Vegetable Crops
Extension Report
VEC 85-2

1985
Florida Tomato Institute

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INTRODUCTORY REMARKS

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Greetings and welcome to the Twenty-fourth Annual Florida Tomato Grower's Institute.

Challenges continue to abound the cultivation and marketing of Florida's most important vegetable crop. The problems facing Florida's tomato grower may vary from year to year but one thing is certain they are always there. One year Florida's tomato growers may be faced with insurmountable problems of insect pestilance such as leaf minor or pin worm, or major losses due to bacteria or root rots, and when these are under control he may run low on water or the crop may freeze. Just when everything is "growing great" and record yields are being recorded, the market falls flat and it no longer becomes profitable to even harvest the crop.

If the Florida tomato farmer is to survive through all of these problems he must remember where he has come from, determine where he is going, then look to the future for methods to circumvent the continued exposure to these problems. One thing should be remembered through all this; if the crop was that easy to grow everyone would grow it. The Florida tomato farmer is in a select group!

The faculty and staff in IFAS have been committed since the beginning of the industry, to help promote and provide answers to problems facing our tomato growers. We have tried to look at this as a multi-disciplinary approach or one which is not confined by department or geographic location. Research done on tomato by the public sector, IFAS, is conductd in no less than seven departments, six locations and by over forty faculty. That every phase of production from tomato breeding to post harvest handling and marketing is covered by IFAS scientists. That IFAS extension personnel both Specialists and County Agents are closely involved in grower research and education programs in the major tomato production areas.

Through all the years we know only one thing for sure about growing and selling tomatoes from Florida, it isn't easy! We hope that through this exchange of ideas, educational materials, and latest research results our Florida Tomato Industry will remain strong. That more than just listening to speaker's talks, our industry will seek out our help and advise on problems facing them. The Tomato Institute has been a valuable tool to spark this cooperation between the industry and public sector and to provide our tomato industry with the information that they need.

FERTILIZER MANAGEMENT: BACK TO BASICS

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Introduction. Modern vegetable fertilization programs are becoming very complex and costly. Technologies in fertilizer sources and application methods are constantly changing. In addition, cultivars of a single crop are known to differ for nutrient requirement. Because of the complexity, tomato growers are constantly searching for methods to improve their fertilizer management skills. They realize that improved fertilizer efficiency will lead to increased profits and to reduced risks to the environment from overfertilization.

The purpose of this presentation is to cover some of the basic components of fertilization programs for tomato growers. More information on general vegetable fertilization can be found in the Commercial Vegetable Fertilization Guide, Circular 225-C.

Plant nutrients. Plants require 16 essential elements: carbon, hydrogen, oxygen, phosphorus, potassium, nitrogen, sulfur, calcium, iron, magnesium, boron, manganese, copper, zinc, molybdenum, and chlorine. An example of typical tomato plant nutrient composition is presented in Table 1.

Table 1. Elemental composition of a typical tomato plant using 3rd and 4th leaf from tip at early fruiting.

Element	composition (dry wt. basis)
Nitrogen	3 to 6 %
Calcium	4 to 6 %
Potassium	2.5 to 4%
Magnesium	0.6 to 0.9%
Phosphorus	0.5 to 0.8%
Iron	100 to 200 ppm
Manganese	60 to 100 ppm
Boron	40 to 80 ppm
Zinc	15 to 30 ppm
Copper	4 to 8 ppm

Approximately 90% of the plant dry weight is derived from the three elements carbon, hydrogen, and oxygen, available in abundant supply from air and water. The remaining 10% of the plant dry weight is composed of the various mineral elements available from many sources including native soil, organic matter and fertilizers. Sound tomato fertilizer programs take into account the nutrient supplying capacity of the native soil. In some cases, this capacity is substantial. In order to have an efficient fertilizer program, soil testing must be practiced to determine precisely the amounts of nutrients that need to be added to the soil as fertilizers. Fertilizers should be thought of as supplements to the native soil fertility where the levels of specific nutrients in the soil are not high enough to achieve maximum yields.

Soil testing. Routine soil testing is a key to efficient fertilizer management. Many laboratories are available to test soil samples for nutrient content. One such laboratory is the University of Florida Extension Soil Testing Laboratory in Gainesville. Sampling kits and instructions can be obtained at the local county extension office.

Often growers are perplexed by the various test reports received on one soil sample if sent to several laboratories. The differences can be due in part to sub-sample differences but are due more likely to differences in chemical procedures employed by the labs to extract the nutrients from the soil. Differences in extractable elements are expected, however, the fertilizer recommendations made by each laboratory should be reasonably close if each laboratory is basing them on appropriate field calibration studies. If a grower has questions regarding a fertilizer recommendation, consult the county extension agent for help.

Control of pH. In general, the most suitable pH range for tomatoes is 6.0 to 6.5. Liming acid soils to this range will avoid aluminum and manganese toxicities. It is in this range on mineral soils that most fertilizer nutrients are in greatest availability. Liming to this range also increases the activity of certain beneficial soil microorganisms such as the nitrifying bacteria. In addition, fusarium wilt of tomato is reduced when the pH is adjusted to 6.5. Raising the pH above 6.5 is not advisable since micronutrient availability can be restricted by the high pH.

The most commonly used liming materials are calcitic lime and dolomite lime. Dolomite is an excellent lime material having a neutralizing value slightly higher than calcitic lime. Dolomite also contributes magnesium, a nutrient often low in Florida soils. Where magnesium levels are low, use dolomite lime. Otherwise, calcitic lime is suitable. Where the pH of the soil is suitable but the magnesium is low, apply sulfate of magnesia or sulfate of potash-magnesia in the fertilizer.

Modification of the high pH of the rockland soils of Dade county is not economically practical. To combat the effect of the pH on certain nutrient availability, practices such as banding and foliar applications can be used.

Many fertilizer materials reduce the soil pH when added to the soil. Fertilizers high in ammoniacal nitrogen are especially acid forming. Liming programs therefore should consider the type of fertilizers to be used on the crop.

Fertilizer rates. Recommended application rates of fertilizers are often abused. Overfertilization is probably the leading factor in fertilizer related damages to tomato crops. It is common to find large amounts of fertilizer present in the tomato beds after the harvest season is completed. Dr. George Marlowe and others studied this problem in a Ruskin tomato field. They found moderate soluble salt levels in the field prior to field preparation, Table 2.

Table 2. Soluble salt and pH readings prior to field preparation.

Depth (in.)	pH	Total soluble salts (ppm)
0-2	6.3	2400
2-4	6.2	1640
4-8	5.9	1540

The researchers then studied three fertility levels of low, medium and high by varying the rate of shoulder-placed high analysis fertilizer. The rates used were 15, 30, and 60 pounds of an 18-0-25 fertilizer per 100 linear bed feet. The total amounts of nutrients applied in the various treatments appear in Table 3. The low treatment approximated recommended fertilizer rates for 7200 linear bed foot acre.

Table 3. Total amounts of nutrients applied for various fertilizer treatments.

Treatment level	Total fertilizer applied (lbs per 100 feet) N	P_2O_5	K_2O
Low	3.57	4.68	5.28
Medium	6.14	4.68	8.85
High	8.71	4.68	12.42

The researchers found no significant difference among the treatments for marketable fruit yields. Plant size was similar in the medium and high levels and both were greater than the low fertilizer treatment. This study showed that high rates of fertilizer only increased plant size while giving no additional marketable yield. In addition, the extra fertilizer can contribute to buildup of soluble salts in the soil to levels that cause plant damage.

The recommended tomato fertility programs in Tables 4, 5, and 6 have resulted from considerable research. The rates are based on a cropped acre having approximately 7200 linear bed feet, i.e. beds six feet between centers. The amounts will need to be adjusted where different cropping patterns are used.

Potassium can be applied at approximately 1.5 to 2.0 times the amount of nitrogen. Research indicates this ratio is beneficial where graywall, yellow shoulder, and blotchy ripening are likely.

Table 4. Fertility recommendations for non-mulched tomatoes on soils testing very low in phosphorus and potassium.

	Nutrient requirements			Supplemental applications			
	Actual lbs/A			Actual lbs/A			No. of
Soil	N	P_2O_5	K_2O	N	P_2O_5	K_2O	applications
Irrigated mineral soil	120	160	160	15	0	30	2-4
Marl	120	160	160	30	0	30	1-3
Rockland	45	90	60	40	60	60	2-4

Table 5. Fertility recommendations for full-bed mulch culture on seep irrigated soils testing very low in phosphorus and potassium.

No of harvests	Nutrient requirements Actual lbs/A N	P_2O_5	K_2O	Supplemental applications Actual lbs/A N	P_2O_5	K_2O	No. of applications
1-2	200	100	300	30	0	30	0-2
3-4	260	100	400	30	0	30	0-2

Table 6. Fertility recommendations for full-bed mulched culture on overhead irrigated soils testing very low in phosphorus and potassium.

soil	No of harvests	Nutrient requirements Actual lbs/A N	P_2O_5	K_2O	Supplemental applications Actual lbs/A N	P_2O_5	K_2O	No. of applications
Mineral	2	160	100	240	30	0	30	0-2
	3-4	220	100	330	30	0	30	2
Rockland	2-3	130	220	260	30	0	30	0-2

Micronutrients. These elements are needed in very small quantities and a fine line exists between adequate and toxic levels. Tomato crops require (per acre; 7200 linear bed feet) 2 lbs Mn, 1 lb Cu, 5 lbs Fe, 2 lbs Zn, 1 lb B and .02 lbs Mo. Use a soil test to determine if these elements should be applied in the fertilizer. Growers using micronutrient containing pesticides should consider these sources when calculating fertilizer micronutrient needs. Avoid overuse of these pesticides since toxic levels of certain elements might build up in the soil. Excess of one micronutrient may cause a deficiency in another. An example of this is copper-induced iron deficiency.

On the high pH rockland and marl soils, certain micronutrients such as manganese, iron and boron may have to be applied foliarly. These elements can be fixed in unavailable forms by the high pH.

Fertilizer sources. The most commonly used nitrogen sources for most tomato crops are ammonium nitrate, calcium nitrate and potassium nitrate. These highly soluble forms are particularly useful in the seep-irrigated system. On soils fumigated with a general purpose fumigant, or for crops planted in cool soils, at least 50% of the nitrogen should be in the nitrate form. High ammoniacal nitrogen levels reduce calcium uptake leading to blossom-end rot and may provide soil conditions favorable to fusarium wilt.

Slow-release nitrogen sources might be used to supply a portion of the nitrogen requirement. On a trial basis, for overhead irrigated sandy soils, apply 1/3 of the total nitrogen as sulfur-coated urea (SCU) or isobutylidene diurea (IBDU). These would be most useful for long-term crops. Be sure the nitrogen release rate corresponds to crop demand. Use only water soluble nitrogen sources for the shoulder applied fertilizer in the seep irrigated crops. Normal (ordinary) and triple (concentrated) superphosphates are excellent sources of phosphorus both contributing calcium in addition to phosphorus. Normal superphosphate also contributes sulfur. Diammonium phosphate should not be used for all of the phosphorus needs since it has been shown to reduce certain micronutrient uptake by some vegetable crops.

Muriate of potash is a widely used source of potassium on vegetables in general, however, its use increases the risk of soluble salt injury over other sources of potassium. Nitrate of potash, sulfate of potash and sulfate of potash-magnesia are suitable alternatives and recommended for tomato crops.

Fertilizer placement. Since phosphorus movement in soil is minimal, it is usually best to incorporate it in the bed so that it is placed in the rooting zone. Where the soil contains moderate amounts of phosphorus so that only small amounts of fertilizer phosphorus are needed, it may be more efficient to band this phosphorus. In some cases, small amounts of phosphorus applied as a liquid starter solution with the transplant may be beneficial in the establishment of transplants.

For seep-irrigated tomatoes, no more than 10% to 15% of the total nitrogen and potassium should be incorporated in the bed. The remainder should be placed in narrow bands on the shoulders. For overhead irrigated tomatoes maximum yields have been obtained with incorporation of the nitrogen and potassium in the bed. A common practice for rockland tomatoes is to band the phosphorus over the center of the bed and band the nitrogen and potassium on the shoulders. Equal or better yields have been obtained with incorporation of all fertilizer.

Micronutrients are usually placed in the bed with the phosphorus. Under conditions of high soil fixation, such as high pH rockland, micronutrients such as manganese, iron and boron can be foliar applied.

More information is available for tomato fertilizer placement from a recent (1983) Tomato Institute. One article deals with seep-irrigated crops; the other deals with overhead irrigated crops.

Soluble salts. Overfertilization, or placement of fertilizer too close to the seed or plant root leads to salt injury or "fertilizer burn". Irrigation water high in soluble salts also can be a contributing factor in the increase of soil soluble salts. One acre-inch of water containing 1000 ppm soluble salts is approximately equivalent to 1000 lbs of 4-8-8 fertilizer in increasing the soluble salt content of a sandy soil.

Foliar fertilizers. In general, foliar applications of nitrogen, phosphorus, and potassium are not effective where a suitable soil fertility program is followed. Foliar applications of certain micronutrients can be effective, especially in conditions of rapid soil fixation or in cases of deficiencies. Follow carefully all application precautions since it is easy to apply toxic amounts of micronutrients.

Sidedressing. Until recently, it was difficult to place supplemental fertilizer in mulched beds. It is a common practice to place dry fertilizer in the bed through holes punched in the plastic. This method is difficult to calibrate and ensure uniform application and often results in plant damage.

For growers using drip irrigation, the problem of sidedressing is removed. In most cases, fertilizer can be applied throughout the season by the drip system.

Recently, a new fertilization tool, the liquid injection wheel, became available. With this tool, fertilizer can be placed through the mulch very efficiently. By using drip irrigation or the injection wheel, it might be possible to reduce the amounts of fertilizer placed in the bed at planting and apply it by drip irrigation or injection wheel throughout the season.

Drip irrigation. Application of fertilizer with the irrigation water (fertigation) is becoming an accepted practice. All phosphorus and micronutrients should be placed in the bed along with 10% to 40% of the nitrogen and potassium. Place no more than 10% to 15% of nitrogen and potassium in seep-irrigated beds. The remaining nitrogen and potassium should be injected through the drip system in increments corresponding to crop development using one or two applications per week. More information on the use of drip irrigation is available from other presentations of this Tomato Institute.

Drip irrigation and the liquid injection wheel are excellent devices for use in double crop schemes. No longer does one have to apply extra fertilizer to the first crop to provide left over fertility for the second crop.

In summary, fertilization, like any other part of the production system requires frequent review to determine any areas in need of modification to improve efficiency. Suggested changes should be tested on a small scale against existing farming practices.

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SOIL-BORNE DISEASES OF TOMATO AND THEIR CONTROL

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The major diseases of tomato in Florida caused by soil-borne pathogens are Fusarium wilt (F. oxysporum f. sp. lycopersici races 1, 2 & 3), Fusarium crown rot (F. oxysporum f. sp. radicis-lycopersici), Verticillium wilt (V. albo-atrum races 1 & 2), the damping-off diseases caused by Rhizoctonia solani and Pythium spp., Pyrenochaeta brown root rot (P. lycopersici), southern blight (Sclerotium rolfsii), bacterial wilt (Pseudomonas solanacearum), and various nematode-incited diseases such as root-knot. These (and all) diseases are controlled through exclusion and eradication, manipulation of the environment and cultural practices, the application of pesticides, and the use of host resistance.

Exclusion and eradication involves plant and soil quarantines, plant inspection and certification, eradication, crop rotation, sanitation, and elimination of overseasoning and alternate hosts. Since the pathogens with which we are concerned are common in Florida, quarantines rarely are invoked by the regulatory agencies. However, growers should establish their own quarantine regulations. They should insist on using only healthy, disease-free plants; they should practice crop rotation; they should eradicate old crops immediately; they should eliminate all overseasoning and all alternate hosts; and they should avoid moving soil from old farms to new farm lands. Dissemination of soil-borne pathogens occurs by the use of infected plants; by the reuse of contaminated stakes; by infested soil clinging to stakes, workers, tools, machinery, trucks, automobiles; by wind and rain movement of infested soil; and by dumping infected cull fruit in fields to be cropped.

Crop losses caused by the soil-borne pathogens commonly found in Florida's sandy soil can be greatly lessened by the proper manipulation of fertilizer, lime, and other cultural practices. Fusarium wilt, Fusarium crown rot, southern blight, and many nematode-incited diseases are inhibited by liming the soil to a pH of 6.5-7.5, using nitrate-nitrogen, and covering the bed with mulch. However, this cultural regime (which is used extensively in Florida) favors the development of Verticillium wilt and root-knot. Since Verticillium wilt potentially may result in very serious yield losses, a Verticillium wilt-resistant cultivar should be selected. Most cultivars currently in use in Florida are resistant to Verticillium wilt incited by V. albo-atrum race 1. None are resistant to Verticillium wilt race 2 or to root-knot. The latter disease, though, is relatively unimportant if copious supplies of fertilizer and water are used.

