not studied in this test. However, other studies on transplants have shown <u>any</u> reduction in plant weight resulting from "in-house" treatments can reduce yield in the field. Our recommendation is to apply 0.005 ml Admire at seeding (perhaps even as a bulk plug mix application) to reduce the impact of phytotoxicity and plant dry matter accumulation loss.

Pathogenic Variation within *Xanthomonas campestris* pv. *vesicatoria*

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Bacterial spot of tomato (*Lycopersicon esculentum*), incited by *Xanthomonas campestris* pv. *vesicatoria*, continues to be a significant problem to tomato growers. Control of this disease has been a major challenge. Chemoprotectants provide some control but during rainy, warm weather adequate control is difficult to achieve. The prevalence of copper tolerant strains of the bacterium has warranted the use of copper-mancozeb combinations to improve the efficacy of copper (Marco and Stall, 1983; Jones et al, 1991).

Disease management practices other than chemical control, when properly implemented, may also help to reduce disease severity. The likelihood for the bacterium to survive and become a problem on future crops is significant since it was shown that the bacterium can survive for extended periods (6 months following a fall crop, 2-3 months following a spring crop) on crop residue (Jones et al,1986). Furthermore, volunteer tomato plants can harbor the bacterium and serve as inoculum sources. Infected tomato volunteers were observed in old tomato fields up to nine months after the field was disked following production. Thus, in order to reduce the risk of severe bacterial spot, considerable attention must be given to clean cultivation. The incorporation of resistance genes into commercially acceptable genotypes will help to reduce bacterial spot. Since the identification of the bacterial spot resistant genotype, Hawaii 7998, considerable attention has been focused on breeding for bacterial spot resistance using the resistance derived from Hawaii 7998, since all strains of the bacterium in Florida until 1991 did not cause disease on that genotype.

Until 1988 strains of *X. c.* pv. *vesicatoria* collected in Florida and from around the world were identified as tomato race 1 (T1). However in 1988, Dr. Hiroshi Nagai, a scientist in Brazil, reported that Hawaii 7998 was susceptible to a Brazilian strain of *X. c.* pv. *vesicatoria*. Wang et al (1990) determined that it was a new race and designated it as tomato race T2 (T2). Thus, race T2 was a major concern to the bacterial spot breeding program in Florida because Hawaii 7998 derived resistance was only effective against T1 strains. Fortunately, in a collection of several hundred strains collected from Florida over a 30 year period none were similar to race T2 (Canteros, 1990). However, once the race T2 race was identified, a limited number of strains obtained from collections in Brazil, Argentina, Taiwan, New Zealand and Australia were also identified as belonging to race T2 (Stall et al 1994). In more intensive surveying of strains, it was determined that race T1 and race T2 strains were fairly well distributed throughout the world (Table 1).

As of 1991 only race T1 strains had been reported in Florida, Korea, Mexico and Taiwan.

In 1991, a survey of tomato fields on the west and east coasts of Florida was done to determine the composition of tomato races. In two fields in west Florida and one field in east Florida, strains were collected which produced disease in Hawaii 7998. Based on these results and several physiological tests, the strains were presumed to be race T2. However, the strains along with representative race T2 strains were tested on two *L. pinnellii* genotypes (PI 126932 and PI 128216). Race T2 strains collected from Florida produced a resistant reaction on these two genotypes, whereas the typical race T2 strains produced a disease reaction (Table 2). Thus the Florida strains were designated race T3 (Jones et al, 1995).

The race T3 strains have been compared with typical race T1 and race T2 strains using physiological, biochemical and serological tests. Based on carbon utilization patterns and fatty acid profiles, the race T3 strains formed a tight group indicating they were very similar (Jones et al 1995), whereas the race T1 and race T2 strains did not form tight groups (Bouzar et al 1994). Furthermore, T3 strains were antigenically distinct from race T1 and race T2 strains. All race T3 strains reacted with the T3 monoclonal antibody (MAb), but not with MAbs that react with race T1 or race T2 strains. This would tend to indicate that the race T3 strains are a fairly homogeneous group as compared to race T1 or race T2 strains and may have been introduced from a small area in the world.

Since the initial discovery of race T3 in Florida, it has also been detected on tomato seed produced in Thailand and isolated from several tomato fields in Mexico. Although race T3 appears to be a recent introduction to Florida, it has increased in prevalence in a very short time. In 1991 it was observed in three fields only, whereas in 1994 it was found in 16 out of 23 fields surveyed. Because of its aggressiveness and ability to overcome Hawaii 7998 dervied resistance, the emergence and establishment of race T3 in Florida tomato fields is a major concern to the future of tomato production in our state.

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Table 1. Geographic distribution of tomato races in a worldwide collection as of 1991

Race	Location
T1	Argentina, Australia, Bahamas, Brazil, Canada, Guadeloupe, Hungary, India, Korea, Mexico, Senegal, Spain, Sudan, Taiwan, Tonga, United States (California, Florida, Hawaii, Indiana, Oklahoma)
T2	Argentina, Australia, Brazil, France, Hungary, New Zealand, Réunion, Spain, Spain, United States (California, Hawaii, Indiana, Louisiana, Oklahoma)

Table 2. Susceptibility of tomato genotypes to the tomato races

Race	Walter	Hawaii 7998	PI126932 or PI128216
T1	+	-	+
T2	+	+	+
T3	+	+	-

[a]+ = disease reaction; - = no disease reaction.