Therefore, on sandy soils, raise the soil pH to 6.5-7.5, select the proper cultivar, use nitrate-nitrogen, and employ the full bed mulch system. This regime, except for the pH adjustment, is also used on the rock land and, regardless of where it is used, will reduce the incidence and severity of several, but not all, diseases. Despite all our cultural and exclusion and eradication manipulations, including the use of multiple disease resistant cultivars, it remains essential to use a broad-spectrum soil fumigant on both sandy and rock soils. These fumigants, which include methylbromide and mixtures of methylbromide + chloropicrin, chloropicrin + nematicides, and methylisothiocyanate + nematicides, will greatly increase disease control and marketable yields.

In summary, tomato diseases caused by the soil-borne pathogens can be controlled very well and yields greatly increased by a crop management scheme involving exclusion, eradication, sanitation, manipulation of fertilizer and liming practices, soil fumigation, and resistant cultivars.

DESIGN AND MANAGEMENT OF DRIP IRRIGATION SYSTEMS FOR TOMATOES

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Drip irrigation systems are systems from which water is applied in small streams or droplets into or near the root zone of the crop being irrigated. Properly designed and managed drip irrigation systems allow water and chemical applications to be accurately made, thus conserving water and energy. Drip systems also allow the soil water status to be accurately controlled at levels required to optimize production.

Design of irrigation systems is the specification of individual components and the conditions under which they will be operated. This includes the specification of the type of each component required, its size, and other characteristics such as its pressure rating.

Major components of irrigations systems must often be designed as groups for compatibility. This paper will discuss the major component groups of control equipment, mainline pipes, irrigation system subunits (manifolds and laterals), and pumping systems. Selection of operating conditions (flow rates and pressures) will also be discussed.

Irrigation system management includes irrigation scheduling and irrigation system maintenance. Irrigation scheduling is the determination of when to irrigate and how much water to apply. Irrigation system maintenance includes mechanical manitenance of components as well as chemical injections and flushing to prevent system clogging.

DRIP IRRIGATION SYSTEM DESIGN

System Components

Control Equipment

Drip irrigation system control equipment consists of the components required to regulate and monitor water and chemical applications to an irrigation system, and safety equipment required to protect the water supply. These include valves, pressure regulators, flow meters, filters, pressure gauges, chemical injection systems, and backflow prevention systems.

Valves: Valves are required to control the filling of an irrigation system on pump startup, to control flows to the desired subsections of a system, and to allow flushing of pipes. Only gate or hydrant valves should be used. Gate valves are used in most applications because of their low pressure losses. Hydrant valves are used to allow extraction of water from permantent underground pipelines, normally for portable irrigation systems.

Globe and ball valves should not be used to control the flow of water in irrigation systems. Globe valves are not recommended because of high pressure losses as compared to gate valves. Ball valves are not recommended because they can be closed almost instantaneously, perhaps causing water hammer problems. Gate valves can be closed only slowly, requiring several turns of the valve handle. Thus flow rates are changed slowly, helping to prevent the shock effects of water hammer.

Automatically controlled irrigation systems will require the use of automatic valves. These may be controlled by electric solenoids or hydraulic pressures, depending upon the type of timer/controller used.

Pressure Regulators: Pressure regulators are required to maintain the desired operating pressure in the event of changing pumping conditions such as due to changes in the water source or flow requirements to subunits of the irrigation system. Regulators will also be required if some subsections of a system operate at different pressures than others.

Pressure regulators may be installed at the irrigation pump outlet, at the entrances to subunits, or both. Pressure regulators may incorporate slow opening and check valve features. The slow opening feature will allow an irrigation system to fill slowly upon pump startup, thus avoiding water hammer problems. The check valve feature will help to prevent backflow to the water source, thus helping to protect the water supply from contamination.

Flow Meters: Flow meters are required to properly manage drip irrigation systems; that is, to measure the amount of water applied at each irrigation. Meters may be located at the irrigation pump to totalize water applications to the entire area irrigated, or they may be located at field subunits to accurately monitor applications to individual fields. Flow meters will also allow the irrigation pumping efficiency to be continuously monitored, will indicate clogging problems by decreases in flow rates, and will allow chemical injections to be accurately made when chemical concentrations in the irrigation water are important.

Backflow Prevention System: Florida law requires that a backflow prevention system be installed on all irrigation systems into which chemicals are injected for agricultural purposes. The backflow prevention system requires a check valve, low pressure drain, and vacuum breaker on the irrigation pipe to prevent water and chemicals from flowing back to the water source. It also requires interlocked power supplies to prevent chemical injection unless the irrigation water is flowing, a check valve on the injection line to prevent water flow to the chemical tank, and a positive shutoff valve on the chemical tank to prevent accidental drainage from the tank.

A double check valve, low pressure drain, and vacuum relief valve assembly is required for the injection of toxic chemicals. Toxic chemicals are those marked with the keywords "Danger" or "Poison" on the label. No backflow prevention assembly is required if chemicals are not injected into the irrigation system.

Filters: Filters are required almost without exception to prevent clogging of drip irrigation systems. Filters remove small particles that may clog the tiny orifices in drip emitters. The type of filtration system required depends upon the type of drip emitter used. Filters should be selected based on emitter manufacturer's recommendations.

If manufacturer's recommendations are not availabe, a rule of thumb is to use the equivalent of a 200 mesh screen filter for drip systems. If organic matter is a problem, as with pumpage from surface waters, media (sand) filters should be used as the primary filter, with a secondary screen filter. For pumping from wells, screen filters only will be adequate unless large amounts of sand are being pumped. In that case, a vortex-type sand separator may be used, followed by a screen filter.

Pressure losses occur through all filters. These losses must be considered when designing an irrigation system. Also, the pressure losses increase as the filter begins to clog. To function properly, filters must be cleaned periodically to maintain their effectiveness and to maintain pressure losses within acceptable limits. Cleaning can be done manually or by automatically backflushing the filter. Automatic backflushing can be based on a timer or on the increase in pressure differential across the filter that occurs as it begins to clog. The pressure differential method is preferred because it avoids unnecessary flushing if not required, yet also avoids unnecessairly large pressure losses through the filter.

The size and number of filters required depend upon the irrigation water quality and on the size of the smallest particle to be filtered. Filter manufacturer's recommendations should be followed for sizing filters for the estimated water quality. Additional filters should be added if clogging occurs too frequently. Also adding more filters, so that the flow rate through each one is reduced, will improve the quality of filtration.

Pressure Gauges: Functioning pressure gauges are required to properly monitor the operation of a drip irrigation system. A minimum of two gauges at the pump discharge (one on each side of the filter system), and one at each field subunit are required. These gauges allow quick checks of the system to be made. They will enable the operator to ensure that the system is operating at the correct pressure, and thus that the proper amount of water is being applied per emitter. They will help detect broken pipes or clogged emitters. Together with the flow meter, they will enable pumping efficiency to be monitored.

Chemical Injection Equipment: Because the small frequent water applications from drip irrigation will leach fertilizers and other salts to the perimeters of the wetted areas, most production systems will probably benefit from chemigation (the injection of chemicals with the irrigation water). Many growers currently inject fertilizer through drip irrigation systems. Chemical injection equipment is required to add the correct amount and rate of chemical.

Several types of chemical injectors are commercially available. These range from the low cost venturi devices and devices that inject on the suction side of centrifugal irrigation pumps to high cost piston type positive displacement pumps. The venturi and suction side injection devices have the advantage of low cost. It is not possible to obtain a high degree of accuracy with these devices, but sufficient accuracy may be obtained for the injection of fertilizers or other chemicals where the total volume rather than the rate of injection is of concern. If a high degree of precision is required as with the injection of toxic chemicals or chemicals that would be detrimental in other than known low concentrations, more precise injection methods should be used. These include the high precision but more costly diaphragm and piston type pumps.

Irrigation Timers and Controllers: Irrigation timers and controllers are required for automatic and semi-automatic operation of drip irrigation systems. They are not manditory for system operation, but they are time and labor saving conveniences. They are especially economically efficient for drip irrigation of vegetables on Florida's sandy soils because of the requirement of very frequent irrigation, often more than once per day.

Irrigation timers use clocks to turn irrigation systems on and off at predetermined times. This function is accomplished by using switch closures at the predetermined times to open and close solenoid valves and/or start and stop pump operation.

Irrigation controllers will also provide timer functions as well as other functions such as starting irrigations based on soil moisture instrumentation, chemigation control, etc. Irrigation controllers range in complexity from very simple timer type devices to very complex solid state systems that are programmable and incorporate microcomputer capabilities. Prices for these systems range from less than $100 for the timer devices to several thousand dollars for the more complex programmable controllers.

Mainline Pipe Design

The mainline pipe in an irrigation system conveys water from its source (normally at the exit from a pump) to the field subunits where water is distributed to the crop. There are 2 primary considerations in mainline pipe design: potential water hammer problems and economic considerations.

Water Hammer: To avoid water hammer problems, velocities should be kept low, normally less than 5 feet per second (fps) for other than experienced irrigation system designers. Under no conditions should velocities ever exceed 10 fps. Velocities in the range of 5-10 fps are permissible if startup velocities are controlled by slow-opening valves, if thrust blocks are installed as required at gasketed tees, elbows, and valves, and if the valves to the irrigation system are not normally closed at pump startup.

Mainline and submain pipes are normally buried. PVC is normally used. All PVC should be buried or protected from the sun. Steel pipe should be used at the pump control head where pipes will be exposed to solar radiation and where extra strength is required because of the shocks associated with pump startups. Steel pipe should be used under roadways where extra strength is required. Aluminum pipe is applicable to portable systems where the pipe will be left on the surface. Aluminum pipe should never be buried.

Pipe used should be compatible with any chemicals injected. PVC is noncorrosive to many chemicals. Steel pipe (SCH 40) should normally be used from the irrigation pump to the first normally closed valve for permanent installations. Inject chemicals and use PVC pipe after that point.

Economic Considerations: Mainline pipe sizes should be selected based on economics and the previously discussed water hammer considerations. The cost of the energy consumed by friction losses should not exceed the amoritized cost of the next larger sized pipe. The economic analysis should consider the additional pumping cost associated with fuel cost escalation for the life of the system, as well as any anticipated expansions of the system that would require greater flow rates in the existing mainline pipes.

Friction loss tables used to estimate energy losses to select mainline pipes assume that the pipes flow full. Air relief valves should be installed at all high points along the pipes to assure that air will not be trapped at these points, causing the pipes to flow less than full.

Irrigation Subunit Design

An irrigation subunit is the group of laterals and manifolds that operate at one time. Figure 2 shows irrigated fields with 6 and 4 subunits in the upper and lower portions of the figure, respectively. Subunits may be only 1 lateral or many. Pressure is normally regulated at the entrance of a subunit, especially for large field scale systems. Control components located here are normally a valve (manual or automatic), pressure regulator, pressure gauge, and secondary (screen) filter.

Subunit design criteria is uniformity of water application and economic considerations. Pipes must be large enough to prevent excessive head losses so that water is applied uniformly from all emitters, but pipes must be small enough to be affordable. Absolute (100%) uniformity is impossible. Extremely high uniformities are costly. Tradeoffs of benefits from uniformities versus cost must be made. As a rule of thumb, maximum - minimum flow rates from emitters in a subunit should not deviate by more than 10% of the average emitter flow rate in the subunit. Uniformity should be higher when chemicals are applied with the irrigation water since chemical application uniformity cannot exceed the water application uniformity.

Subunit uniformity is based on flow unifromity, but it must be experssed in terms of pressure variation (loss) to allow the designer to select pipe sizes. The translation from flow to pressure variation depends on the emitter hydraulic characteristics, that is, how the individual emitter flow varies with pressure. These data must be obtained from the manufacturer of the drip irrigation system used.

In Florida, line source drip irrigation tubes are commonly being used for drip irrigation of tomatoes. These include Bi-Wall * tubing manufactured by Hardie Irrigation Inc., Twin-Wall tubing by Chapin Watermatics Inc., T-Tape by T-Systems Corp., and others. Manufacturer's data giving allowable length of lateral to achieve a given uniformity of application should be available from each manufacturer. These data must be used because each product has different hydraulic characteristics. Each flow variation would be different because of differences in the effective lateral diameter, differences in the manufacture of the emitting device, and differences in the recommended operating pressures.

When using the manufacturer's data on uniformity of water application from line source lateral pipes, care should be taken to determine whether the data given apply to only 1 lateral or to several laterals served by a manifold. Laterals must be designed to apply water more uniformly than the final subunit uniformity because pressure losses will occur in the manifold pipe, reducing overall subunit uniformity. Manufacturer's procedures for sizing of manifolds should be followed for each individual product. The minimum acceptable subunit uniformity of water application should be 80% for Florida conditions. If chemicals are applied with the irrigation water, the minimum acceptable uniformity is 90%.

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* Manufacturer's and trade names are given for information only. No endorsement or preferential treatment is implied.

Subunit lateral pipes are typically the line source tubes previously described. These are thin-walled, perforated, collapsible Polyethylene (PE) or Poly Vinylchloride (PVC) tubes. Tubes are typically installed on the soil surface, with the perforated side facing upwards to minimize clogging problems. Most of these laterals are disposable after 1 growing season or 1 year of use. Some of the thicker walled tubing can be recovered for later use. Labor and storage costs commonly prohibit reusing line source tubing in Florida.

Subunit manifold tubing may be flexible plastic pipe normally installed on the soil surface or rigid plastic pipe that must be buried. The flexible pipe used is pressure rated (60 or 80 psi) PE or PVC pipe. This is smooth-walled, non-collapsible pipe which is connected using barbed insert connectors. These tubes are normally installed on the surface but they can be buried if they will not be buried so deep or located in traffic zones so that they will be collapsed by the overburden pressures.

Subunit manifold tubing may be white PVC pipe. This is rigid pipe which must be buried, with risers to the laterals. Burial is required to prevent organic growths in the pipe and to protect it from deterioration in the sunlight. Pipe is connected using glued slip couplings.

Pumping System

An irrigation pumping system for drip irrigation must have sufficient capacity to irrigate all subunits to meet crop water requirements. Crop water requirements includes evaportanspiration (ET) and other requirements such as cold protection or water required as a carrier for fertilizer applications, etc. The pump must have sufficient flow and pressure for the most extreme subunit conditions. The critical flow is that of the largest subunit. The critical pressure is that of the most distant, that at the greatest elevation, or that which for other reasons requires the greatest pressure to deliver its water.

Ideally, all subunits should be of about the same size and have about the same pressure requirements because an irrigation pump operates most efficiently at 1 flow rate and pressure.

The total pressure head required to be produced by the pumping system is the sum of the pressures required to operate the critical subunit, friction losses through the mainline (including all losses through valves, filters, meters, fittings, etc.), and elevation changes including pumping lift.

For surface water supplies and water at pumping levels of less than 20 ft in wells, centrifugal pumps are the most economical option. For water at greater depths in wells, turbine pumps must be used. For large systems, deep well turbines, with power units on the surface, are commonly used. For smaller units, submersible turbines are a less expensive option. With submersible turbines, electric motors are directly connected to the pumps and lowered into the well. For automatic operation, turbine pumps have the advantage of not requiring priming for the pump to operate. Conventional centrifugal pumps reqauire priming to operate. Although self-priming centrifugal pumps are available, they will operate less efficiently than turbines. Turbines are recommended for systems that will start and stop automatically.

For automatic operation, electric motors are recommended as power units for drip irrigation systems. They have a lower initial cost than internal combustion engines, especially for smaller sizes. There may be a demand charge associated with the power bill for their use, especially for larger units. Most power companies now have off-peak rates for irrigation pumps. Some of these have eliminated demand charges as well. Local power company policies will dictate actual costs.

Diesel power units are the most common type of internal combustion engine used for irrigation in Florida. They are more efficient than other types of internal combustion engines. Internal combustion engines are recommended when irrigation systems will be used for cold protection because of the possibility of power (and pumping) losses on cold nights.

Selection of Operating Conditions (Flow and Pressure)

The irrigation system operating pressure is the pressure at which the typical subunit operates. Because emitter flow rate depends on pressure, selection of an operating pressure also sets the average flow rate for the system. Likewise, specifying the average flow rate specifies the operating pressure required to achieve that flow rate.

High operating pressure increases irrigation cost of operation because the pumping cost increases directly with the pressure against which the pump is operating. Low pressure increases pipe costs because the allowable pressure loss is less in order to still achieve a high degree of uniformity of water application. The decision is economically based. The optimum set of operating conditions will result from a detailed cost analysis. Fortunately, however, the range of operating pressures and the recommended operating pressure for line source drip irrigation laterals are much less than those of other types of drip systems.

The typical recommended operating pressure for line source drip laterals is 5-15 psi. Most manufacturers recommend 1 value such as 8 or 10 psi. These are the pressures which should be used in design. Pressures exceeding these may be excessive for the tubing being used, and may void the warantee on the tubing.

Although pressure ratings of the pipes being used in a drip irrigation system may be large, use of high pressures in drip irrigation systems discards one of the main advantages of using drip irrigation rather than other types of irrigation systems, that of low pumping cost.

Flow rates from individual emitters in a drip irrigation system are rarely greater than 1 gallon per hour (gph). For line source emitters, they are typically in the range of 0.1 to 0.3 gph per emitter. These limits are set by the manufacturers in order to limit the flow rates per lateral, and therefore, to increase the allowable lateral length.

The rate of flow from an individual emitter is relatively unimportant to soil water redistribution in this range of flows. Rather soil water distribution is dominated by the soil hydraulic properties. Lateral movement of water in Florida's sandy soils is typically small, almost always in the range of a 1-4 ft diameter circle from the emitter. Because of the wide range in possible values, this data can best be obtained by field observation. If the wetted area is not a significantly large fraction of the crop bed, increasing the flow rate per emitter will not greatly increase the area wetted. Rather, more than 1 lateral will be required to distribute the water across the bed. The soil water status will also influence the lateral movement. Greater lateral movement will occur in a wetter than a drier soil. This fact further supports the need for frequent small irrigations when using drip irrigation (2 or 3 irrigations per day during peak water use periods).

Lateral movement of water influences the emitter spacing to be selected for drip laterals. Many growers are currently using 12 inch emitter spacings in order to adequately irrigate the areas between emitters along crop beds. The choice to be made in any specific situation would again, however, be specific for the unique soil conditions at that location. Greater spacings will permit greater lateral lengths of run, while smaller spacings will require shorter lateral lengths because of the larger number of emitters and therefor the greater flow rates.

IRRIGATION SYSTEM MANAGEMENT

Irrigation Scheduling

Determining How Much Water to Apply

Scheduling of drip irrigation systems for vegetable production in Florida typically involves small, frequent applications. This is because vegetable crops are shallow rooted, and typical Florida sandy soils are very sandy. Both of these factors limit the amount of water which can be retained in the plant root zone. Vegetable crops are also typically very sensitive to water stress. Thus it is desirable to keep the soil water content high in the plant root zone.

To keep the water content high in the plant root zone, irrigations may need to be scheduled more than once per day.

It may be necessary to schedule 2-4 irrigations per day during peak water use periods. This is not a problem with drip irrigation systems because they can be readily automated to take full advantage of their capabilities.

The amount of time to operate a drip irrigation system at each irrigation depends on several factors: emitter flow rate, soil water holding capacity, depth of the crop root zone, and soil water content when irrigations are scheduled. The possible varability in each of the above factors makes the determination of the operating time very system specific.

Normal operating times for Florida vegetable crops would be expected to range from 2-4 hours per irrigation. To calibrate hours of operation for a specific system, run the system for a preset period of time, then dig into the soil profile to see where the water has penetrated. Adjust hours of operation if the wetted zone is smaller than the crop root zone or if it extends below the crop root zone.

Note that chemicals that remain soluble in soil water (such as many fertilizer elements) will move to the perimeter of the wetted areas as irrigation is applied. Therefore, it is critical from the standpoint of fertility to maintain the irrigated zone within the plant root zone. This is particularly a problem if fertilizers are applied only periodically, and pulses of fresh water are used for frequent irrigations. Then pulses will push the fertilizer salts (and other soluble salts) to the perimeter of the wetted region. This problem can be alievated by injecting small amounts of fertilizers frequently, and by maintaining the irrigation water within the plant root zone.

Determining When to Irrigate

For crops sensitive to water stress such as vegetable crops, irrigations should be scheduled when about 1/3 to 1/2 of the available water in the crop root zone has been depleted. The exact value for a specific soil-crop combination must be determined by field experience.

Tensiometers located 4-6 inches below the soil surface in the drip irrigated area where most of the plant roots are located will indicate a need for irrigation when they read in the range of 12-25 cb soil water potential. The exact value will depend on the specific soil and crop characteristics and on the system manager's production objectives. Also lower values should be used during peak water use periods because of the lag times associated with tensiometer response, and the critical need for water during these periods. Irrigations would be expected to occur on approximately a daily basis unless rainfall occurs.

Alternatively, the need for irrigaion can be calculated from a water balance of the plant root zone using the accounting method and an indicator of climatic demand on a daily basis. For example, if the daily evapotranspiration (ET) is estimated to be

0.25 inches (from pan evaporation or other weather records), then (0.25 inches)(27,154 gal/acre-inch) = 6,800 gal of water must be applied per acre per day. If emitters are spaced at 1 ft intervals on tomatoes which are on 6 ft beds, then there are 6 ft x 1 ft = 6 sq ft of land area per emitter, and 43,560 sq ft/acre / 6 sq ft/emitter = 7,260 emitters per acre. Thus, each emitter must apply about 0.9 gal on that day. This amount should be increased about 10% (to 1.0 gal/emitter) to allow for losses due to the less than perfect efficiency of a drip irrigation system (assumed 90% irrigation system efficiency).

If the depth of water penetration is not beyond the crop root zone when 1 gal is applied (as detected by field observation), then this amoun can be applied in 1 application per day. If the depth is excessive, then 2 or more applications should be made per day, allowing time for soil water depletion by the crop between irrigations.

In this example the length of time per irrigation would be calculated from the amount to be applied divided by the rate of application per emitter. If each emitter applies 0.20 gal/hour (GPH), then (1.0 gal)/(0.20 GPH) = 5 hours would be the irrigation time. This would be applied in 1 5-hour set or 2 2.5 hour sets as required by the soil water holding ability. Field experience would be required to refine irrigation schedules using this procedure.

Irrigation System Maintenance

Irrigation system maintenance implies the maintenance of the functioning of the mechanical components of the irrigation system and the prevention of clogging of the drip emitters. Routine maintenance programs must address both of these potential problem areas.

In order for a drip irrigation system to function properly, all mechanical components must be in good repair and properly adjusted. Primary among these is the irrigation pump and its power unit. Records of flow rate and pressure that the pump delivers should be maintained on at least a monthly basis. When its output drops to the point that irrigation efficiency suffers and pumping energy is wasted, repair specialists should be employed to repair or adjust it. Specialists will have the necessary equipment to determine whether the cause of the decline in efficiency is due to the pump or the power unit.

Other mechanical components should be inspected periodically. Irrigation timers and controllers should be routinely inspected to assure that valves are opened and closed when required. Automatic valve solenoids or diaphragms may need periodic replacement. Flow meters may require periodic lubrication or inspection for clogging. Pressure regulators will need periodic inspection to verify that they function properly. This can be done with pressure gauges on system subunits. Pressure gauges, likewise should be inspected by checking their performance against a new gauge. A routine maintenance program for all mechanical components is required to assure their continued performance.

Clogging of drip emitters by particulate matter or organic growths should be prevented by filtration and/or water treatemnt. Filtration is required almost without exception for all drip irrigation systems. See the previous discussions in this paper on filtration systems.

Filters need periodic flushing and cleaning to continue to operate effectively. A regular routine of inspections and maintenance should be established. This may need to be a daily procedure during peak water use periods, depending on water quality.

Water treatment may be required to control organic growths in irrigation systems. Chlorination or other chemical additives may be used to kill and prevent further organic growths. Procedures for the use of chlorine for control of organic growths have been developed and published in IFAS Lake Alfred CREC Res. Rpt. CS79-3 by Dr. Harry Ford. These procedures require that a water quality analysis be made and that liquid chlorine be injected during irrigation. Depending upon water quality, chlorination may need to occur with each irrigation. Alternatively, chlorination may be required only periodically, but on a regular basis. The key is to establish a regular program of prevention of clogging problems, rather than attempting to clean up clogged emitters. Flow meter and pressure readings on irrigation system subunits will help the irrigator determine whether the system is performing satisfactorily.

SUMMARY

Major components of drip irrigation systems for tomato production in Florida were defined. Design of control equipment, mainline pipes, system subunits, and pumping stations were discussed. Considerations in selecting the irrigation system design pressure and flow rate were presented. Management procedures, including irrigation scheduling alternatives and irrigation system maintenance were presented.

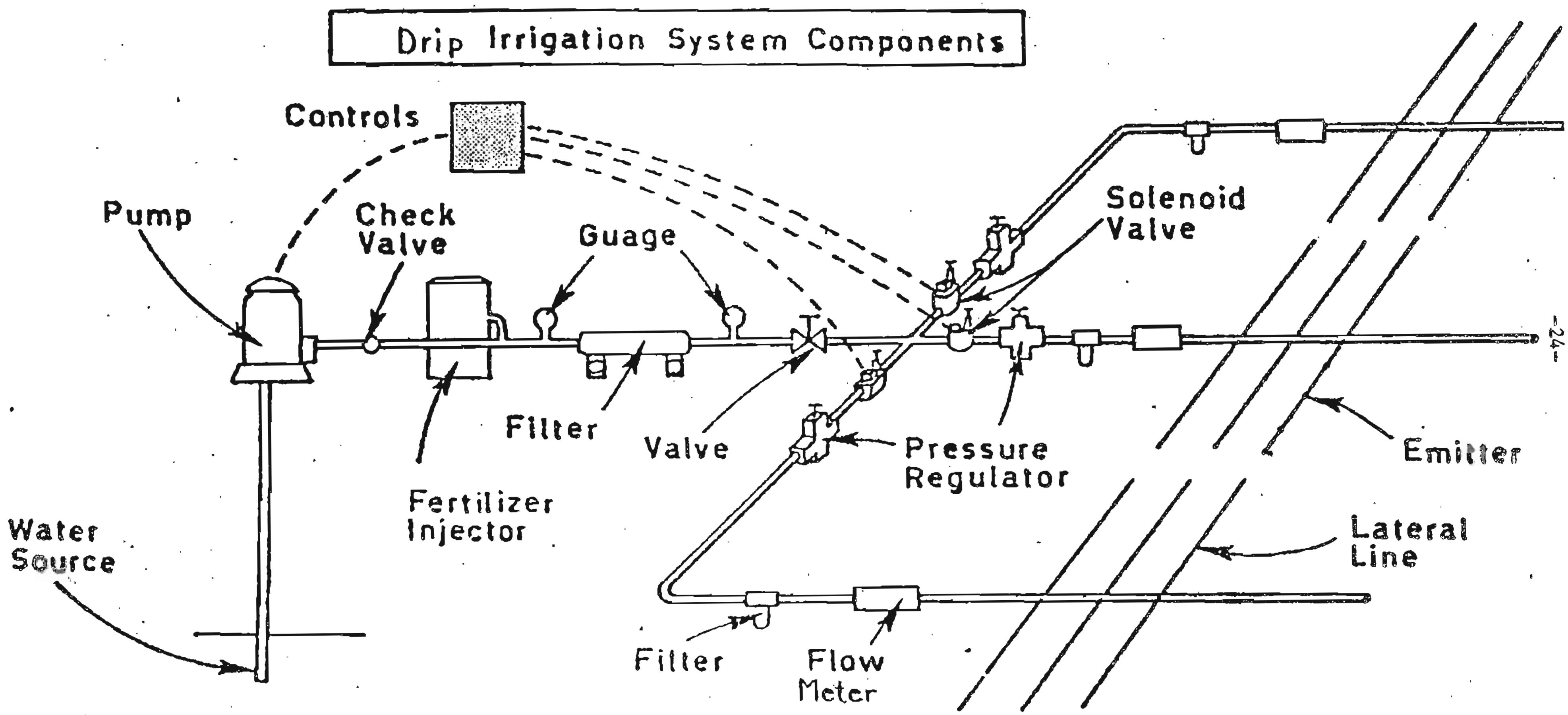

Figure 1. Drip irrigation system components.

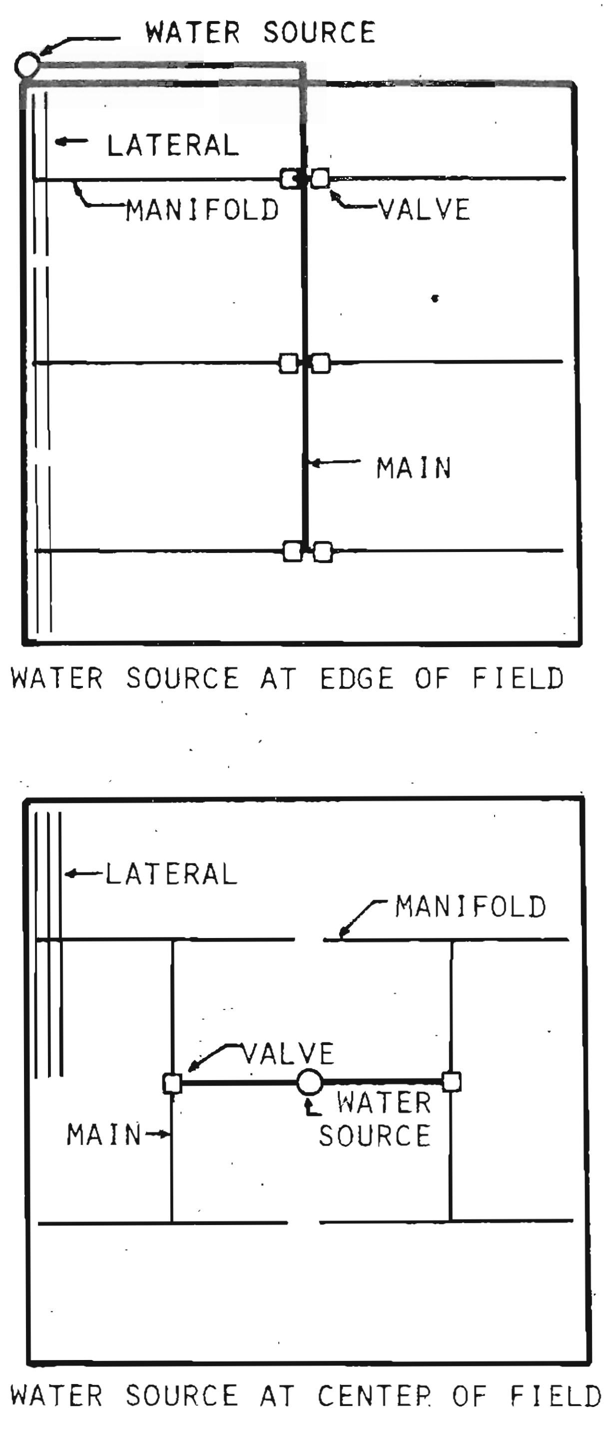

Figure 2. Subunit layout showing mainlines, manifolds, and laterals for two different field configurations.

WATER MANAGEMENT WITH DRIP IRRIGATION SYSTEMS

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Introduction

With increasing frequency many areas of the state of Florida are experiencing periods of water shortages during which restrictions or reductions of water use are imposed by regulating authorities. Tomato production can be severely affected if these restrictions are imposed and enforced during production seasons since one of the most predominant irrigation systems, seep subirrigation, requires large quantities of continuous water flow to maintain the water table in production areas at a desired level. Because of the great potential of drip irrigation to reduce water use per production acre, grower interest is increasing for its possiblity as an alternative to present systems.

Drip irrigation systems, by their design, greatly increase the potential for efficiently applying water to a tomato crop. This potential for increased efficiency comes from the ability of the system to apply water to the crop in the right place, at the right time, and in the right amounts. The level to which this potential is realized depends on the level of water management that one is willing to input. Water can be as easily wasted with drip irrigation as it can be with other irrigation systems.

Irrigation Water Requirements

The amount of water required for optimal plant growth and fruit production depends upon factors such as the time of year the crop is grown (affecting potential evapotranspiration) and growth stage of the crop (affecting coverage of the bed, rooting depth, and amount of transpiring leaf area). There are many ways to determine the water requirements for a crop, but many of these involve complicated equations requiring meteorological measurements which are not readily available. Historical weather data utilized with these methods can give an indication of water requirements from a broad perspective (Kovach, 1984) for large areas, but may be limiting in use for specific periods of time at specific locations.

Water requirements can be determined by an accounting method which requires knowledge of soil water holding and transmitting characteristics, initial soil moisture, water use and rooting characteristics of the crop grown, and water applications (natural precipitation or irrigation). The accounting method utilizes this information to maintain the soil moisture regime at an optimal level which avoids stress on the crop. This method of water requirement determination works well on deep soils where water storage capacity is such that irrigation frequency would be no more than once per day. However, with shallow-rooted tomato crops grown on sandy soils where more than one application of water per day may be required, there are limitations to its usefulness.

Estimates of crop water requirements can be made by using data collected from an evaporation pan. Pan evaporation tends to integrate many of the meteorological factors (temperature, solar radiation, wind, humidity, etc.) influencing potential evaporation. Water requirements are estimated by using a crop factor multiplied by the amount of evaporation. Although in reality, crop coefficients change as the crop matures, practical and simple use of this method would involve using a crop coefficient of 1.0 throughout the growing season, and using a weekly average of daily pan evaporation measurements to make water application amount determinations. Once an average daily application rate (ie. - inches/day) is determined, it is multiplied by 27,154 gallons/acre-inch and by the number of acres to be irrigated. These amounts may change weekly as pan evaporation amounts change.