BACTERIAL SPOT RESISTANCE BREEDING, 1995 VERSION

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Introduction

In the early 1970's Crill et al. (1972) reported the outlook for breeding tomato (Lycopersicon esculentum Mill.) varieties resistant to bacterial spot incited by Xanthomonas campestris pv. vesicatoria (Doidge) Dye was bleak due to a lack of adequate resistance. In 1983 we discovered an indeterminate accession with cherry sized fruit, Hawaii 7998, was highly resistant to bacterial spot in tomato (Scott and Jones, 1986). This provided some optimism in breeding for resistance. Later we determined that resistance from Hawaii 7998 caused hypersensitivity and that the inheritance was complex (Jones and Scott, 1986; Scott and Jones, 1989; Wang et al., 1994). An intensive bacterial spot resistance breeding program has been ongoing at the University of Florida since 1983 but progress has not been as rapid as desired due in part to the complex inheritance which requires several generations of screening between crosses as opposed to the backcrossing of simply inherited traits. Furthermore, considerable experimentation has not provided any highly reliable and simple seedling screening procedures (Somodi et al., 1994). Thus, to insure lines had high levels of resistance required field selection which could only be done once per year when it was hot and rainy, conditions conducive to the disease. Also, there was a tendency for the best resistance to be associated with large vine types without the concentrated fruit setting ability, which is desirable for Florida varieties. There was further difficulty in obtaining resistant plants with large fruit size. Nevertheless, inbreds were obtained which had heat tolerant fruit setting ability and enough fruit size that it appeared that heterozygous resistant hybrids horticulturally comparable to existing commercial varieties could be made. When heterozygous hybrids were tested, they were close to existing varieties in horticultural type but not quite as good. Scott et al. (1991) reported the heterozygous resistant hybrids had resistance intermediate to their parents. The best resistance would be provided by homozygous resistant varieties, but this does not appear possible for several years due to the breeding difficulties mentioned earlier.

However, before even heterozygous resistant varieties became commercially available, a new race of Xanthomonas appeared in Florida as described by Dr. Jones in the previous paper in this proceedings and elsewhere (Jones et al., 1995). As described in the previous paper there are 3 races of Xanthomonas which are known to infect tomatoes and two of them have been isolated in Florida. The original race has been called race 1 (T1) and the new Florida race is race 3 (T3). Race 2 (T2) was described earlier being first noted in South America. T3 was first identified in 1991. We found that fields inoculated with T1 had primarily T3 in them when leaf samples were taken later in the season. The antagonism of T3 to T1 was also demonstrated in petri dishes in the laboratory (El-Morsy et al., 1993). It became impossible to select for T1 resistance in the field and it quickly became apparent that resistance to T3 needed to be found if bacterial spot resistance breeding was to progress. Accessions were tested in the summers of 1992 and 1993. Details of these tests has been recently published (Scott et al., 1995). The highlight of the work was the response of Hawaii 7981, a sister line of Hawaii 7998 both of which were bred in Hawaii for resistance to bacterial wilt incited by Pseudomonas solanacearum E. F. Smith. In 1993, Hawaii 7981 was first tested and was more resistant than any other accession (Table 1). Hawaii 7981 was also highly resistant in 1994 tests (data not shown). Recent experiments indicated Hawaii 7981 has a hypersensitive response to T3. Furthermore, the resistance appears to be controlled by a single incompletely dominant gene. Hawaii 7981 has hardly any disease when field inoculated and the hybrid is nearly as good on the conditions tested to date. This simplifies the breeding work considerably compared to working with T1 resistance. T3 is being incorporated into T1 resistant breeding lines by selecting for T3 hypersensitivity in a backcrossing program. In 1996 the backcrossing cycles should be completed in some of the lines and they should be resistant to both races.

We are not sure what to expect at that point. Will T3 resistant lines prevent the T3 pathogen from antagonizing T1 and thus allow T1 to infect plants in the field? If so then needed field work on T1 resistant lines can continue. If not then selection for T1 resistance will require hypersensitivity tests, seedling inoculation in the growth chamber, and/or sensitive ELISA tests in the laboratory. Although these tests are useful they are not as definitive as a field test under high disease pressure. At present we have some new inbreds which are hypersensitive to T1 and may have good T1 resistance in the field as well as outstanding horticultural type. Backcrossing T3 into these lines is not as far along as it is in some of the lines which will be ready in 1996. However these lines should be ready to make hybrids with in 1997 and some hybrids should be commercially acceptable.

We are also backcrossing T3 resistance into T1 susceptible lines. Hybrids between improved T1 resistant inbreds and these T3 resistant inbreds may provide good bacterial spot protection to both races. In fact if there is some T3 in the field it might prevent T1 bacteria from doing any damage and, as mentioned earlier, heterozygous hybrids for T3 have very good resistance levels to that race.

We are also trying to find resistance to T2 of the bacterial spot pathogen in case it should move into Florida.

As mentioned, this pathogen was discovered in South America. It has also been isolated in several states in the United States. A test is underway in Ohio in cooperation with Dr. Sally Miller of The Ohio State University. If resistance is found we will do genetic studies to determine the best breeding procedures to incorporate the resistance into improved breeding lines. Obviously varieties adapted to Florida with resistance to all 3 races is considerably into the future. However, it may not be necessary to have T2 resistance here.

Another approach is via genetic engineering. In pepper (*Capsicum annuum*) there is a gene *Bs-2* which has a hypersensitive reaction to all 3 tomato races. A laboratory in California is trying to clone this gene. If this is successful the *Bs-2* gene can be transferred into tomato. We want to cooperate by providing elite breeding lines for this transformation work. Although transformation of tomato with *Bs-2* would take about 2 years it would provide varieties resistant to all 3 races. Of course once such a variety were available on a large scale a mutation of the pathogen to race 4 could occur resulting in more problems. However some single genes are stable for many years and this could be one of them.

Summary

Bacterial spot of tomato has caused considerable damage to the Florida tomato industry ever since tomatoes have been grown here. Cultural control measures, primarily spraying, has been expensive and not effective when weather conditions favor the pathogen. Thus, the lure of breeding for resistance has been a strong one for tomato breeders. However, just as this pathogen has been a problem to farmers it has proven to be a formidable adversary to those breeding for resistance. For a long time there was no effective resistance. Then good resistance was found but not easy to manipulate genetically. Yet considerable progress was made before the emergence of T3 set the program back. At present the identification of single gene resistance to T3 has allowed the program to move ahead again and it is possible that acceptable resistant varieties may be available in less than five years. It should be apparent that it is hard to make such predictions based on the complexity of the problem. On the bright side we do have new tools to detect and screen for the disease which were unavailable previously. Also we have much more information to work with and some good resistant sources which were not available in the past. It is evident that all resources will be needed to overcome this most challenging problem. Of course resistance to tomato mottle virus will be needed as well but that is the topic of the next paper.