Application Frequency

Once a daily rate is determined, the frequency of irrigation needs to be addressed. Frequency of application depends on factors such as soil type, crop requirement, system design, and pumping capacity. If the soil that the crop being grown on is a loam soil with high water holding capacity, water may need to be applied only a few times a week. But with the sandy soils on which much of the tomato production in Florida occurs, at least daily irrigation is required. Amounts of water applied in one irrigation time should not exceed the water holding capacity of the soil volume in which rooting occurs. If excessive amounts are applied, water and any fertilizer that it may contain can be lost to soil areas below the effective rooting zone. Research at the Gulf Coast Research and Education Center has shown that for drip irrigated tomato production on EauGallie fine sands, 3-4 applications/day seemed to be optimal.

The use of any method of determining irrigation amounts and frequencies also involves the periodic monitoring of the soil moisture to ensure that an adequate amount of water is being applied. Portable tensiometers (Smajstrla et al, 1981) are useful for estimating soil moisture at several locations in a relatively short period of time.

Drip Irrigation In Combination With Seep Irrigation

One of the major limitations of drip irrigation is its lack of ability to be used as an irrigation system for field preparation purposes. Since tubing installation doesn't occur until after the mulched beds are formed, either reliance on natural precipitation or some other means of irrigation is required to ensure adequate soil moisture for proper bed formation and fumigation. A study supported by the Florida Tomato Committee was carried out during the 1985 spring season to investigate the water use and yield characteristics of tomato production using seep irrigation for field preparation and plant establishment prior to initating the drip system. This was compared to production using drip irrigation without seep irrigation. Other treatments included in the study were fertilizer (liquid vs dry + liquid), plant spacing (20 vs 30 inches), and cultivar ('Duke' vs 'Sunny'). Water application during the growing season is shown in Table 1. In the combined system treatment, seep irrigation was initiated 21 days prior to transplanting and remained on for 14 days after transplanting. Drip irrigation was initiated 2 days after transplanting and continued to the end of the season. Drip irrigation in the other treatment was intiated 14 days prior to transplanting and continued to the end of the season. Drip irrigation application rates were determined using pan evaporation data. The amount of water applied to the combined system treatment (31.3 inches) was 1.6 times the amount applied to the drip system only treatment (19.2 inches), although well below most estimates of water use for seep irrigation alone (50-60 inches).

Yield data are shown in Table 2. The combined seep and drip irrigation treatment significantly increased yields for extra large and the combined extra large + large fruit sizes although the total marketable yields were not significantly affected. Significant differences for the other main effects are indicated in Table 2.

Significant rainfall (2.26 inches) was received 4 days prior to transplanting and may have beneficially affected the ability of the drip system to establish transplants and, ultimately, the final yields. A true test of treatment differences will come if no rainfall is received prior to transplanting. However, the results from this first season seem to indicate that a combination irrigation system may be required to ensure that drip irrigation will work consistantly for tomato production (especially for large fruit size) on similar soils as those used in the study. This experiment will be repeated during the 1985 fall season.

Other Considerations

Research at the Gulf Coast Research and Education Center has shown that for drip irrigation to be effective on sandy soils, the production bed must be at or near field capacity when the irrigation system is initiated. This is due to the poor water holding and transmitting characteristics of these soils and the extereme difficulty in getting good water distribution when drip is used to irrigate a relatively dry bed. For this reason, the use of some other irrigation system to moisten the soil for bed preparation and fumigation is required, and that the beds are not allowed to dry prior to transplanting.

Another aspect of water management for drip irrigation on poorly drained soils that must be considered is the need for adequate drainage. Although the internal soil water storage is greater for drip irrigation compared to seep irrigation since there is no supplementation of the natural water table occurring, properly spaced drainage ditches are still required to remove excess water that can result from heavy rainfall.

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Table 1. Amount of water applied as a function of irrigation treatment for tomato production, GC-REC, Spring 1985.

Irrigation Treatment		Water Application (inches): Prior to Transplanting	Following Transplanting		Total Applied
Combined	(Seep)	7.7 (21 days)	5.2 (14 days)		12.9
	(Drip)	2.6 (12 days)	15.8 (74 days)		18.4
				Total	31.3
Drip alone		3.1 (14 days)	16.1 (74 days)	Total	19.2

Table 2. Tomato yield responses to irrigation, fertilizer, plant spacing, and cutivar treatments, GC-REC, Spring 1985.

Treatment	Tomato yields (Cartons/acre): 5x6	6x6	6x7	7x7	Total Marketable	Comb. [1]
Irrigation						
Drip + Seep	716*	523	378	77	1694	1239*
Drip alone	538	463	429	103	1533	1001
Fertilizer						
Liquid	723*	491	338	68	1619	1213
Liquid + Dry	532	496	470*	112*	1609	1027
Plant Spacing						
20 inches	604	493	434	96	1628*	1098
30 inches	650*	494	372	84	1599	1143*
Cultivar						
'Duke'	670*	479	337	67	1553	1149
'Sunny'	583	508	470	113*	1674*	1091

* denotes significant difference (5% level) between treatments for indicated measurement

[1] Combined large + extra large fruit sizes

FERTILIZER MANAGEMENT WITH DRIP IRRIGATION SYSTEMS

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Tomato production with drip irrigation will require more intense management than with overhead or seep irrigation. Along with more intense management other disadvantages include clogging of lines, limited watering pattern in the horizontal plains and possible excessive downward movement of water along with the water-soluble nutrients.

Some of the advantages include reduced water use (maybe up to 50%), lower energy costs since smaller pumps can be utilized, the crop and row middle remain drier and facilitate better insect and disease control, reduced weed growth in row middles and better harvesting conditions since row middles are not wet, increased yields with some crops and precise application of nutrients and certain pesticides. This latter advantage can lead to the use of the plastic cover and drip tube for a second crop since additional fertilizer can be added.

Fertilizer Rates: Rates used for tomato production with drip irrigation are similar to those used for both overhead and seep irrigation. Rates should be related to number of harvests intended. The following rates should provide maximum yields:

1-2 harvests: 160-240-240 lb/A N-P_2O_5-K_2O
3-4 harvests: 220-240-330 lb/A N-P_2O_5-K_2O

Amounts of P_2O_5 and K_2O may be reduced depending upon soil test indicating residual P_2O_5 and K_2O.

Where micronutrients are known to be needed, apply 0.5-1.0 lb/A of Cu and B; 1.5-2.0 lb/A of Mn and Zn; 3.0-5.0 lb/A of Fe and 0.01-0.02 lb/A of Mo. Sources can include oxides, sulfates and/or chelates. Where tomatoes have been planted before Cu should not be needed because of Cu spray materials used to control bacterial diseases.

Fertilizer Application: Soluble nutrients are rapidly moved away from the point of application with the water front. Since the zone nearest the tube is the most highly leached, placement of the tube 5 to 6 inches away from the plant has resulted in better plant growth and nutrient uptake than with tubes placed nearer the plant. Tubes placed further away may not be able to provide water or nutrients especially in a sandy soil.

With drip irrigation about 30-40% of the N and K_2O, all the P_2O_5 and micronutrients are applied broadcast before bedding. As soon as the drip system is operational, N and K_2O should be applied with the water until the other 60-70% is applied.

The additional N and K_2O may be applied weekly, biweekly or daily. Amounts to be applied each week of the growing season can be based on a percentage of the total N and K_2O to be injected. A general schedule based on a 14 week season could look like the following: 0, 2, 4, 6, 8, 12.5, 12.5, 12.5, 12.5, 7.5, 7.5, 7.5, 7.5 and 0%. This schedule can be modified to make it more simple, suit growers schedules or suit calibration of injection equipment. With the availability of microprocessors for field use, injection of fertilizer can be done automatically.

In a sandy soil where water moves rapidly down, the grower will benefit from putting 30-40% preplant and the rest through the drip lines since frequent watering will move the nutrients out of reach of the plant roots and one will need to replenish the nutrients. Frequent watering or over watering can result in moving nutrients out of system and may result in nutrient deficiencies.

In a heavier soil, or a soil that contains a heavy subsoil near the surface, the use of the split application may not be of benefit. In 2 out of 3 years of research in Northwest Florida there were no yield differences when all N and K_2O was applied preplant or applications were split between preplant and through drip tube. In the heavier soil the wetting pattern will spread out more and the broadcast nutrients can be reached by the plant roots. This will also occur in soils with heavy subsoils since the wetting pattern will be modified. In a sandy soil it is hard to keep even one side of a bed wet and in many instances the off tube side will remain dry and those nutrients on that side will not be utilized.

Fertilizer Sources:

a. Nitrogen (N) - This element is most frequently injected into drip systems as it is readily leached and most soils are deficient in it. Sources include ammonium nitrate, potassium nitrate or calcium nitrate. Research in North and West Florida have shown no differences between these sources. Other sources such as anhydrous ammonia, aqua ammonia and ammonium phosphate should not be used due to the clogging hazards they present.

b. Phosphorus (P) - Injection of this element is not recommended since; properly applied preplant P will satisfy the plant needs, P is limited in its movement in the soil and P injected into the system may present clogging problems in the tubes.

c. Potassium (K) - This element is also easily leached in sandy soils and usually must be replenished to maintain a proper N:K ratio for good crop production. Sources include potassium sulfate, potassium chloride or potassium nitrate.

d. Micronutrients - Generally, micronutrients are applied preplant but at times it may be necessary to add certain micronutrients to correct a problem. Chelates or sulfates or iron, zinc, copper or manganese can be applied by the drip system. Chelates are preferred since they are highly water soluble and will usually not cause clogging problems that may occur with sulfate sources.

<u>Fertilizer Injection</u>: The drip system must be allowed to reach the working pressure of the tube before injection of the fertilizer solution is started. The length of time that fertilizer is injected into the system depends upon the amount of time it takes the fertilizer to reach the farthest emitting orifice. This can be determined through use of a dye or injecting chlorine and testing at intervals. In order for the injected fertilizer to be equally distributed, only irrigation water must be run through the drip system after fertilization injection stops for the same amount of time that injection of fertilizer occurred.

STATEWIDE TOMATO VARIETY TRIAL UPDATE

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INTRODUCTION

The statewide tomato variety trials are essential to the IFAS tomato breeding program. Advanced selections are compared with commercially grown tomato cultivars in several Florida locations and seasons. Fruit yield, size, and quality characteristics are measured in each trial. The purpose of the following investigations was to evaluate several advanced tomato genotypes and commercial cultivars for fruit yield and size at four locations in Florida.

MATERIAL AND METHODS

Commercially grown tomato cultivars, 'Duke,' 'FTE-12,' 'Hayslip,' 'Horizon,' 'Sunny,' and two advanced breeding lines from the IFAS breeding program, 7130 and 7131, were grown in four locations in Florida during the Fall of 1984 and Spring of 1985. Cultural practices used at each location are presented (Table 1). Each cultivar or advanced line was replicated a minimum of three times at each location. Tomato fruit weight and numbers were measured in each plot and summed after fruit harvest. Tomato yield was expressed in units of 25 lb. boxes per acre and average fruit size in oz. per fruit.

RESULTS AND DISCUSSION

Mean yield of marketable tomato fruit per trial ranged from 1533 to 3740-25 lb. boxes/acre (Table 2). The Spring season trials had more marketable fruit than the Fall season trials at Bradenton and Ft. Pierce. Average weight per fruit per trial ranged from 5.0 to 6.3 oz/fruit (Table 3).

Mean yield of marketable tomato fruit per cultivar ranged from 2296 to 2541-25 lb. boxes/acre. 'Sunny' and 7131 had the highest average marketable fruit yields. Average weight per fruit per cultivar over all locations ranged from 5.5 to 5.8 oz/fruit (Table 3). 'Duke' and 7130 had the largest fruit.

Differential cultivar responses for tomato fruit yield and size occurred among the trials. This suggests that individual cultivars are more productive at a particular location or season when compared to toher cultivars. Therefore, growers must select a cultivar based on area of production and time of planting.

Table 1. Cultural practices used for tomato performance trials.

Location	Season	Plant Arrangement: Spacing between: Beds (ft.)	Plants (in.)	Rows/bed (no.)	Number of Harvests	Staking[z]
Bradenton	Fall	4.5	29	1	2	+
	Spring	4.5	29	1	3	+
Ft. Pierce	Fall	7.0	24	1	4	-
	Spring	7.0	24	1	5	-
Homestead	Fall	6.0	15	1	2	-
Immokalee	Fall	6.0	15	1	3	+
	Spring	6.0	15	1	2	+

[z] (+) or (-) indicate staked or unstaked trials, respectively.

Table 2. Mean yields of marketable fruit for several tomato genotypes grown at four locations in Florida during Fall 1984 and Spring 1985

	Fruit yields (25 lb. boxes/acre)							
	Bradenton		Ft. Pierce		Homestead	Immokalee		
Genotype	Fall	Spring	Fall	Spring	Fall	Fall	Spring	Mean
Duke	2277	3472	1524	2006	1604	3026	2162	2296
FTE-12	1855	3667	1359	1833	1592	3356	2734	2342
Hayslip	2088	3706	1459	1792	1297	2721	3076	2306
Horizon.	2258	3628	1446	1894	1742	2940	2488	2342
Sunny	2038	3875	1814	2079	1717	3254	3009	2541
7130	1892	3597	1516	1526	1897	3077	2839	2335
7131	1579	4233	1610	1922	1970	2802	3264	2483
Mean	1998	3740	1533	1865	1688	3025	2796	

Table 3. Average weight per fruit for several genotypes grown at four locations in Florida during Fall 1984 and Spring 1985

	Fruit weight (oz/fruit)							
	Bradenton		Ft. Pierce		Homestead	Immokalee		
Genotype	Fall	Spring	Fall	Spring	Fall	Fall	Spring	Mean
Duke	5.2	5.7	6.7	5.9	5.2	6.5	5.7	5.8
FTE-12	4.9	5.5	6.0	5.3	5.3	6.3	5.5	5.5
Hayslip	5.1	5.1	6.3	5.3	5.1	6.1	5.6	5.5
Horizon	5.1	5.5	5.3	6.1	5.3	6.0	5.6	5.6
Sunny	4.8	5.6	5.5	5.5	5.1	6.2	5.6	5.5
7130	5.1	5.4	6.5	5.5	4.9	6.8	5.7	5.7
7131	5.1	5.5	5.8	5.5	5.1	6.2	5.7	5.6
Mean	5.0	5.5	6.0	5.6	5.1	6.3	5.6	

RECENT FINDINGS IN THE IFAS TOMATO BREEDING PROGRAM

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I will focus on three areas: 1) the outlook for future variety releases, 2) bacterial spot resistance, and 3) new sources of Fusarium wilt race 3 resistance.

Variety Release Outlook: A new cherry tomato line, Fla 7166, has just entered the advanced trial stage. Features on this open-pollinated line include prolific heat tolerant fruit setting ability, good flavor, uniform fruit size, jointless stems, tolerance to bacterial spot, resistance to Fusarium wilt races 1 & 2, resistance to Verticillium wilt, and resistance to gray leafspot. If advanced trial performance merits release, it will be available in 1986.

Yield performance of some large fruited lines was summarized by Pete Stoffella. Although some of the tested lines may prove comparable to established varieties, the outlook for release is currently guarded. The most promising lines have been submitted for advanced testing this fall and a release is not likely before 1987. Major objectives are to obtain varieties with high fruit yields, good eating and shipping qualities, and fruit size greater than that which is presently available.

Advanced testing of several breeding lines with additional disease resistances will begin shortly. One group has tolerance to Fusarium wilt race 3 derived from Australian sources. The objective is to obtain breeding line releases to be utilized by other plant breeders in their varietal development programs. Other lines with resistance to bacterial spot, bacterial wilt, or fusarium crown rot should enter advanced testing in the next two years.

Bacterial Spot Resistance. As I've reported in the past, resistance to this disease is from a line called Hawaii 7998. Jeff Jones and I are in the process of determining the genetic control of this resistance. Results of one completed experiment and an experiment presently underway should elucidate the inheritance. Present data indicate two or more genes control resistance to bacterial spot. Hybrids between resistant and susceptible parents are intermediate in disease reaction. If such a hybrid were released as a variety, it would have tolerance to bacterial spot as opposed to the susceptibility of present day varieties.

In other work we have found that Hawaii 7998 is partially susceptible to bacterial spot on the fruit. In greenhouse inoculation experiments Hawaii 7998 had significantly fewer spots than 'Walter' (Table 1). Another line, PI-270248-'Sugar,' was resistant to fruit infection but susceptible to foliar infection. A hybrid between Hawaii 7998 and 'Sugar' has been made and will be tested this fall. We have never seen fruit infection on Hawaii 7998 in the field, even with artificial inoculation. Thus, significant loss in fruit grade due to bacterial spot on fruit of lines with resistance from Hawaii 7998 is not anticipated. Reduced bacterial populations on resistant foliage (1) may decrease the chances of fruit infection.

Fusarium wilt race 3 resistance. This breeding work started with Australian sources which are considered to be tolerance to this disease because their level of resistance can sometimes be overcome. Often plants with these sources of tolerance are killed by standard seedling inoculation tests. In field inoculation tests, which more accurately depict grower conditions, severe disease symptoms sometimes occur on lines with this tolerance. Several new accessions with improved levels of resistance have been tested in both seedling and field inoculation experiments. The most resistant accessions were LA716 (*Lycopersicon penellii*), PI126449 and PI127826 (*L. hirsutum's*), and Chang 1 and PI129028 (*L. esculentum's*). Results have been hampered by lack of seed from crosses of some of the wild species. Thus far the most resistant line is LA716. This appears to be a true resistance which should definitely hold up under grower conditions. Tests are underway in cooperation with J. P. Jones to determine the genetics of this resistance. Preliminary indications are that perhaps only 1 gene is involved, but temperatures may affect expression of this gene. Further data are needed to verify these preliminary findings. Meanwhile, resistance from other sources is still being evaluated. The long term solution to Fusarium wilt race 3 will probably come from one of these sources. Breeding of resistance from LA716 has proceeded well and some early generation selections have pretty good horticultural characteristics. Advanced testing of lines with this resistance will probably not start until 1988.

LITERATURE CITED

1. McGuire, R. G., and Jones, J. B. 1985. Patterns of susceptibility among six tomato genotypes to infection by *Xanthomonas campestris* pv. *vesicatoria*. Phytopathology 75: (Abstr.).

Table 1. Incidence of bacterial spot on fruit of Hawaii 7998 and 'Walter' tomatoes.

Treatment[z]	Genotype	Infected fruit (%)[y]
Pollination	Hawaii 7998	10.8
	Walter	18.7*
Emasculation	Hawaii 7998	14.0
	Walter	26.2*

[z]Pollination = vibration of flowers
Emasculation = removal of anthers before anthesis with hand pollination at anthesis

[y]The * signifies genotype with significantly greater fruit spot (t test, 5% level) for that treatment.

ADVANCES IN WEED MANAGEMENT IN TOMATOES

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Among the many weed species which are pests in tomato production, nightshade has rapidly become a major problem in production fields in southwest Florida. This rapid spread is believed to be due to current herbicide practices, most notable of which is the use of herbicides, such as Devrinol, which do not control this weed. Growers have reported lack of nightshade control with Paraquat, Sencor/Lexone, and other labeled herbicides. Sencor and Paraquat have provided fair control in research when applied to nightshade seedlings in the 2 to 4 true leaf stage of development. Application of Paraquat to larger plants or those which have been hardened off by cold or other factors will not adequately control nightshade. Due to the close genetic relationship between tomato and nightshade, any herbicide which will control nightshade will usually injure tomato. Tomato production with polyethylene mulch may allow one to apply herbicides which would normally be injurious to tomato, provided the spray material is directed at the row middles and does not contact tomato plant foliage or roots. Generally, in mulched, seepage irrigated tomato production, plant roots are confined to the bed and are seldom found in the row middles. This allows us to consider use of otherwise injurious herbicides in row middles. Research conducted at the GCREC-Bradenton and the Immokalee AREC has emphasized selection of herbicides which have low water solubility and thus less potential for movement into the bed. The following is a report of some of this research.

Over the past 4 years a number of herbicides, both grass and broadleaf, have been evaluated for use in mulched and non-mulched tomato, both alone and in combination. The most promising of these herbicides have been extensively evaluated on the research station and in area growers' fields. This research is continuing in order to develop additional information and data to support registration of at least one new herbicide. Among the most promising are Fusilade for postemergence grass control, Cinch for preemergence grass control and partial control of some broadleaf weeds, and Goal for pre- and early postemergence control of grass and broadleaf weeds, most notably nightshade.

Research conducted in the fall of 1984 demonstrated that row middle applications of Devrinol, Lexone, Goal, Cinch, Paraquat or Fusilade 2000 (PP005), alone and in various combinations, had no effect on tomato plant vigor (Table 1). Acceptable early season grass control was obtained with all of these herbicides; however, the best control was obtained with Lexone + Paraquat, Goal + Paraquat, Lexone + Cinch + Paraquat, Lexone + Fusilade 2000 (PP005), or Goal + Cinch + Paraquat. Early season broadleaf weed control varied, depending upon species, with the best overall control provided by these same treatments. In this and other unrelated studies it was observed that a tank mix of Goal + Fusilade 2000 provided better and more rapid weed control than individual applications of these herbicides. Excellent season long control of the major weed species was obtained with tank mixes of Devrinol + Paraquat, Lexone + Cinch + Paraquat, Goal + Cinch + Paraquat, Lexone + Fusilade 2000 followed by a second application of Fusilade 2000 to control crabgrass, and two applications of a tank mix of Goal + Fusilade 2000 (rates of 0.125 lb. a.i./A or higher of Fusilade 2000) (Table 2). None of these herbicide combinations reduced yield when compared to Paraquat alone (Tables 3 and 4). The highest yield of 5 x 6 size tomatoes was obtained with Lexone + Fusilade 2000.

Additional work was conducted with the best of these herbicide combinations in the spring of 1985 with a major emphasis on control of nightshade in row middles. Again, no crop vigor reductions were observed with any of the treatments (Table 5). Control of most grass and broadleaf weeds was excellent, except with Devrinol + Paraquat, presumably due to photodegradation of Devrinol as a result of the absence of rainfall which is required to move it into the soil surface (Tables 5 and 6). Nightshade was not controlled with Devrinol + Paraquat, while early season control with Lexone or Paraquat was fair, provided application was made to plants in the 2 to 4 leaf stage of development (Table 5). Goal + Fusilade 2000 provided the best nightshade control and was effective against other weeds with rapid contact kill or "burn down" of emerged weeds. Good weed control was also provided by a combination of Goal + Cinch + Paraquat, Lexone + Cinch and Lexone + 0.25 lb. a.i./A Fusilade 2000. Goal + Fusilade 2000 (both rates), Lexone + Cinch and Goal + Cinch + Paraquat provided excellent season-long control of nightshade (Table 6). No yield differences existed among the treatments (Table 7 and 8).

Overall, Lexone consistently provides very effective broadleaf weed control, with the exception of nightshade. Deficiences in grass and nightshade control can be overcome with timely applications of Paraquat. Where grass weeds are the problem, Fusilade will provide excellent control of emerged grasses, while affording maximum crop safety in the event of spray drift. Tank mixes of Lexone + Cinch, Goal + Cinch + Paraquat and Goal + Fusilade show considerable promise for use in mulched tomatoes. By combining Lexone and Cinch, the poor grass control occassionally obtained with Lexone can be overcome and full season weed control is provided. Where nightshade is a problem, Goal has consistently provided good to excellent control. Safe application of spray preparations containing Goal requires use of a shielded sprayer or directed spray to prevent contact with tomato plant foliage which could result in considerable crop injury. In cases where nightshade is larger than the 4 leaf stage, a tank mix of Goal + Fusilade has consistently provided rapid, excellent post- and preemergence control of this and other weeds. More than one application of Goal may be required to provide acceptable season-long weed control. This may be considered an advantage as it indicates that residues of Goal have a relatively short life in our soils, which translates into less potential problems from herbicide residues for rotational or double cropped crops as is observed often with Sencor/Lexone.

This research is continuing with emphasis on collection of data to further evaluate these herbicides and to provide supportive documentation for registration of these promising new materials for weed control in row middles of mulched tomatoes. An IR-4 project has been initiated to provide data in support of registration of Goal in mulched tomato middles. Hopefully, within the next 2 years Goal will be labeled for this use. It is believed that Fusilade will also be labeled in the near future, while Cinch is in the early developmental stages and is not close to registration at this time.

Note: Mention of a specific product does not constitute an endorsement by the author or the University of Florida. Goal, Cinch and Fusilade 2000 are not labeled for use on tomatoes and growers are advised to not use these products until this research has been completed and the products are labeled.

Table 1. Effect of post transplant herbicide treatments on plant vigor and early season weed control in the row middles of fall transplanted 'Sunny' tomato grown on raised mulched beds. Bradenton, FL, September 21, 1984.

Treatment[z]	Rate (lb. a.i./A)	Vigor rating[y]	Weed control rating[x]		
			Crabgrass	Pigweed	Eclipta
Weedy check		9.5 b[w]	0.0 f	0.0 c	0.0 c
Paraquat	0.5	9.9 a	8.6 de	9.4 ab	9.1 ab
Devrinol + Paraquat	2.0 + 0.5	9.9 a	8.6 de	9.7 ab	9.6 a
Lexone + Paraquat	0.375 + 0.5	10.0 a	9.9 a	10.0 a	10.0 a
Goal + Paraquat	0.5 + 0.5	10.0 a	9.4 abc	10.0 a	9.8 a
Lexone + Cinch + Paraquat	0.375 + 0.6 + 0.5	10.0 a	10.0 a	10.0 a	10.0 a
Goal + Cinch + Paraquat	0.5 + 0.6 + 0.5	10.0 a	9.3 a-d	10.0 a	10.0 a
Lexone + Fusilade 2000	0.375 + 0.125	9.9 a	9.6 ab	9.8 ab	10.0 a
Lexone + Fusilade 2000	0.375 + 0.188	10.0 a	9.8 a	10.0 a	10.0 a
Lexone + Fusilade 2000	0.375 + 0.25	10.0 a	9.5 abc	9.9 a	10.0 a
Goal + Fusilade 2000	0.5 + 0.06	9.9 a	8.4 e	9.5 ab	9.1 ab
Goal + Fusilade 2000	0.5 + 0.125	9.9 a	8.9 b-e	8.9 b	7.3 b
Goal + Fusilade 2000	0.5 + 0.188	9.9 a	8.8 cde	9.0 b	7.9 ab
Goal + Fusilade 2000	0.5 + 0.25	9.9 a	8.9 b-e	9.0 b	8.1 ab
Fusilade 2000	0.25	10.0 a	8.6 de	0.0 c	0.0 c

[z]Application of Paraquat included X-77 at 0.25% v/v, while applications of Fusilade 2000 included Agridex crop oil concentrate at 1% v/v.

[y]Vigor was evaluated on a 0 to 10 scale where 0 = all plants dead and 10 = no injury.

[x]Weed control was evaluated on a 0 to 10 scale where 0 = no control and 10 = 100% control.

[w]Duncan's multiple range test, 5% level.

Table 2. Effect of post transplant herbicide treatments on late season weed control in the row middles of fall transplanted 'Sunny' tomato grown on raised mulched beds. Bradenton, FL, November 23, 1984.

Treatment[z]	Rate (lb. a.i./A)	No. of applications	Weed control rating[y] Crabgrass	Pigweed	Eclipta
Weedy check	-	-	0.0 f[x]	0.0 d	0.0 c
Paraquat	0.5	2	8.0 bcd	8.4 c	8.8 ab
Devrinol + Paraquat	2.0 + 0.5	1 + 2	8.8 a-d	9.0 abc	9.4 a
Lexone + Paraquat	0.375 + 0.5	1 + 1	7.8 d	8.6 bc	9.0 ab
Goal + Paraquat	0.5 + 0.5	1 + 1	7.9 cd	8.9 abc	8.8 ab
Lexone + Cinch + Paraquat	0.375 + 0.6 + 0.5	1 + 1 + 1	9.5 a	9.5 ab	9.6 a
Goal + Cinch + Paraquat	0.5 + 0.6 + 0.5	1 + 1 + 1	9.2 a	9.6 a	9.4 a
Lexone + Fusilade 2000	0.375 + 0.125	1 + 2	8.9 a-d	8.9 abc	9.5 a
Lexone + Fusilade 2000	0.375 + 0.188	1 + 2	9.5 a	8.4 c	9.4 a
Lexone + Fusilade 2000	0.375 + 0.25	1 + 2	9.4 a	8.9 abc	9.6 a
Goal + Fusilade 2000	0.5 + 0.06	2 + 2	6.5 e	9.2 abc	8.2 b
Goal + Fusilade 2000	0.5 + 0.125	2 + 2	9.0 abc	9.1 abc	8.7 ab
Goal + Fusilade 2000	0.5 + 0.188	2 + 2	9.1 ab	9.5 ab	8.8 ab
Goal + Fusilade 2000	0.5 + 0.25	2 + 2	8.8 a-d	9.0 abc	8.9 ab
Fusilade 2000	0.25	2	8.4 a-d	0.0 d	0.0 c

[z]Application of Paraquat included X-77 at 0.25% v/v, while applications of Fusilade 2000 included Agridex crop oil concentrate at 1% v/v.

[y]Weed control was evaluated on a 0 to 10 scale where 0 = no control and 10 = 100% control.

[x]Duncan's multiple range test, 5% level.

Table 3. Effect of post transplant herbicide treatments on total seasonal yield when applied to row middles of fall transplanted 'Sunny' tomato grown on raised mulched beds. Bradenton, FL. November 1984.

Treatment[z]	Rate (lb. a.i./A)	No. of applications	No. of fruit/size grade/plot 7 x 7	7 x 6	6 x 6	5 x 6	Culls	Total
Weedy check	-	-	75 a[y]	215 ab	157 ab	49 b	86 a	576 a
Paraquat	0.5	2	74 a	253 ab	167 ab	55 b	89 a	649 a
Devrinol + Paraquat	2.0 + 0.5	1 + 2	94 a	286 a	165 ab	77 ab	100 a	707 a
Lexone + Paraquat	0.375 + 0.5	1 + 1	90 a	250 ab	171 ab	56 b	111 a	675 a
Goal + Paraquat	0.5 + 0.5	1 + 1	86 a	250 ab	152 ab	56 b	111 a	650 a
Lexone + Cinch + Paraquat	0.375 + 0.6 + 0.5	1 + 1 + 1	72 a	244 ab	174 ab	86 ab	86 a	662 a
Goal + Cinch + Paraquat	0.5 + 0.6 + 0.5	1 + 1 + 1	72 a	189 b	140 b	64 ab	103 a	564 a
Lexone + Fusilade 2000	0.375 + 0.125	1 + 2	79 a	211 ab	176 ab	67 ab	91 a	623 a
Lexone + Fusilade 2000	0.375 + 0.188	1 + 2	79 a	230 ab	166 ab	71 ab	98 a	643 a
Lexone + Fusilade 2000	0.375 + 0.25	1 + 2	68 a	234 ab	192 a	105 a	74 a	647 a
Goal + Fusilade 2000	0.5 + 0.06	2 + 2	75 a	228 ab	184 ab	65 ab	95 a	642 a
Goal + Fusilade 2000	0.5 + 0.125	2 + 2	105 a	221 ab	143 ab	46 b	114 a	637 a
Goal + Fusilade 2000	0.5 + 0.188	2 + 2	79 a	232 ab	147 ab	67 ab	95 a	635 a
Goal + Fusilade 2000	0.5 + 0.25	2 + 2	103 a	236 ab	158 ab	64 ab	117 a	717 a
Fusilade 2000	0.25	2	92 a	240 ab	160 ab	62 ab	92 a	625 a

[z] Application of Paraquat included X-77 at 0.25% v/v, while applications of Fusilade 2000 included Agridex crop oil concentrate at 1% v/v.

[y] Duncan's multiple range test, 5% level.

Table 4. Effect of post transplant herbicide treatments on total seasonal yield when applied to row middles of fall transplanted 'Sunny' tomato grown on raised mulched beds. Bradenton, FL. November 1984.

Treatment[z]	Rate (lb. a.i./A)	No. of applications	Fruit weight/size grade/plot (lbs.) 7 x 7	7 x 6	6 x 6	5 x 6	Culls	Total
Weedy check	-	-	15.6 a[y]	53.0 ab	47.8 ab	23.3 b	18.3 ab	157.6 b
Paraquat	0.5	2	15.0 a	62.9 ab	48.8 ab	26.2 b	20.2 ab	178.8 ab
Devrinol + Paraquat	2.0 + 0.5	1 + 2	19.1 a	69.3 a	53.6 ab	35.9 ab	24.6 ab	206.4 a
Lexone + Paraquat	0.375 + 0.5	1 + 1	17.9 a	62.1 ab	56.6 ab	25.6 b	23.3 ab	186.4 ab
Goal + Paraquat	0.5 + 0.5	1 + 1	17.8 a	62.6 ab	48.2 ab	31.4 ab	22.8 ab	178.8 ab
Lexone + Cinch + Paraquat	0.375 + 0.6 + 0.5	1 + 1 + 1	14.5 a	57.9 ab	54.9 ab	39.4 ab	19.7 ab	190.0 ab
Goal + Cinch + Paraquat	0.5 + 0.6 + 0.5	1 + 1 + 1	14.4 a	46.5 b	46.4 ab	29.8 ab	23.2 ab	161.0 b
Lexone + Fusilade 2000	0.375 + 0.125	1 + 2	15.8 a	53.0 ab	53.4 ab	31.6 ab	21.8 ab	181.1 ab
Lexone + Fusilade 2000	0.375 + 0.188	1 + 2	15.6 a	56.2 ab	53.9 ab	33.4 ab	20.4 ab	181.0 ab
Lexone + Fusilade 2000	0.375 + 0.25	1 + 2	13.6 a	57.0 ab	61.7 a	50.1 a	16.4 b	199.0 ab
Goal + Fusilade 2000	0.5 + 0.06	2 + 2	15.6 a	55.0 ab	59.0 ab	31.8 ab	20.0 ab	181.8 ab
Goal + Fusilade 2000	0.5 + 0.125	2 + 2	21.1 a	52.3 ab	47.6 ab	21.2 b	22.0 ab	167.1 ab
Goal + Fusilade 2000	0.5 + 0.188	2 + 2	16.1 a	57.3 ab	48.0 ab	31.1 ab	19.3 ab	172.9 ab
Goal + Fusilade 2000	0.5 + 0.25	2 + 2	20.4 a	57.8 ab	45.3 b	30.2 ab	25.4 a	186.8 ab
Fusilade 2000	0.25	2	18.6 a	57.2 ab	52.4 ab	28.2 b	20.0 ab	179.2 ab

[z]Application of Paraquat included X-77 at 0.25% v/v, while applications of Fusilade 2000 included Agridex crop oil concentrate at 1% v/v.