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Table 1. Hypersensitivity and disease severity for tomato accessions inoculated with _Xanthomonas campestris_ pv. _vesicatoria_ race T3 in 1993.

Accession[z]	Species	Disease severity[y]
Hawaii 7997	_L. esculentum_	5.0 a[w]
'Solar Set'	_L. esculentum_	4.7 ab
PI 128216	_L. pimpinellifolium_	4.5 abc
Hawaii 7982	_L. esculentum_	4.5 abc
Hawaii 7976	_L. esculentum_	4.5 abc
PI 273445	_L. esculentum_	4.5 abc
Hawaii 7996	_L. esculentum_	4.5 abc
PI 79532-S	_L. pimpinellifolium_	4.3 abcd
PI 126932	_L. pimpinellifolium_	4.3 abcd
Hawaii 7983	_L. esculentum_	4.3 abcd
'Campbell 28'	_L. esculentum_	4.3 abcd
PI 271385	_L. esculentum_	4.3 abcd
PI 128216-1-2	_L. pimpinellifolium_	4.3 abcd
PI 306216	_L. pimpinellifolium_	4.0 bcde
Hawaii 7998 x Walter	_L. esculentum_	4.0 bcde
PI 262173	_L. esculentum_	3.8 cdef
Hawaii 7975	_L. esculentum_	3.7 defg
Hawaii 7998	_L. esculentum_	3.5 efgh
PI 114490-S	_L. esculentum_	3.5 efgh
PI 126932-1-2	_L. pimpinellifolium_	3.3 efgh
PI 126428	_L. esculentum_	3.3 efgh
PI 340905-S	_L. pimpinellifolium_	3.2 fgh
PI 155372-S	_L. esculentum_	3.0 gh
Hawaii 7998 x PI 126932	_L. esculentum_ x _L. pimpinellifolium_	2.8 hi
PI 271385 x PI 126932	_L. esculentum_ x _L. pimpinellifolium_	2.8 hi
PI 128216-S	_L. pimpinellifolium_	2.2 i
Hawaii 7981	_L. esculentum_	1.3 j

[z]PI numbers with -S, -S1 or -1-2 were selections of that PI number for XCV race T3 resistance.
[y]Horsfall-Barratt (1945) scale, higher numbers indicate greater disease.
[x]Mean separation by Duncan's Multiple Range Test at $P \leq 0.05$.

OUTLOOK FOR TMoV AND TYLCV RESISTANCE BREEDING

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Virus diseases caused only minor damage to tomato (Lycopersicon esculentum Mill.) in Florida during the 1970's and 1980's. However, the emergence of the sweetpotato whitefly (Bemisia tabaci biotype B) also known as the silverleaf whitefly (Bemisia argentifolii Bellows & Perring) in the late 1980's changed the situation. The whitefly vectors many geminiviruses which have caused serious damage in many tropical regions of the world. One of the most prominent of these is tomato yellow leaf curl geminivirus (TYLCV). In Florida a unique whitefly transmitted virus was identified in tomato fields and was named tomato mottle geminivirus (TMoV) (Abouzid et al.,1992; Polston et al.,1993). Damage from TMoV was estimated at 125 million dollars in the 1990-1991 season (Schuster, unpublished). Tomato growers in Florida have been able to minimize the damage from TMoV by cleaning up old fields, diligent spray programs and use of the systemic insecticide Admire to control the whitefly. However, insects are notorious at mutating against chemical controls such as Admire and it is just a matter of time before its efficacy is overcome. Also stringent insecticide programs necessary to control TMoV are expensive. Host resistance would be beneficial in combating the whitefly virus problem.

Another serious change has occurred, TYLCV once an old world disease, was discovered in the Dominican Republic in 1992 and caused devastating losses (90%) to their processing tomato industry in 1993 (Polston et al., 1994). Since then TYLCV has been identified in Jamaica and Cuba. It seems only a matter of time before it moves into Florida. The symptoms of TYLCV-stunting, leaf curl, and epinasty-are more severe than those of TMoV and yield losses are often much worse. Again host resistance could provide a good solution to this threat.

The University of Florida breeding approach to TMoV began in 1990 with the screening of an array of accessions with reported resistance to geminiviruses and other tomato viruses. We found no disease symptoms in several accessions of L. chilense (Scott and Schuster, 1991). It is difficult to obtain F_1 plants from crosses between tomato and L. chilense. Of 597 fruit obtained by crossing 12 L. chilense accessions with tomato, 15 F_1 plants were obtained some by the use of embryo rescue techniques. Embryo rescue was again used extensively to obtain 555 backcross plants. To date over 40,000 plants have been screened for resistance to TMoV and details of this work have been described (Scott et al., 1995). Our best resistance sources have been from LA 1938, LA 2779, and to a lesser extent LA 1932. Intercrosses of a tolerant L. pimpinellifolium, (PI 211840) with L. chilense derived-resistant lines have also shown good resistance.

Considerable TYLCV resistance work has taken place in other breeding programs, primarily in the Middle East and France. The best resistance has been found in L. chilense accession LA 1969 (Zakay et al., 1991; Laterrot and Moretti, 1994). Zamir et al. (1994) identified a major incompletely dominant resistance gene from LA 1969 which was named TY-1.

If breeding for resistance to geminiviruses is to be effective, the resistance must be general and not specific to any one virus. For instance, if a resistant variety diminished the impact of a prevalent virus like TMoV in Florida, the introduction of a new virus, like TYLCV, would render the resistance useless. However, a resistance against both viruses would maintain it's value. Having to add individual specific virus resistances would be a nightmare to breeders and growers.