[y]Duncan's multiple range test, 5% level.

Table 5. Effect of postemergence herbicide treatments on tomato plant vigor and early season weed control when applied to row middles of polyethylene mulched, spring transplanted, 'Hayslip' tomatoes. Bradenton, FL. April 29, 1985.

Treatment	Rate (lb. a.i./A)	Vigor rating[z]	Weed control rating[y]		
			Crabgrass + goosegrass	Nightshade	Smooth pigweed
Weedy check	-	10.0 a[x]	0.0 c	0.0 e	0.0 d
Paraquat	0.50	9.8 a	9.9 a	6.8 cd	9.9 ab
Devrinol + Paraquat	2.0 + 0.50	9.9 a	9.4 ab	1.0 e	9.4 c
Lexone + Paraquat	0.375 + 0.50	10.0 a	9.8 a	7.2 bcd	9.6 abc
Goal + Fusilade 2000	0.50 + 0.125	10.0 a	10.0 a	10.0 a	10.0 a
Goal + Fusilade 2000	0.50 + 0.25	10.0 a	10.0 a	9.6 a	9.9 ab
Lexone + Fusilade 2000	0.375 + 0.188	10.0 a	8.8 b	6.0 d	9.4 bc
Lexone + Fusilade 2000	0.375 + 0.25	9.3 b	9.4 ab	8.4 abc	9.8 abc
Lexone + Cinch	0.375 + 0.60	9.8 a	10.0 a	8.2 abc	10.0 a
Goal + Cinch + Paraquat	0.50 + 0.60 + 0.50	10.0 a	9.8 a	9.0 ab	9.5 abc

[z]Vigor was evaluated using a pretransformed 0 to 10 rating scale where 0 indicates all plants were dead and 10 represents no injury to the plants and optimum growth.

[y]Weed control was evaluated using a pretransformed 0 to 10 rating scale where 0 indicates no control of weeds and 10 represents 100% control.

[x]Duncan's multiple range test, 5% level.

Table 6. Effect of postemergence herbicide treatments on late season weed control when applied to row middles of polyethylene mulched, spring transplanted, 'Hayslip' tomatoes. Bradenton, FL. June 15, 1985.

Treatment	Rate (lb. a.i./A)	Weed control rating[z]		
		Crabgrass + goosegrass	Nightshade	Smooth pigweed
Weedy check	-	0.0 e[y]	0.0 d	0.0 c
Paraquat	0.50	9.0 abc	7.0 b	7.4 ab
Devrinol + Paraquat	2.0 + 0.50	8.5 cd	3.5 c	7.4 ab
Lexone + Paraquat	0.375 + 0.50	7.9 d	6.5 b	7.0 b
Goal + Fusilade 2000	0.50 + 0.125	9.6 ab	10.0 a	7.4 ab
Goal + Fusilade 2000	0.50 + 0.25	9.9 a	10.0 a	7.9 ab
Lexone + Fusilade 2000	0.375 + 0.188	9.4 abc	7.6 b	7.8 ab
Lexone + Fusilade 2000	0.375 + 0.25	8.9 bc	7.4 b	7.1 b
Lexone + Cinch	0.375 + 0.60	9.8 ab	9.4 a	8.8 a
Goal + Cinch + Paraquat	0.50 + 0.60 + 0.50	9.5 abc	10.0 a	7.1 b

[z]Weed control was evaluated using a pretransformed 0 to 10 rating scale where 0 indicates no control of weeds and 10 represents 100% control.

[y]Duncan's multiple range test, 5% level.

Table 7. Effect of postemergence herbicide treatments on seasonal yield when applied to row middles of polyethylene mulched, spring transplanted 'Hayslip' tomatoes. Bradenton, FL. Spring, 1985.

Treatment	Rate (lb. a.i./A)	Number of fruit/size grade/plot (lbs.) 5 x 6	6 x 6	6 x 7	7 x 7	Culls	Total
Weedy check	--	43 a[z]	122 a	133 a	41 a	48 a	393 a
Paraquat	0.50	46 a	96 a	105 a	37 a	41 a	323 a
Devrinol + Paraquat	2.0 + 0.50	65 a	123 a	134 a	38 a	43 a	400 a
Lexone + Paraquat	0.375 + 0.50	50 a	112 a	140 a	43 a	45 a	391 a
Goal + Fusilade 2000	0.50 + 0.125	35 a	96 a	119 a	34 a	45 a	328 a
Goal + Fusilade 2000	0.50 + 0.25	36 a	90 a	117 a	45 a	50 a	335 a
Lexone + Fusilade 2000	0.375 + 0.188	49 a	97 a	124 a	47 a	49 a	373 a
Lexone + Fusilade 2000	0.375 + 0.25	34 a	68 a	87 a	45 a	85 a	321 a
Lexone + Cinch	0.375 + 0.60	65 a	106 a	135 a	43 a	44 a	363 a
Goal + Cinch + Paraquat	0.50 + 0.60 + 0.50	44 a	99 a	104 a	55 a	74 a	373 a

[z]Duncan's multiple range test, 5% level.

Table 8. Effect of postemergence herbicide treatments on seasonal yield when applied to row middles of polyethylene mulched, spring transplanted, 'Hayslip' tomatoes. Bradenton, FL. Spring 1985.

Treatment	Rate (lb. a.i./A)	Fruit weight/size grade/plot (lbs.)					
		5 x 6	6 x 6	6 x 7	7 x 7	Culls	Total
Weedy check	-	19.9 a[z]	41.2 a	34.4 a	7.9 a	8.7 a	113.8 a
Paraquat	0.50	21.7 a	31.6 a	26.9 a	7.5 a	7.8 a	103.0 a
Devrinol + Paraquat	2.0 + 0.50	28.3 a	39.9 a	35.1 a	7.4 a	8.3 a	120.4 a
Lexone + Paraquat	0.375 + 0.50	22.9 a	38.1 a	36.3 a	8.6 a	7.9 a	115.3 a
Goal + Fusilade 2000	0.50 + 0.125	16.0 a	32.1 a	30.5 a	6.7 a	7.4 a	93.8 a
Goal + Fusilade 2000	0.50 + 0.25	16.3 a	30.4 a	29.9 a	9.0 a	8.6 a	94.6 a
Lexone + Fusilade 2000	0.375 + 0.188	22.0 a	32.1 a	31.8 a	9.9 a	9.0 a	105.8 a
Lexone + Fusilade 2000	0.375 + 0.25	15.5 a	23.2 a	22.4 a	8.8 a	12.7 a	83.4 a
Lexone + Cinch	0.375 + 0.60	28.8 a	34.9 a	33.4 a	8.8 a	7.9 a	115.3 a
Goal + Cinch + Paraquat	0.50 + 0.60 + 0.50	19.0 a	32.1 a	26.9 a	10.9 a	26.9 a	102.2 a

[z]Duncan's multiple range test, 5% level.

AVOIDING PEST CONTROL ENTROPY: A REVIEW OF SOUND INTEGRATED PEST MANAGEMENT PRINCIPLES FOR FLORIDA TOMATOES

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When the first stages of the pilot integrated pest management (IPM) program on tomatoes was implemented 9 years ago in Homestead, the industry was experiencing a severe outbreak of leafminers (LM)(*Liriomyza* spp.) (12). Although there were a number of reasons for initiating the pilot tomato IPM effort, the "crisis" in LM control was indeed a very strong motivating force.

It is well-known and generally accepted that the LM problems of the late 1970's were related in part to intensive use of insecticides on the tomato crop. These insecticides were applied to prevent economic losses from primary insect pests (those attacking the fruit directly), such as tomato pinworm and tomato fruitworm, and to suppress populations of leaf feeders, especially LM. However, as has happened all too often in a number of intensively-managed crops with strong emphasis on one-dimensional strategies, LM eventually reached unmanageable levels. This unfortunate circumstance was related to familiar phenomena: pesticide resistance and LM resurgence due to parasite mortality.

The IPM working group sought to enhance the control of LM using multiple strategies: intensive twice-weekly scouting, application of insecticides at action thresholds only, and use of insecticides for caterpillar pests with less negative impact on LM parasites (and other beneficials).

While LM may have been the center of attention at the time of the program inception, diseases, nematodes, and other insects were essential components of the IPM effort.

In addition to parasite conservation for LM management, IPM principles offered growers the opportunity to save money, achieve overall better pest control through increased information flow from the field, and, at least in theory, provide the basis for increased longevity of pesticides against particular target pests.

By about 1980, new insecticides became available with good activity against LM. Some of these materials were broad-spectrum, providing excellent control of several primary lepidopterous pests. Therefore, we should not be surprised to see some IPM implementation "entropy", using the terminology of Whalon and Croft (13) to describe periods of relaxation of good IPM principles once a particular crisis in a crop has past. Entropy is a term borrowed from chemistry, which describes the tendency of systems to go from a state of order to a state of disorder. With the arrival of the new LM insecticides, many of us do not want to see the ordered application of multitactic IPM principles revert to a less structured, one-dimensional dependence. Therefore, this seems to be an appropriate spot in the time frame of tomato IPM implementation in Florida to review the IPM recommendations made by the extension service, with emphasis on updates brought about by recent research.

Scouting. Certainly the most important and conspicuous feature of the tomato IPM program has been the introduction of systematic, twice-weekly scouting. The information gathered in the field is then used by farmers in making management decisions. The increasingly widespread use of scouting has been aided immeasurably by the enterprenuerial efforts of several private pest management advisory companies.

While considerable work has been done with the goal of economizing the program, sampling intensity (i.e., the number of samples/acre) and the sampling methods remain similar to initial recommendations. Several noteworthy modifications include substitution of live larval counts for total LM mines (7), and eggs for larvae after fruiting in assessment of caterpillars (11). It is also suggested that scouts examine the lower canopy for tomato pinworm, rather than the upper canopy as previously described (8). Action thresholds for tomato pinworm have been established as 0.67 larvae per plant or 0.83 larval foliar injuries per plant (6). A visual rating system that could save considerable time in assessing LM populations (especially at higher densities) could prove economically appealing to scouts (10).

Programs have been offered at various times to make both commercial scouts and county agents more familiar with using the microscope as an additional tool in the diagnosis of pest problems, especially diseases. Several problems can be easily confirmed with the aid of a microscope and can be done "on the spot", cutting down the turn-around time that is associated with sending samples to a central facility.

Choice of insecticides compatible with IPM principles. Recommendations for insecticide treatments evolved during the last years, based on product efficacy and availability at the time. In the late 1970's, LM was resistant to virtually all registered materials, including dimethoate, monocrotophos, parathion, and others. Therefore, out of necessity, applications of insecticides for caterpillars and other target pests were used which had less disruptive effects on the insect natural enemies of LM - often quite effectively. These options, still valuable today, include endosulfan and tank mixes of reduced rates of methomyl and Bacillus thuringiensis.

Permethrin was the first of a new class of compounds, the synthetic pyrethroids, which arrived on the scene about 1980. These compounds had a different metabolic mode of action. We saw very good control of caterpillar pests with the synthetic pyrethroids, and, at least for a time, fairly good control of LM. However, we admittedly had a more difficult time incorporating the synthetic pyrethroids into our IPM program, because we did not have a good adult LM sampling technique and no comfortable, empirical action threshold based on adults.

Resistance probably has now developed to one or more of the synthetic pyrethroids, and cross resistance, known to occur in this class of insecticides (5), is likely to result in short lifetimes for "second and third generation" pyrethroids.

Methamidophos, which is primarily a larvicide, has proven useful for LM management when applied on demand (i.e., at the action threshold of 0.7 live larvae per "trifoliate"), compared to scheduled-interval sprays. Proper timing is critical to the use of methamidophos and can best be acommplished by having fields scouted according to extension service recommendations.

New leafminer insecticides and insecticide longevity. Several insecticides with unique modes of action may soon be available for Florida tomato growers. Insect growth regulator (IGR) compounds, notably cyromazine, should fit in well with ongoing IPM programs. Cyromazine is fairly specific for LM, with minimal toxicity to beneficials. Since it is primarily a larvacide, it readily can be used with current LM population assessment methods. Avermectin is another IGR that has shown promise for LM control in research plots. The latter insecticide also has a fairly wide spectrum of activity for many of the common tomato pests.

The opinion has been expressed that resistance to IGR's will not readily develop in LM. However, some of us feel resistance may very well develop over a period of time of exposure in the field. The new IGR's should best meet the needs of the industry for the longest time if used only when needed - only at the recommended action threshold.

Foliar disease management. Foliar diseases require periodic preventative applications of fungicide (bactericide). Recent work (2) has shown that maneb and copper is one of the better bactericides available to growers. We again caution growers to be aware of possible sporadic outbreaks of fungal diseases, if there is heavy dependence on copper/maneb sprays. Cases have been reported of outbreaks of late blight (1) and target spot (3) linked to copper/maneb spray schedules applied for foliar bacterial diseases. This problem may be lessened, if fields are regularly scouted by well-qualified personnel who may be able to help the producer diffentiate between specific foliar diseases. Very fundamental microscopic techniques enhance the correct identification of these problems.

Several materials on the market, notably metalaxyl, are now registered for use on tomato and provide excellent control of a limited number of target fungi. However, resistance can develop to "site-specific" fungicides, such as metalaxyl. Manufacturers have shown their concern for this problem by labeling metalaxyl in combination with a broad-spectrum protectant fungicide to be applied at judicious intervals. Metalaxyl gives excellent control of Phytophthora and related fungi, but resistant fungus biotypes can occur (9), accompanied by high degrees of cross-resistance to other compounds.

We might expect that use of site-specific fungicides could be enhanced, if we could accurately predict specific diseases. Our attempts to predict the first occurrence of tomato late blight (caused by Phytophthora infestans) with

BLITECAST (4), a weather-based prediction system used in many parts of the country, have not proven very useful in south Florida. BLITECAST usually predicted the first outbreaks of late blight too early in the Homestead winter vegetable season to be of pragmatic value to local farmers (Table 1). It is likely that the failure in Homestead of the BLITECAST system is related to lack of inoculum at the times that weather conditions are favorable for blight development, or to fundamental differences in weather patterns over time, making it difficult to predict future weather on the basis of real-time weather measurements.

Conclusions. Chemists insist that in a system left unattended, entropy increase is natural and inevitable - things proceed inexorably downhill from order to disorder. Only directed expenditures of energy can reverse the tide. There is little doubt in my mind that history will repeat itself, if LM control, or any other component of the tomato cropping system, is allowed to be become a one-dimensional enterprise. The use of intensive scouting, action thresholds, less broad-spectrum insecticides, proper disease identification, and other sound IPM principles can delay the onset of "crisis" situations and provide a firm basis for dealing with those that may some day occur.

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Table 1. Blitecast prediction dates, and dates on which tomato late blight was first obeserved, Dade County, FL.

Vegetable season	Predicted date	Date late blight first observed
1976-77	17 Oct.	26 Dec.
1977-78	3 Nov.	20 Dec.
1980-81	8 Nov.[a]	No disease observed
1981-82	16 Nov.[a]	No disease observed
1982-83	8 Dec.[a]	No disease observed

[a]Includes observations in a tomato "disease nursery" at the Homestead Tropcial Research and Education Center to which no fungicides were applied.