In 1994, 12 lines with L. chilense derived resistance to TMoV and control lines were greenhouse-inoculated with TYLCV in the Dominican Republic and then field grown with the help of Dr. Colmar Serra of the Instituto Superior de Agricultura in Santiago. All 12 lines showed a reduction in TYLCV symptoms compared to the susceptible variety 'UC-82' (Table 1). Nine of the 12 lines had less disease symptoms than 'TY-20', a TYLCV tolerant variety bred in Israel, while the other three had symptoms similar to those of 'TY-20'. In 1995, lines bred for either TMoV or TYLCV resistance were tested against TYLCV in the Dominican Republic and TMoV in Bradenton, Florida. In both locations the highest resistance levels were from TMoV selected lines which had only slight virus symptoms (data not shown). Almost all lines selected for either virus had less disease than susceptible varieties. Overall, the results were encouraging. The lines selected only for one virus also had resistance to the other virus. The TMoV lines from the Florida program had indeterminate plant habits, whereas the lines bred for TYLCV resistance were determinate. It remains to be seen if the higher resistance levels observed in the TMoV selected lines can be transferred to more advanced determinate lines as the breeding proceeds. The L. chilense derived resistances we are dealing with appear to be controlled by more than one gene which make them somewhat difficult to work with. However, this type of resistance may ultimately provide varieties with more stable resistance which is not so likely to be overcome by variations in the virus population.

Some unpublished information from Israeli breeders indicate that the best TYLCV resistant lines now available combine resistances from several sources; L. chilense, L. pimpinellifolium, and L. peruvianum. Moreover, some of our best TMoV and TYLCV resistant lines have been derived from crosses between L. chilense and L. pimpinellifolium resistant lines. We are also intercrossing lines derived from different L. chilense sources of resistance in order to enhance resistance levels but these have not been tested yet. As mentioned, our best lines have only slight symptoms but are not totally free of disease under the heavy inoculation pressures being used. It is hoped that these resistance levels would prevent any losses under lower disease pressures encountered in commercial field production. Such varieties would allow growers to ease whitefly control measures since low numbers of whiteflies would not cause any problems. High populations of whiteflies would need to be avoided to prevent irregular ripening.

It will likely be several years before resistant varieties become available since there remain a lot of unanswered questions regarding the genes which confer these resistances. It may well be that the first non-susceptible varieties have partial resistance due to anticipated difficulties in fixing the resistance genes in horticulturally advanced inbreds. Evidence so far indicates that hybrids between resistant and susceptible parents have intermediate disease reactions. Such varieties would fit in well with cultural practices to control the whitefly. To facilitate the breeding effort a PhD student, Phillip Griffiths, will be studying the inheritance of resistance and searching for molecular markers linked to resistance genes which can then be used to enhance selection work.

The other approach to develop resistant varieties is by genetic engineering which is being carried out at this time in two laboratories, Dr. Polston's and Dr. Hiebert's at the University of Florida. Details of these approaches will not be presented here. At present, genes from the viruses which may prevent infection of tomatoes have been inserted into tomato plants and these plants are being screened for resistance in the greenhouse. A modification of one viral gene has been shown to give resistance when it was transformed into the tobacco chromosome. Efforts are in progress to put this gene into tomatoes. Once resistance has been identified in tomatoes, the plants will need to be tested for horticultural type to be sure they have not been altered in the transformation process. If one or more of these approaches work, resistant varieties could be available in five years or so. In the meantime growers will have to use other means to control the whitefly-vectored geminiviruses.

Summary

Much work has been done since 1990 but much more work needs to be done before resistant varieties are commercially available. It is encouraging that resistant lines derived from L. chilense have high levels of resistance to both TMoV and TYLCV. The resistances appear to be controlled by more than one gene which makes them difficult to work with. Furthermore, most lines to date with high resistance levels are indeterminate and small fruited. It is hard to predict how long it will take to develop resistant varieties with this material, but it will be five more years at least. The first non-susceptible varieties may have partial resistance levels. Genetic engineering approaches are as yet unproven but if they work it is unlikely that resistant varieties will be available to growers for at least five years.

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Table 1. Disease severity for tomato mottle virus (TMoV) in Florida, USA and tomato yellow leaf curl virus (TYLCV) in the Dominican Republic on introgressed tomato lines, spring 1994.

Genotype	Resistance Source[z]	Disease Severity[y] TMoV	TYLCV
I856-5	LA 1932	0.5 g	0.3 fg
I925-2	LA 1938	1.1 f	1.9 bc
571-1	LA 1961	1.2 ef	0.0 g
II794-9	LA 2779	1.5 def	1.2 cde
790-1	LA 1968	1.6 cde	0.1 fg
I898-9	LA 1938	1.7 cd	2.2 b
659-2	LA 1938	1.7 cd	1.7 bc
592-6	LA 1961	1.8 cd	0.4 fg
854-3	LA 1932	1.9 cd	0.5 efg
672-15	LA 1938	2.0 bcd	0.8 def
701-4	LA 1959	2.1 bc	1.3 cd
608-2	LA 1968	2.4 b	1.2 cde
'TY 20'	PI 126935	-	2.3 b
'UC 82'	-	-	3.3 a
'Solar Set'	-	3.2 a	-

[z]All from Lycopersicon chilense except PI 126935 from Lycopersicon peruvianum.

[y]On a 0 to 4 scale where 0 = no symptoms, 1 = slight symptoms visible only after close inspection, 2 = moderate symptoms on part of the plant, 3 = symptoms over entire plant, 4 = severe symptoms over entire plant and stunting. Ratings made 62 and 63 days after seedling inoculation for TMoV and TYLCV, respectively.

LATE BLIGHT OF TOMATO AND POTATO...OR WHO'S ON FIRST?

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For years the comedians Abbot and Costello generated belly laughs with their famous "who's on first routine." Unfortunately the issue of "who's on first" regarding late blight in Florida potato and tomato crops is not a laughing matter. The purpose of my presentation is to update the industry on the status of late blight in Florida tomatoes and potatoes and to offer management suggestions for the disease in 1995-96.

Background

The new wave. New strains (genotypes) of the late blight fungus (*Phytophthora infestans*) are attacking potato and tomato crops across North America. Since the summer of 1992 most North American potato producing regions including irrigated desert areas in the far west (e.g. Idaho) have experienced problems with late blight. Similarly, tomatoes have been victim to blight in many states including California, Florida, Idaho, North Carolina, New York, Ohio, and Tennessee. Greenhouse grown as well as field tomatoes have been affected. Molecular and genetic analyses of North American isolates of *P. infestans* strongly support the hypothesis that the "new wave" of late blight in North America is due to migration of new genotypes of *P. infestans* into North America from Mexico coupled with highly favorable weather for late blight in the various producing regions. It is believed that this is the first major change in North American populations of *P. infestans* in 150 years. This migration is presently having and will have profound effects on late blight epidemics in potato and tomato in the future.