THE ENIGMA ASSOCIATED WITH TANK MIXES

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Tank mixes refer to the use of more than one chemical besides water in a spray that is to be mixed and delivered to a target. Tank mixes facilitate farming operations by providing a mechanism whereby multiple pests can be controlled simultaneously and spray equipment and personnel are used judiciously. As a result, timely mitigation of multiple pest and nutritional problems can be achieved, variable costs are reduced and human exposure to pesticides is minimized. Further, certain tank mixes are necessary to maximize control of some pests. For example on peppers and tomatoes, the addition of a maneb or mancozeb fungicide to a copper spray is required for improved control of those strains of the bacterial spot organism that are resistant to low amounts of soluble copper. Also, the efficacy of a chemical can be enhanced in some instances by the addition of a select adjuvant such as a wetting and sticking agent. Benefits from tank mixes are sometimes offset by undesirable effects such as nozzle plugging, precipitation of the tank mix in spray equipment, reduced efficacy of components within the tank mix, and damage to the spray target.

In the production of tomatoes in Florida, tank mixing of fungicides, insecticides, foliar nutrients, and adjuvants is the rule rather than the exception. Usually the final spray mix is effective and does not burn the leaves or the fruit. The composition of tank mixes varies from farm to farm and on a temporal basis. Because research on tank mixes is limited, the successful use of a tank mix by a grower is based on experience and trial and error. Research associated with the development of agricultural chemicals is primarily conducted on efficacy and factors related to environmental safety. Only a limited amount of information is available on tank mixing a compound prior to its release and such should appear on the label. This is understandable as the number of treatment combinations with just 14 different compounds is 16,384 if all compounds are tested in the presence and absence of all other compounds at one rate. If such a test were conducted using two rates of each compound in the presence and absence of all other compounds, 4,782,969 treatments are possible. These enormous number of treatment combinations are further confounded by numerous weather situations and the condition of the crop at the time of spray applications.

Formulations of chemicals that are included within sprays include soluble salts (primarily fertilizers), chelated fertilizers, various types of granules, powders (wettable, soluble, etc), and liquids (emulsifiable concentrates, flowables, adjuvants, etc). When tank mixing, the grower not only combines different active ingredients, but he also combines the various carriers and adjuvants ("inert ingredients") that are part of the pesticide. Carrier and adjuvant ingredients can cause or be associated with phytotoxic reactions. Xylene and other organic solvents are part of the emulsifiable concentrate formulations. Such solvents can alter the integrity of the plant cuticle and related waxes (plant skin) which protect the plant from adverse environmental factors. Further, some spray adjuvants apparently function by altering the cuticle and waxes in such a way as to allow transport of pesticides and foliar nutrients into the softer inner tissues of the leaves, stem and fruit.

These additional ingredients are determined by the manufacturer to be beneficial for reasons related to shipment, storage, spray mixing, spray delivery to the target, spray deposition, spray tenacity on the target, safety, etc. If the active ingredient, by itself, could be used exclusively, many of the manufacturer's logistical and economic problems could be avoided and a large number of tank mixing problems would also be avoided. However, other tank mixing problems would appear as some of those additives within the pesticide formulations act as safening agents. Therefore, it is incumbent on all those associated with pesticides to realize that chemical spray tank mixes are and will continue to be an enigmatic topic.

Some General Guidelines On Tank Mixing For Growers:

1. Tank mix only the necessary rates of those chemicals that are needed at that time. Tank mixing for status among your friends or for the purpose of developing an all-purpose spray mix is rarely to your advantage.

2. Possible sources of information on tank mixes include product labels, commercial company representatives, county extension agents, extension specialists, university researchers, other growers, experienced consultants, and your experience. If you decide that available information on a given tank mix is inadequate, it would be to your advantage to conduct a test.

3. When you decide to add or substitute a new chemical to your spray mix, test the new tank mix on a small portion of the crop that will eventually receive the spray about a week before you intend to use it on a large scale. That will allow you some time to evaluate the results. Admittedly, the sudden appearance of a pest problem may require immediate action but in such a situation, consider deleting all those chemicals from the spray mix that are not necessary at that time.

4. Chemical types that seem to be associated frequently with chemical burn on foliage or fruit include emulsifiable concentrate pesticides, paraffin or oil based adjuvants (including crop oils) and non-chelated formulations of fertilizers.

5. Tender plants, such as those recently transplanted, emerged or grown under cloudy overcast conditions, are more apt to incur chemical burns.

6. Plants that have sustained mechanical damage from sand blasting or wind driven rains or other forces are more likely to incur chemical burns because the outer protective tissues on the plant have been disrupted.

7. Tank mixing epsom salts or other magnesium products in a spray for nutritional purposes can be counter productive to the copper-maneb spray mix used for bacterial spot control. Magnesium is an essential growth factor for bacteria and any excess of this element means the copper-maneb spray mix must contend with a higher population of bacteria.

8. While the maneb increases the solubility of the copper, thus improving bacterial spot control, some research shows that copper reduces the effectiveness of the maneb or mancozeb for control of fungus diseases such as late blight and grey leaf spot. However, this phenomenon does not occur according to other research. This enigma is partially rectified by the availability of Ridomil products for late blight and the availability of resistant varieties for grey leaf spot. Also, because late blight is a cool weather disease and bacterial spot is a warm-hot weather disease, the grower can reduce or alternate the use of copper sprays during cool weather to maximize control of late blight with those fungicides other than Ridomil.

9. The use of Dyrene with copper fungicides particularly during hot weather can result in phytotoxicity to tomatoes.

10. Reduced effectiveness of pesticides with use of hard or high pH water is often discussed. Certainly Benlate and probably many other pesticides have reduced effectiveness when used with high pH water. However, until we find another source of water, not much can be done about this situation. A point to consider is whether the high pH water reduces the efficacy of the pesticides as much as some may think it does. Also, why do different crop fields, sometimes adjacent to each other, differ so greatly in pest control? Remember, numerous other factors such as spray timing, use of the correct material, cultural practices, varietal susceptibility, time of planting, weather, and soil type can drastically alter pest populations and nutrient problems. Maybe, the enigma is ours and not necessarily associated with tank mixes.

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FROST PROTECTION FOR FLORIDA TOMATOES WITH OVERHEAD IRRIGATION OR ROW COVERS

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Properly designed portable pipe overhead irrigation systems saved over 2,220 acres of tomatoes during the last freeze (January 21-22) in Dade County. Temperatures were below freezing (32 degrees F) in some areas for as long as 10 hours. Minimum temperatures ranged from 26 to 29 degrees F across the agricultural area for 6 hours.

Considerable interest in frost protection techniques have surfaced recently because of the severe back to back freezes Florida growers have experienced. Many research projects using sprinkler irrigation for cold protection have been conducted in Florida (2, 5, 8). Specific guidelines have been developed by IFAS/University of Florida which will allow growers to implement this technique in their fields (1). Using row covers to protect vegetables from adverse weather is becoming a common practice in more northern agricultural areas of the United States (4, 7, 9, 10). Only recently has substantial work begun by IFAS to determine the value of row covers for the Florida vegetable industry.

This report will discuss in detail the sprinkler irrigation techniques needed for cold protection and will review the available information on row covers with a view towards their potential value for cold protection in Florida tomato fields.

BEFORE COLD WEATHER ARRIVES

Fields that are irrigated well in advance of cold weather, with healthy unstressed plants, always fair better in a freeze compared to stressed plants in dry land. Even if a farmer does not have the right equipment for freeze protection he can provide from 1-2 degrees protection by keeping his fields in the right condition prior to a freeze.

Soil absorbs heat during the day and radiates heat at night. This radiational heat will not be helpful in a windy freeze but in a freeze with low wind speeds or calm conditions radiational heat can be trapped in the crop's plant canopy and provide some protection. To take advantage of radiational heat, keep the row middles as weed free as possible with cultivation or herbicides. Weeds or ground cover prevent radiational heat from moving into the crop canopy.

In anticipation of cold weather, stop all cultivation and begin irrigating. The water application (by seep, drip or overhead irrigation) should precede the freeze by several sunny days to get the maximum heat storage in the soil (6). Be careful not to overdo it and cause water-logging especially if you plan to operate your irrigation during the freeze. Increasing soil moisture increases the soils capacity to conduct and store heat. Thus the soil will absorb more heat during the day for subsequent release at night. A clean, compact, moist soil is best to take advantage of radiational heat.

PRINCIPLES OF COLD PROTECTION WITH SPRINKLER IRRIGATION

Sprinkler irrigation provides cold protection by maintaining the environment around the plant at or near 32 degrees F. eventhough the surrounding air temperature may be colder (1). When the air temperature becomes cold enough and the irrigation water begins to freeze, heat is liberated (latent heat of fusion) as the water changes from liquid to ice. As long as there is a mixture of water and ice present, the temperature will remain near 32 degrees. Since vegetable plants require slightly colder temperatures before they will freeze (Table 1) they are protected from freeze damage.

For the plant to be adequately protected, enough water must be applied to maintain the freezing ice-water mixture and the distribution of the water application must be sufficiently uniform to thoroughly wet and coat all parts of the plant. If an insufficient amount of water is applied or the distribution of the water is inadequate, then the plant damage will be more severe than if sprinkler irrigation had not been used. In the absence of sufficient heat created by the proper ice-water mixture, a wet leaf can be as much as 4 degrees colder than a dry leaf due primerily to the affects of evaporative cooling. Thus the importance of proper design and operation of the sprinkler system for cold protection cannot be overemphasized.

DESIGN CRITERIA FOR COLD PROTECTION WITH OVERHEAD IRRIGATION

1. Use an accurate sheltered thermometer positioned at the same height as the plant.

2. Start the system when the temperature reaches 32-34 degrees F. and do not shut the system off until the wet bulb temperature is above freezing and ice is melting from the crop.

3. Use irrigation rates suggested in Table 2 for the lowest temperature you can expect in your area with wind speeds of 5-8 M.P.H.

4. Risers should be spaced at 50-60 percent of their effective diameter of water coverage for proper uniformity of application.

5. Nozzles should rotate at 1 revolution per minute.

6. If wind speeds are greater than 8-10 M.P.H. don't turn the system on or damage is likely to be more severe than it would have been without the water application.

Table 1. Freezing points of selected vegetable plants.[z]

Variety	Range in freezing pts.	Highest freezing pt.
Beans, snap	29.8 to 30.7 F	30.7 F
Cabbage, J. W.	29.8 to 30.4 F	30.4 F
Eggplant, B. B.	30.2 to 30.6 F	30.6 F
Lettuce, iceburg	30.8 to 31.3 F	31.3 F
Okra	28.3 to 28.7 F	28.7 F
Tomato, Homestead	29.9 to 30.5 F	30.5 F
Squash, yel. cr.	30.1 to 30.8 F	30.8 F

[z]Adapted from: U.S. Marketing Research Report No. 196, USDA, ARS-MRD.

Table 2. Application rate recommended for cold protection under different wind and temperature conditions.[z]

Minimum temperature expected	Wind speed in M.P.H. 0 to 1	2 to 4	5 to 8
	Application rate (inches/hour)		
27 F	0.10	0.10	0.10
26 F	0.10	0.10	0.14
24 F	0.10	0.16	0.30
22 F	0.12	0.24	0.50
20 F	0.16	0.30	0.60
18 F	0.20	0.40	0.70
15 F	0.26	0.50	0.90

[z]Ext. circular 287, Florida Agricultural Extension Service, by Gerber and Martsolf.

SPECIAL CONSIDERATIONS WITH OVERHEAD IRRIGATION

1. Be sure you have an adequate water supply and good field drainage. Considerable water may need to be applied for as much as 10 hours or more.

2. Use a diesel or gasoline powered pump. Avoid electric pumps since rural areas are usually the first to be blacked out when electrical use reaches a critical level.

3. There is no need to protect tomato fields with plants in the full flowering stage. Most of the flowers will be lost and you will end up with a beautiful field with little fruit production. Other stages of tomato plant development can be effectively protected.

ROW COVERS FOR PLANT PROTECTION

Traditionally row covers have been used to protect tender young vegetable plants from wind and cold in the early spring. This has resulted in earliness and increased yields for many vegetable crops. This early spring plant protection continues to be the main use of row covers, however, cold protection in the fall season is also possible (3). It should be emphasized that row covers will only provide protection in a light frost or freeze.

There are two main types of row cover materials: polyethylene (poly) and non-woven polyester or polypropylene. Poly covers are installed over the row, supported by wire hoops, Non-woven covers can be laid directly on the plants (floating row covers). Poly covers may be vented or unvented. If they are not vented with slits or perforations, they require manual opening on warm sunny days. Excessive temperatures up to 120 degrees F can develop under covers on sunny days. This could significantly reduce pollination and fruit set in tomatoes and thus should be monitored carefully. The non-woven covers are self-ventilating and porous to irrigation water and rainfall.

Slitted row covers have been reported to provide 1-2 degrees F. protection while the non-woven covers can give up to 7 degrees protection (3). However, some research indicates that using slitted row covers in combination with plastic mulch negates the frost protection benefit, at least as far as air temperatures are concerned (9). Preliminary data from the University of Florida (Table 3) shows that at the coldest point recorded (6:47 AM) air temperatures were the same under the clear slitted tunnel and in the control (no row cover). However, soil temperatures were higher under the tunnel. Future research should contain information on leaf temperatures to determine exactly where the plant fits into these varying environmental changes.

Tomato growers contemplating the use of row covers for frost and freeze protection should be cautious. Further research is needed to determine their effectiveness under Florida conditions and to establish guidelines for their use. Row covers may find a place in the Florida vegetable industry based on their overall growth enhancing characteristics rather than their frost protection potential. Growers seeking further information on row covers should obtain a copy of the bulletin entitled "Row Covers for Commercial Vegetable Culture in Florida" by G. J. Houchmuth (currently in print) IFAS/Fla. Cooperative Extension Ser.

Table 3. Soil and air temperatures for tomatoes grown on black plastic mulch with and without row covers. March 17, 1985. Gainesville, Florida.[z]

Time (AM)	Clear slitted tunnel		Floating row cover		No row cover	
	Temperature in degrees F.					
	Air	Soil	Air	Soil	Air	Soil
12:47	49.0	70.0	50.5	74.0	48.0	67.0
1:47	47.5	68.0	49.5	72.0	47.0	65.0
2:47	46.5	67.0	47.5	70.5	46.0	62.0
3:47	46.5	66.0	47.5	68.5	45.0	61.0
4:47	45.5	64.0	47.0	68.0	45.0	61.0
5:47	44.5	63.0	46.5	65.5	44.0	59.0
6:47	44.0	61.0	46.5	64.5	44.0	58.0
7:47	56.5	56.0	61.0	58.0	53.5	54.0
8:47	73.5	61.0	72.5	58.5	67.0	58.0

[z]Preliminary data: S. R. Kostowicz

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MANAGEMENT OF SECOND CROPS FOLLOWING TOMATOES

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The utilization of residual salts in tomato lands by a second or catch crop is desirable for economic and environmental reasons. Irrigation furrows and equipment and plastic mulched beds are already in place for the second crop. The high amounts of salts usually remaining in the soil after the tomato harvest should require relatively small amounts of additional fertilizers to provide nutrients for the second crop. Growing a catch crop after tomatoes would reduce the chance of salt accumulation. It would also reduce the chance of pollution in adjacent lands by salts in the runoff water when residual salts are leached out by rain.

There are a number of steps to be taken to establish a second crop:

1) Soil analysis for residual total soluble salts (TSS) pH and nutrient concentrations.
2) Removal of the main crop residues and weed control.
3) Fertilizer application for the second crop.

1) Soil analysis

Soil surveys conducted by G. A. Marlowe, Jr. and C. M. Geraldson on tomato fields in Hillsborough County revealed high concentrations of residual plant nutrients in the soil (Table 1). Soil samples should be collected from several locations across the land. Samples should be taken from 0-9 inch depth from the fertilizer bands, from between the band and the plant row (mid-bed) and from the plant row. The intensity and balance (I & B) of nutrients for the second crop are just as important as they were for the main crop.

2) Removal of main crop

The usual method is to kill the tomato plants by a herbicide (Paraquat at 1.0 lb a.i. per acre), then burn the strings from the stakes. Finally, stakes and plants are removed. Plants can be removed by a special mower that fits over the plastic, or cut out by hand. The land, if necessary, may be treated again with paraquat to kill weeds before planting the second crop.

3) Fertilizer application

Amount and source of nutrients will depend on the crop. The total amount of residual and added nutrients should be equal to the recommended quantity of nutrients required for maximum yield for the second crop. It is important to remember, 100 lbs of soluble salts applied per gross acre and incorporated to a 6-inch depth, are equivalent to 400 ppm TSS at 12.5% soil moisture content. If the fertilizers are applied in a narrow band in the bed or the moisture content of soil is lower, then the TSS concentration will increase accordingly. For example, if the 100 lb salt is spread in a 1 ft wide swath and applied at 6 ft row spacing at 10% soil moisture, then the TSS concentration will be 3025 ppm. Salt index of the fertilizers (salt effect of the fertilizer on plants relative to sodium nitrate, which has a rating of 100) is also important. For example, superphosphate (20%) has a salt index of 7.8, calcium nitrate 52.5, potassium nitrate 73.6, ammonium nitrate 104.7, and potassium chloride (50%) 109.4.