Late blight has been a disease problem in Florida potatoes ever since the first crop was grown in the state during the 1890's. The disease was not reported in Florida tomatoes until the mid-1940's, but has been a frequent problem since then. Late blight was rarely seen in either crop during 1983-1992. Records of late blight in Florida potato and tomato crops reveal that in a given year the disease can be a problem in both crops, can occur in one or the other, or can be totally absent. Statewide epidemics which have occurred in all tomato or potato production regions of Florida during a single season have been rare. Although late blight has been recorded in either Florida tomatoes or potatoes during each month of the year, such reports have not been made during a single year, and the fungus is not presently known to persist from season to season in Florida. The Florida potato industry annually imports nearly 1.3 million cwt seed potatoes from 20 seed potato producing states and provinces. The primary inoculum for late blight epidemics in Florida potato crops is believed to be reintroduced each year in infected seed. There may be additional sources of inoculum for epidemics in tomato.

Characteristics of *P. infestans* isolates. Populations of *P. infestans* can be characterized by using mating type determination, sensitivity to metalaxyl, allozyme analysis, and DNA fingerprinting. Goodwin, et al. have devised a simple, convenient designation for different strains or genotypes of *P. infestans* using a letter and number code. The letter designates location (e.g. US=United States and BC=British Columbia) and the number the chronological sequence of the identification -- 1=first, 2=second, etc. Thus US-1 would be the first genotype identified in the US. Clonal or asexual lineage of each genotype are designated with a sub code e.g. US-1.5 is fifth member of the US-1 clonal lineage (1). Use of Goodwin's code provides a simple and convenient method for communicating the identification of genotypes of *P. infestans*. Until recently, the common strain of *P. infestans* in the US was US-1.

Late blight in Florida during 1993-1995. During the past three seasons late blight has been wide spread in Florida. The disease was a problem in both potatoes and tomatoes in 1993 and 1995 and was most important in potatoes in 1994. When all three seasons are considered, a mixture of *P. infestans* genotypes have been detected, however, there have been several significant differences among the seasons. During 1993 Goodwin et al. identified US-1, US-6, and US-7 in Florida. Metalaxyl sensitive US-1 was found early in the season but was quickly replaced by the metalaxyl insensitive US-7. The US-7 genotype is an active pathogen on both potato and tomato. Although a limited number of samples were analyzed, the general trend was for genotypes in potato to be similar to the genotypes detected during the previous fall in the regions supplying the seed tubers. Epidemics in tomato fields and potato fields, especially in Manatee County developed simultaneously.

The situation in 1994 was different in that US-8 was the predominant genotype in the state, although US-7 was detected in at least one sample from tomatoes in Manatee County. The disease was generally more severe in potato in 1994 than in tomato.

Late blight was again widespread during the 1995 season. It was especially severe in southern potato producing regions and was a problem in tomatoes as well. Limited genotype analyses have been run, however, all samples sent to Hastings were the A-2 mating type and were insensitive to metalaxyl (samples were obtained from: Collier, Manatee, Okeechobee, St. Johns, and Putnam Co.) and samples analyzed by Goodwin, Fry et al. and Ciba were mainly US-8. Interestingly, US-8 which is primarily a "potato strain," was detected in Florida tomatoes during 1995. Although late blight was present in the Hastings area all season, the disease caused minimal losses due to hot, dry weather conditions which limited its capacity to multiply.

Who's on first. Due to the limited number of samples collected statewide in Florida during 1991-1995, it is difficult to draw firm conclusions on the movement of late blight back and forth between potatoes and tomatoes. Genotype data from 1995 would suggest movement from potato to tomato because US-8 was found in both crops and US-8 was predominant in potato seed producing states in 1994. However, when US-6 was found in S.W. Florida tomatoes in 1991, the disease was absent in potatoes. Similarly, although late blight was common in all potato producing regions in 1994, the disease was localized in tomatoes. Also, US-8 was the predominant genotype in potato and US-7 was detected in at least one tomato field. Thus, although it seems likely that in some instances late blight may be moving from potatoes to tomatoes, there are outbreaks in tomato which are independent of epidemics in potato. It is therefore important for both industries to recognize that late blight is indeed a community problem and that both industries adhere to sound management practices in dealing with the disease.

Prognosis for 1996. Late blight is again widespread in northern potato and tomato producing regions. Although seemingly slowed by the prevalent hot, dry weather in many states, the disease is showing up following periods of moisture. At this writing (July 31, 1995) there have been no reports of late blight in the seed producing regions of states which supply the majority of Florida's seed potatoes. This situation could change as the season progresses. Although the inoculum level in seed may be reduced when compared to recent seasons, Florida growers are advised to maintain maximum diligence and to stay with maximum management strategies.

Fungicides. Fungicides tested at the Hastings AREC during the past two years included: mancozeb, maneb, metiram, metalaxyl, metalaxyl + mancozeb, metalaxyl + copper, metalaxyl + chlorothalonil, chlorothalonil, copper hydroxide, fosetyl Al, cymoxamil, several combinations of these fungicides and several unnamed numbered compounds. When applied in 100 gallons/acre at 80 psi using 6 nozzles/row, all of the fungicides except fosetyl Al and metalaxyl each applied singly, have controlled late blight. Propamocarb hydrochloride (Tatto), and dimethomorph (Acrobat) have <u>not</u> been tested at Hastings. Evidence from Florida and elsewhere during the past two seasons suggest that timing (i.e. before infection) and good coverage (stems as well as leaves) are essential to adequately control the new genotypes of *P. infestans*.

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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 1200 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 35% of the acreage in Florida in the 1994-95 season - down somewhat from the 41% planted the previous season. 'Agriset 761' was grown on 59% of the acreage in southwest Florida, 24% of the acreage in west central Florida, and was the predominant variety in north Florida.

The acreage planted with 'Sunny' was about 15% of the state total - down from 18% the previous year. However, about 66% of the crop on the east coast continued to be planted with 'Sunny'.

'Sunbeam' and 'Solar Set' each had about 10% of the state's planted acreage. Both were grown in the west central area on about 16% of the acreage. 'Sunbeam' was grown on 37% of the acreage in Dade County while 'Solar Set' was grown on 11% of the acreage on the east coast. 'Solar Set' continued to be a major variety in north Florida.

'Solimar', 'Merced', 'BHN 26', 'Olympic', 'Colonial', 'Bonita', 'Flavr Saver' and 'Cobia' were grown on 1 to 5% of the state's acreage. Several other varieties were grown on less than 1% of the 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; Ft. Pierce Agricultural Research & Education Center; and North Florida Research & Education Center, Quincy for the Spring 1994 season are shown in Table 1. High total yields and large fruit size were produced by XPH 10005 in Bradenton and 'Agriset 761', 'Equinox', and Florida 7578 in Ft. Pierce. 'Sunny' produced high yields at all three locations and 'Agriset 761', Florida 7578, Florida 7603, and 'Solar Set' produced high yields at two of the three locations. 'Merced' and 'Mountain Spring' produced large size fruit at two of the three locations.

It is important to note that the same entries were not included in all of the trials.

Table 1. Summary of University of Florida tomato variety trial results. Spring 1994.

Location	Total Yield (ctn/acre)		Large Fruit Size (oz)	
Bradenton (1)	XPH 10005	3196	HMX 2822	6.6
	Sunny	3183	XPH 10005	6.5
	Equinox	3114	Merced	6.5
	Florida 7578	3113	HMX 2824	6.3
	Solar Set	3008[1]	Mountain Spring	6.2[2]

Ft. Pierce (3)	Florida 7603	1189	Sunbeam	6.6
	Agriset 761	1140	Agriset 761	6.4
	Equinox	1138	Florida 7578	6.1
	Sunny	1116	Equinox	5.9
	Florida 7578	1099[3]	Solar Set	5.9[4]
Quincy (4)	Sunny	2444	XPH 10046	8.0
	Mountain Fresh	2417	Solimar	7.1
	Agriset 761	2402	Merced	7.0
	Solar Set	2376	Joker	6.8
	Florida 7603	2335[5]	Mountain Fresh	6.7[6]

[1]14 additional entries had yields similar to those of 'Solar Set'.
[2]8 additional entries had fruit weight similar to that of 'Mountain Spring'.
[3]Yields among the 9 varieties in the trial were not significantly different.
[4]2 other entries had fruit weight similar to that of 'Solar Set'.
[5]22 other entries had yields similar to those of Florida 7603.
[6]26 other entries had fruit weight similar to that of 'Mountain Fresh'.

Seed Sources:

Agrisales: Agriset 761
Asgrow: Solar Set, Solimar, Sunbeam, Sunny, XPH 10005, XPH 10046
Ferry-Morse: Mountain Fresh
Harris Moran: HMX 2822, HMX 28245
Rogers: Merced, Mountain Spring
University of Florida: Equinox, Florida 7578, Florida 7603
Vilmorin: Joker

Summary results listing outstanding entries in order from trials at the University of Florida's Gulf Coast Research & Education Center, Bradenton and the Ft. Pierce Agricultural Research and Education Center for the fall 1994 season are shown in Table 2. High yields and large fruit size were produced by 'Agriset 761', 'Sunmaster' and 'Merced' at Ft. Pierce. 'Merced', Florida 7578, and Florida 7579 produced high yields at both locations while 'Merced' also produced large fruit at both locations. As in the spring trials, the same entries were not included in both trials.

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

Table 2. Summary of University of Florida tomato variety trial results. Fall 1994.

Location	Total Yield (ctn/acre)	Large Fruit Size (oz)	
Bradenton (2)	PSX 803090	Tango	5.7
	Florida 7578	Merced	5.6
	Florida 7579	Solar Set	5.5
	Equinox	Spitfire	5.3
	Merced[1]		
Ft. Pierce (3)	Agriset 761	Agriset 761	6.2
	Sunmaster	Merced	6.2
	Merced	Sunmaster	6.1
	Florida 7578	Equinox	5.7
	Florida 7579[3]	Sunny	5.6
		Bonita	5.6[4]

[1] 10 other entries had yields similar to those of 'Merced'.
[2] 17 other entries had fruit weight similar to that of 'Spitfire'.
[3] 4 other entries had yields similar to those of Florida 7579.
[4] 4 other entries had fruit weight similar to that of 'Bonita' and 'Sunny'.

<u>Seed Sources</u>:

Agrisales: Agriset 761
Asgrow: Solar Set
Ferry-Morse: Spitfire
Petoseed: PSX 803090, Sunmaster
Rogers: Bonita, Merced, Tango
University of Florida: Equinox, Florida 7578, Florida 7579

It should be noted that in some of these trials, there were little or no significant differences among the entries. This indicates that there are a large number of varieties that produce large yields and have large fruit size which are available to growers. In some instances, other factors may dictate the selection process.

TOMATO VARIETIES FOR COMMERCIAL PRODUCTION

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

Agriset 761 (Agrisales). 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 (Rogers). 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.

Merced (Rogers). 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 (Petoseed). 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 (Asgrow). 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.

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

Sunny (Asgrow). 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.

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, 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 rate (lb/A/day)[z]	
stage	weeks	N	K_2O
1	4	1.5	2.0
2	8	2.0	2.5
3	2	1.5	2.0

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 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

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-

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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, fall 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.				

Insect Control in Tomatoes

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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 not for use in Dade Co.
lindane (Prentox)	1.63 EC	20 ozs/100 gals H^20	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^20 150 - 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
esfenvalerate (Asana XL) (aids in control)	0.66 EC	5.8 - 9.6 fl ozs	1

Insecticide	Formulation	Formulation Rate/Acre	Min Days to Harvest
BEET ARMYWORMS (See also: Armyworms) (cont.)			
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^2O 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
CABBAGE LOOPERS (See also: Loopers) (cont.)			
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 not for use in Dade Co.
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

Insecticide	Formulation	Formulation Rate/Acre	Min Days to Harvest
COLORADO POTATO BEETLES (cont.)			
pyrethrins + rotenone (Pyrellin)	EC	1 1/2 - 2 pts	0
rotenone (Rotenox)	5% L	2/3 gal	0
(Rotacide)	EC	1 gal	0
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^20 150 - 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

Insecticide	Formulation	Formulation Rate/Acre	Min Days to Harvest
CUTWORMS (cont.)			
cyhalothrin (Karate, Warrior)	1 EC	1.92 - 3.20 ozs	5 - caution, read label
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
permethrin (granulate cutworm)			
(Ambush)	2 EC	3.2 - 12.8 ozs	up to day
(Pounce)	3.2 EC	2 - 8 ozs	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.			
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

Insecticide	Formulation	Formulation Rate/Acre	Min Days to Harvest
FALL ARMYWORMS (See also: Armyworms) (cont.)			
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
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 Not for use in Dade Co.
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

Insecticide	Formulation	Formulation Rate/Acre	Min Days to Harvest
	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
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

Insecticide	Formulation	Formulation Rate/Acre	Min Days to Harvest
LEAFHOPPERS (cont.)			
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
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

Insecticide	Formulation	Formulation Rate/Acre	Min Days to Harvest
LEAFMINERS (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) (serpentine leafminers except *Liriomyza trifolii*)	2 EC	2 - 4 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.			
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 $H^2 0$ 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
MEALY BUGS			
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

Insecticide	Formulation	Formulation Rate/Acre	Min Days to Harvest
MITES (cont.)			
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^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 + 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^2O	1
methyl parathion	4 EC	1 - 3 pts	15
pyrethrins + piperonyl butoxide (Pyrenone)	66% L (EC)	2 - 12 ozs	0
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

Insecticide	Formulation	Formulation Rate/Acre	Min Days to Harvest
		SOUTHERN ARMYWORMS (See also armyworms) (cont.)	
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
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 not for use in Dade Co.
malathion (Cythion)	5 EC	1 1/2 - 2 pts	1
oil (Sun Spray)	98.8%	1 - 2 gals/100 gals $H^2 0$	1

Insecticide	Formulation	Formulation Rate/Acre	Min Days to Harvest
THRIPS (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 + 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
TOMATO FRUITWORMS (CORN EARWORM)			
azadirachtin (Neemix)	0.25%	2 1/2 pts/100 gals H^20 150 - 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.			

Insecticide	Formulation	Formulation Rate/Acre	Min Days to Harvest
		TOMATO PINWORM	
abamectin (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
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^2O 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

Insecticide	Formulation	Formulation Rate/Acre	Min Days to Harvest
		WHITEFLIES (cont.)	
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 Not for use in Dade Co.
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
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	---

Insecticide	Formulation	Formulation Rate/Acre	Min Days to Harvest
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.

Methyl Bromide Update and Alternatives Research

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Within the United States, decisions regarding the production and use of methyl bromide for any purpose is currently dictated in large extent by the Environmental Protection Agency (EPA), by federal laws such as the Clean Air Act of 1990 which enforces a complete phase-out of methyl bromide use by January 1, 2001, and finally, by subsequent decisions and amendments developed by the Parties of the Montreal Protocol. The Montreal Protocol is an international body of scientists and representatives from 128 countries, who have mutually agreed upon to review and limit the production and use of substances which deplete the earth's ozone layer. Methyl bromide is just one of many substances which fall into this category. This body or group is important therefore, since the USA as a member of the Montreal Protocol is obligated to adopt, implement, and enforce any new amendment mutually agreed upon. The purpose of this brief report is therefore to update Florida tomato growers with regard to any significant change in US policy or to any new international developments which have occurred during 1995.

Two significant developments with regard to US policy or methyl bromide use has occurred during 1995. The first involves a freeze on the production and use of methyl bromide at 1991 levels, effective January 1, 1995 and continuing until the phase-out date of January 1, 2001. This act will, in effect, serve to restrict any expanded use of methyl bromide within the US. Globally, methyl bromide use was previously estimated to be increasing at a level of 15% annually. Based on recent discussions with manufacturers and distributors, a 1991 based production cap has not, at least in the short term, had a significant impact on methyl bromide availability or price.

The second development, permitted exclusively within Florida, involved a granting, by EPA, of a specific exemption (section 18) for the use of methyl bromide to control nematodes, fungi, and weeds on watermelons. The specific exemption is subject to a number of conditions and restrictions and expires April 12, 1996.

Internationally, the major developments of 1995 are evolving from a recent meeting in May of the Parties of the Montreal Protocol in Nairobi, Kenya. As in previous meetings, the objective was to discuss and review global production and use of methyl bromide within developed and developing countries and the ways and means in which to diminish its use. The most pertinent and relevant aspects of this meeting are itemized below.

1). A new amendment was proposed and is now under consideration involving a further limiting of global production and use of methyl bromide, beginning January 1, 1998, to 75 percent of the levels produced in 1991. If adopted in the US, this would translate to a further 25 percent reduction in product availability for soil fumigation uses.

2). Also included for further consideration were proposals which provide for continuing exemption, after the official phase-out date, for pre-shipment and quarantine applications of methyl bromide, as well as for and as deemed necessary, exemptions for "essential uses". Most if not all of the recommendations to preserve some form of essential use, are related to the time constraints in which practical alternatives or substitutes for methyl bromide will likely be developed. Exemptions for at least quarantine and pre-shipment treatments were viewed as unavoidable and necessary to preserve international trade. Although not clearly stated, it would appear, that an exemption for essential uses in developing countries could be construed for any purpose, including that of soil fumigation. It is not clear at this point what the potential outcome may be in the United States with regard to possible exempted uses since the Clean Air Act of 1990, as currently written, does not allow for ANY exemption for continued methyl bromide use after the year 2000.

3). Finally, a proposal from at least some of the developing countries involve a request for an extension or delay of 6 to 10 years of their compliance with the original phase-out date of January 1, 2011. The phase-out date for developing countries was previously defined as 2011, 10 years longer than that of the US. If adopted, this would in effect extend the global phase-out of methyl bromide within developing countries to the year 2017 or to as long as 2021.

RESEARCH ON ALTERNATIVES WITHIN FLORIDA

Recognizing that the withdrawal of methyl bromide could have a significant impact on Florida agriculture, research efforts here in the state were focused, beginning in 1993, to identify and evaluate possible chemical and nonchemical alternatives to methyl bromide soil fumigation. In Florida, concerted efforts by University of Florida IFAS research faculty sponsored, in part, by the Florida Fruit & Vegetable Association (FFVA), were initiated in 1994 and are still underway to conduct comparative tomato yield and pest efficacy trials using a number of different chemical compounds at four locations within the state. The locations of these studies include University of Florida research and education facilities at Quincy, Bradenton, Gainesville, and Immokolee.

As previously reported in 1994, nine different chemical treatments were under evaluation. In general, the results from the 1994 trials indicated that all of the alternative chemicals were generally less effective than that of methyl bromide with regard to nematode control. It was also apparent, from the results of 1994, that satisfactory nutsedge control could only be achieved when an alternative fumigant was combined with a herbicide treatment such as with Tillam. After each experimental trial or cycle, appropriate modifications to the treatment lists will be made to maximize evaluations of promising alternative compounds and their combinations. A listing of new treatments, which were evaluated in experimental trials during spring 1995, are listed in Table 1. At the time this document was prepared, the results from these trials were not yet available. The table is therefore presented as a list of treatments which are currently under evaluation as next best alternative treatments to methyl bromide.

Table 1.

TREATMENT	RATE
Untreated	-- -- --
Telone C-17 + Tillam	35 gal/acre + 4 lbs/acre
Methyl Bromide + Chloropicrin (67:33)	350 lbs/acre
Vapam + Tillam	100 gal/acre + 4 lbs/acre
Basamid + Tillam	400 lbs/acre + 4 lbs/acre
Chloropicrin + Tillam	350 lbs/acre + 4 lbs/acre

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
7-30	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
Telone II[2]	12-15 gal	12"	3	6-7.5 gal	26.4-52.8 fl oz
Teletone C-17	10-17 gal	12"	3	5-8.5 gal	30.3-50.2
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. The manufacturer of Telone II and Telone C-17 has reinstated sale and distribution in South Florida effective September 1, 1994.

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. Calculations assume 7,260 linear feet of row per acre using row spacing of 6'.

Rates are believed to be correct for products listed when applied to mineral soils. Higher rates may be required for muck (organic) soils. Growers have the final responsibility to guarantee that each product is used in a manner consistent with the label. The information was compiled by the author as of July 10, 1995 as a reference for the commercial Florida tomato grower. The mentioning of a chemical or proprietary product in this publication does not constitute a written recommendation or an endorsement for its use by the University of Florida, Institute of Food and Agricultural Sciences, and does not imply its approval to the exclusion of other products that may be suitable. Products mentioned in this publication are subject to changing Environmental Protection Agency (EPA) rules, regulations, and restrictions. Additional products may become available or approved for use.

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UNIVERSITY OF FLORIDA

Cooperative Extension Service

Institute of Food and Agricultural Sciences

PLANT PROTECTION POINTERS

PLANT PATHOLOGY EXTENSION

EXTENSION PLANT PATHOLOGY REPORT NO. 6
GAINESVILLE, FLORIDA JULY 1995

Chemical Control Guide For Diseases of Vegetables

SS-PLP-804
PP/PPP 6

Control of plant diseases is achieved by utilizing numerous cultural, biological, regulatory and chemical tactics. This publication serves as a guide to chemical control for vegetables grown in Florida. The performance of a chemical is enhanced by utilizing non chemical tactics to reduce inoculum. Also, within chemical control, numerous variables influence the performance of the chemical. Time of applications, nozzle arrangement, spray dilution, chemical rate per unit area, adjuvants, and rainfall are some of the variables associated with chemical application technology. Beginning spray programs prior to or at first sign of disease is best. Starting a spray program when disease is visible through the windshield of a moving vehicle costs less initially but often results in substandard yields and quality.

USE A SPRAY ADJUVANT WITH A SPREADER AND A STICKER IN CONJUNCTION WITH SOME WETTABLE POWDER AND SOME FLOWABLE FORMULATIONS. SPREADER-STICKER ADJUVANTS ARE USEFUL PARTICULARLY ON SLICK LEAF AND VERTICALLY LEAF-ORIENTED CROPS LIKE ONIONS, CRUCIFERS AND SWEET CORN. SEE PLANT PROTECTION POINTER NO. 37 FOR MORE DETAIL ON ADJUVANTS. DO NOT USE SPRAY ADJUVANTS IF THE LABEL INDICATES THAT ADJUVANTS SHOULD NOT BE USED.

The purpose of this listing is to guide you with legal use of sprayable plant disease control chemicals. All legally available, plant disease control chemicals sold in Florida are not listed. For such a listing contact the Florida Department of Agriculture. Chemicals listed in this guide are 1) those for which data from Florida are available for the active ingredient, 2) those for which no other compound(s) is known to be available, but is legal for use (tolerance established and labelled) utilizing performance data from the United States, 3) those which are legal to use and lack data from Florida but would be expected to perform satisfactorily based upon professional judgement. It may seem rhetorical but read the label: you paid for it. **Read labels for information about crop rotational limitations with fungicides. Also note within this publication the crop groupings for tolerance establishment that are available. REENTRY into fields treated with any pesticide is restricted by the use of a time interval, type of clothing to be worn, or protective wear needed. Use of fungicides containing tin, copper, or chlorothalonil requires a 48 hour reentry interval (REI). Most other fungicides have a 24 hour REI. Rovral and Botran fungicides have a 12 hour REI.** Label information supersedes all other sources of information.

Tom Kucharek
Extension Plant Pathologist

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	
	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.

Crop	Chemical	Maximum Rate/Acre/ Application	Crop	Min. Days to Harvest	Pertinent Diseases	Select Remarks
Tomato (cont'd)	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	
	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.

Crop	Chemical	Maximum Rate/Acre/ Application	Crop	Min. Days to Harvest	Pertinent Diseases	Select Remarks
Tomato (cont'd)	Botran 75W	1 lb.	4 lbs.	10	Botrytis	Greenhouse tomato only. Limit is 4 applications. Seedlings or newly set transplants may be injured.
	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.

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