Fertilizer application can be made in holes punched through the mulch near the plants by a hand-held device, or by a modified plug-mix planter. The newly introduced fertilizer wheel for application of liquid fertilizers opened up new possibilities for producing a second vegetable crop after tomatoes.

In previous experiments, H. H. Bryan and J. D. Dalton, on Rockdale soils in southeast Florida, raised a second crop of Butternut-23 squash after winter tomatoes. The tomato crop received 1500 lbs/A 7-14-14-3 analysis fertilizer. The fertilizer was placed in bands or spread on the top of the bed, not rototilled. Squash yields were higher with 3000 than with 1500 lb/A fertilizers. Fertilizer placement had no effect on yields.

At Fort Pierce, N. C. Hayslip et.al. planted 'Iobelle' sweet corn, 'Hawaii 7997' tomato, and 'Carolina' pickling cucumbers after a winter tomato crop. The winter tomatoes received 124 lb/A N, 256 lb/A P_2O_5, and 268 lb/A K_2O. The second crop vegetables received 85 lb/A N and 170 lb/A K_2O in liquid or in dry form. Liquid fertilizer was applied by the IFAS square-bar applicator. Dry fertilizers were placed in plugs either on both sides or on one side of the plant row. Yields of the 3 second crops were higher with added than with residual fertilizers. Fertilizer placement had no effect of yields.

In southwest Florida, P. H. Everett evaluated tomato (cv. Walter) and cucumber (cv. Poinsett) yields when planted as second crop after mulched tomatoes. The tomato main crop received 205 lb/A N, 40 lb/A P_2O_5, and 290 lb/A K_2O. Fertilizer for the second crop was applied at 1x (1x = 65 lb/A N and 91 lb/A K_2O), 2x and 4x rates. Fertilizer was placed in a 1-inch wide and 2-3 inch deep hole in 3 different locations: a) one hole on one side of the plant, b) one hole on each side of the plant, and c) one hole in the drill halfway between plants. The only significant yield increase for both tomatoes and cucumbers was between the control (no added fertilizers) and the 1x fertilizer rate. Fertilizer placements had no significant effect on yields.

At the GCREC-Bradenton in spring 1977, 'Green Comet' hybrid broccoli, 'Golden Acre' cabbage, 'Snow King' hybrid cauliflower, and 'Fordhook' zucchini were transplanted and 'Danvers Half Long' carrot, 'Evergreen White Bunching' green onion, 'Bibb' lettuce and 'Scarlet Globe' radish were seeded with or without added fertilizers after a fall tomato crop. The tomato crop was grown with 252 lb/A N, 100 lb/A P_2O_5 and 351 lb/A K_2O. Residual TSS concentrations were 14,000 ppm at planting. Nutrients for the second crops were: 196 N, 100 P_2O_5 and 100 K_2O lb/A. Total soluble salt concentrations with the added fertilizers were 23,700 ppm. Carrot, green onion and lettuce seeds failed to germinate in the fertilized halves of the split-plots. Radish seeds had a poor germination. Seedling survival and yield of transplanted vegetables except for zucchini were also poor in the fertilized plots (Table 2). It is important, therefore, to analyze the amounts and distribution of TSS in the plant beds before deciding the type of second crop and the amount of fertilizers for the crop. In other experiments at the GCREC-Bradenton we found nitrogen the most important nutrient for a second crop of cauliflower after tomatoes (Table 3). Without added N, cauliflower plants failed to produce marketable curds, regardless of added P and K. Phosphorous and K rates had little effect on cauliflower yields and curd size. Soil salt concentrations will be reduced by the second crop according to the length of growing season for the crop and its nutrient requirement. For example, in the spring 1977 experiments at the GCREC-Bradenton mentioned earlier, broccoli required 60 days, cauliflower 70 days and cabbage 86 days from transplanting to first cut. Soil TSS concentrations in a composite sample with added fertilizers were 23,700 ppm at planting. After harvest, TSS concentrations were 16,500 ppm in the broccoli, 13,500 ppm in the cauliflower, and 5,500 ppm in the cabbage plots. Thus, the longer the season and greater the biomass produced by the second crop, the lower the soil TSS concentration will be after harvest.

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Table 1. Post season concentrations of total soluble salts (TSS) and selected minerals in the soil solution. Hillsborough Co., Spring, 1976 (After Marlowe and Geraldson)

Location	Depth (in.)	TSS	NH_4	NO_3	K	Ca	Mg
		ppm					
Band	0-2	24,500	0	1,600	6,040	960	860
	2-4	4,230	0	251	274	244	174
	4-8	1,010	10	36	18	38	39
Mid-bed	0-2	14,000	49	605	900	1,000	1,250
	2-4	5,040	9	142	80	496	283
	4-8	1,090	7	27	19	78	41
Plant row	0-2	11,060	21	428	84	298	29
	2-4	3,610	25	24	16	262	8
	4-8	1,390	4	5	10	106	8

Table 2. Seedling survival and yield of vegetable crops with residual (R) and added fertilizers (F) after a fall tomato crop. Spring 1977. (Csizinszky 1978 and 1979).

	Broccoli[z]		Cabbage[z]		Cauliflower[z]		Zucchini[z]	
	R	F	R	F	R	F	R	F
Seedling survival (%)[y]	85**	45	93**	65	78	55	100	100
Yield per plant (lb)	0.68	0.52	2.37	2.11	1.81	1.08	15.75	12.50
Yield per acre (cwt)[y]	37*	17	142*	89	91*	39	610	484

[z]Average of 4 replications.

[y]Mean differences are significant at the 5% (*) or 1% (**) level.

Table 3. Effect of applied nutrients on a second cropped cauliflower yield. Winter-spring, 1985. (Csizinszky, unpublished data).

Added nutrient (lb/100 lin. ft.)	Carton per acre[z]	Curd weight (lb)	Curd diameter (in)	Number of curds per carton
Nitrogen				
None	0.0	0.0	0.0	0.0
1.0	328	1.87	7.06	12.3
2.0	448	1.92	7.11	12.0
Phosphorous (P_2O_5)				
None	229	1.26	4.72	18.3
0.75	290	1.28	4.73	18.0
Potassium (K_2O)				
None	268	1.26	4.72	18.3
1.2	264	1.23	4.72	18.7
2.4	245	1.30	4.72	17.7

[z]Average of 4 replications

TOMATO STEM SCAR POROSITY: MINIMIZING THE POTENTIAL FOR POSTHARVEST DECAY

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When tomato stem scars are infiltrated with water during harvesting and handling operations, there is a high risk for postharvest decay even if the water is chlorinated properly. Under controlled conditions in the laboratory, infiltration of tomato fruit with water containing up to 1000 ppm free chlorine was associated with excessive decay (> 5%) during subsequent storage. On the other hand, nearly every tomato fruit infiltrated with as little as 0.035 oz. (0.1 gm) of non-chlorinated water that contained decay pathogens inevitably decayed during a simulated marketing period. For these reasons, infiltration of fruit with dump tank water during harvest and handling represents an unacceptable risk with regard to postharvest decay.

Decay fungi and bacteria suspended in flume and dump tank water are rapidly destroyed by 50 ppm or more free chlorine. Fruit infiltrated with this water will not decay. However, microbes located in stem scars or the corky ring around stem scars may not be destroyed before they enter fruit because chlorine is inactivated almost instantaneously by internal fruit tissues.

Fruit become infiltrated with water if they cool while submerged or are submerged too deeply. Infiltration is not instantaneous with fruit-water contact but rather requires some period of time. Experimentally, effective infiltration resulted within 30 sec to more than 20 min depending on several variables including fruit and water temperature, the surface tension of the water, the depth of submersion, age of the stem scar, etc. The porosity of the stem scar is also an important variable since porous stem scars are more likely to be infiltrated than non-porous ones. Porous stem scars on floating fruit (= a single layer in a packinghouse flume) may be infiltrated within 10 min even if the fruit and water have identical temperatures. Non-porous stem scars appear to be nearly impervious to water. They may be flooded with water for hours and not absorb a drop.

The relative porosity of stem scars is a dynamic fruit characteristic. It changes with the prevailing temperature in the field, temperature of the fruit, period of time after harvest, relative size of the fruit, and cultivar. The quantity of water absorbed when fruit are submerged to 4 ft for 1 to 2 min appears to be a reliable measure of the potential for infiltration of fruit in packinghouse situations. In tests with freshly harvested fruit, the weight absorbed by fruit submerged to 4 ft for about 2 min was equal to the amount absorbed over a 20 min period by fruit held just under the surface of water (<2 in). In observations of commercial packinghouses, fruit have been observed in "dead" spots in flumes for 20 min or longer.

The amount of water absorbed by submerged fruit may vary significantly among pickings, field location and season. Most of this variation seems to be associated with variation in fruit size because large fruit are prone to greater infiltration than small fruit of the same cultivar. Fresh stem scars on warm (85 to 105 F) fruit are much more porous than old scars (2 or more days after harvest) on cool fruit (70 F). Florida MH-1 fruit consistently have absorbed more water when submerged than have those of any other cultivar tested. Horizon and Sunny fruit have absorbed the least amount of water (about 20% of the amount absorbed by MH-1). Walter fruit are intermediate to high with regard to porosity, whereas FTE-12 and Duke are intermediate to low.

Stem scar porosity appears to be an inherited character. Fruit of the F_1 and F_2 progeny of a cross between a highly porous cultivar, Florida MH-1, and an intermediately porous cultivar, Hayslip, absorbed an amount of water that averaged halfway between the amounts absorbed by the parents. Fruit of the backcrosses absorbed amounts between the quantities absorbed by fruit of the F_1 or F_2 progeny and the respective parent.

Minimizing the potential for postharvest decay currently involves three practices: 1) free chlorine in dump tank or flume water at a minimum of 75 ppm at all times; 2) fruit submersion periods less than 2 min; and 3) no more than two layers of fruit in the water at one time. If the exposure period for every single fruit is limited to 2 min or less under all circumstances including temporary packinghouse shutdowns, then the need to warm dump tank water as a decay control measure is eliminated. Use of cultivars with low stem scar porosity will make the risk of postharvest decay even smaller than currently exists and will reduce the need to limit fruit exposure to water to 2 min or less.

UPDATE ON FLORIDA: WEST MEXICO COMPETITION IN THE FRESH MARKET TOMATO INDUSTRY

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The competitive situation between Florida and West Mexico producers in the winter fresh produce industry has been an issue of concern for several years. The United States Department of Agriculture has commissioned 3 studies since the 1967/68 season to assess the competitive position between the two areas (1,2,3). The results have been important in assessing the competitive situation and the factors influencing the situation in each area.

The most recent study assessed the competitive situation of the two areas for the 1977/78 production season. The commodities analyzed were tomatoes, green peppers, eggplant and cucumbers. The results showed that Florida had a slight competitive advantage in producing and marketing tomatoes in the United States domestic market while West Mexico producers had an advantage for peppers, cucumbers and eggplant.

The objective of this report is to present the results of an update of the competitive situation between Florida and West Mexico in producing and marketing tomatoes in the United States domestic market. The cost of production for tomatoes was determined for each of the major producing areas in Florida during the period that Florida and West Mexico compete for the domestic U.S. market. The costs included in the analysis were preharvest, harvest and packing, and marketing. The competitive advantage in the cost of production was then determined based on the advantage in production costs for growing and marketing tomatoes in the domestic U.S. market.

The cost of production was determined in each area by surveying growers and others contributing to the production-marketing process for tomatoes. Those selected were chosen to represent the major technology used in each growing area. A representative sample of growers was chosen for each growing area for developing a budget.

This study was conducted by cooperating institutions; the University of Florida, University of Missouri and the United States Department of Agriculture. The University of Florida collected and summarized the data for Florida producers. The University of Missouri collected and summarized the data for the West Mexico producers. The USDA helped to coordinate the study and summarize the results.

Trends in Florida Production

Tomato production in Florida has increased in the last 10 seasons (table1). Harvested acres increased from the low of 31,500 acres in the 1974/75 season to a high of 47,600 acres in the 1983/84 season. Yields increased from an average of 796 cartons (25 pound equivalents) per acre in the 1973/74 season to a high of 1,250 cartons per acre in the 1981/82 season. Total production almost doubled in the last 10 years because of increases in acreage harvested and yield. Yields and production may have increased even further if not for the killing freezes experienced in the last few seasons. The average price received for tomatoes increased from $4.39 per carton in the 1973/74 season to $7.39 per carton in the 1982/83 season. The total value of tomatoes sold increased from $122.3 million in the 1973/74 season to $390.6 million in the 1982/83 season.

Table 2 shows the acres harvested of tomatoes in each of the major producing areas during the last 7 seasons. The data show that Dade County increased harvested acres from 10,750 acres in the 1977/78 season to 12,800 acres in the 1983/84 season. Harvested acres in the southwest production area (Collier and Hendry Counties) increased only slightly, from 8,725 acres in the 1977/78 season to 9,735 acres in the 1983/84 season. The Palmetto-Ruskin production area (Manatee and Hillsborough Counties) increased harvested acres substantially, from 14,710 acres in the 1977/78 season to 17,540 acres in the 1983/84 season. The Palm Beach - Broward County area varied only slightly from 1,920 to 3,250 harvested acres during the same period.

The areas contained in the analysis included the Dade County area, Southwest production area and Palmetto-Ruskin production area. These are the production areas that compete most with West Mexico producers.

Table 1: Florida fresh Tomato Acreage, Yield, Production and Value, 1973/74-1983/84

Season	ACREAGE Planted	ACREAGE Harvested	Yield per Acre	Production	Value per Carton	Total Value
	Acres		Cartons*	1000 CTS	Dollars	1000 DLRS
1973/74	35,500	34,700	796	27,624	$4.39	$122,342
1974/75	31,700	31,500	1,026	32,316	$4.57	$148,709
1975/76	38,700	38,300	918	35,151	$4.59	$162,649
1976/77	43,200	34,000	854	29,052	$5.30	$155,019
1977/78	42,100	41,500	826	34,260	$5.28	$182,284
1978/79	41,300	40,800	981	40,008	$5.47	$220,216
1979/80	42,900	42,200	1,102	46,492	$5.23	$244,240
1980/81	47,000	46,300	1,003	46,432	$5.49	$256,584
1981/82	41,300	40,500	1,250	50,632	$5.23	$266,306
1982/83	45,600	45,600	1,154	52,640	$7.39	$390,612
1983/84	49,300	47,600	1,128	53,712	$6.83	$367,955

* Net weight approximately 25 lbs.

Source: Vegetable Summary.

Table 2: Florida Ground and Staked Tomato Acreage Harvested, by Selected Counties, 1977/78-1983/84

County(type)	1977/78	1978/79	1979/80	1980/81	1981/82	1982/83	1983/84
				Acres			
Dade(GR)	10,750	10,760	11,400	13,000	10,900	12,900	12,800
Collier-Hendry(GR)	780	570	1,510	1,960	1,125	1,620	1,110
Collier-Hendry(ST)	7,945	8,810	8,500	9,700	8,465	7,860	8,625
Manatee-Hills.(ST)	14,710	12,650	13,650	15,630	14,385	16,250	17,540
Palm B.(ST)	2,185	2,425	2,425	2,285	1,920	2,430	3,150
Other Cos.	5,130	5,585	4,715	3,725	3,705	4,540	4,375
State Total	41,500	40,800	42,200	46,300	40,500	45,600	47,600
Ground Total	14,465	13,655	13,650	15,400	12,540	12,910	13,950
Staked Total	27,035	27,145	28,550	30,900	27,960	32,690	33,650

Note: Small ground acreage included in Collier County in 1977/78-1978/79.

Source: Vegetable Summary.

Cultural Practices

Tomatoes grown in Florida for the winter market are produced in two distinct ways: 1) staked tomatoes grown mainly in the Southwest area and the Palmetto-Ruskin area, and 2) ground tomatoes grown in Dade County. Staked tomatoes are transplanted onto a raised plastic mulch bed and later staked by tying the plants with 3 to 4 lines of plastic strings held by 4.5 foot stakes placed between plants. Ground tomatoes are direct seeded onto slightly less raised plastic mulch beds. At planting the seeds are mixed with a "plug mix" containing peat, vermiculite and a wetting agent.

Another important difference in the way tomatoes are grown is the irrigation system used. There are two principal irrigation methods used: 1) overhead irrigation and 2) seepage irrigation. Overhead irrigation is used almost exclusively in the Dade County area while seepage is used in the Southwest, Palmetto-Ruskin, and Palm Beach areas.

Overhead irrigation uses large water guns with diesel engine pumps mounted on trucks or trailers. A typical 40 acre block of land will have 25 shallow wells located in the center of alleys, 5 wells per alley. The distribution of wells in a field permits the irrigation pumps to be moved throughout the field to provide a complete coverage.

Seepage irrigation consists of maintaining the water table 12 to 15 inches below the soil surface, close enough for plants to absorb water and nutrients without damaging the roots by producing rot. This is done by pumping water into the fields if dry conditions prevail or draining water from the fields after excess precipitation.

The principal change in tomato production practices in the past 5 years has been the widespread adoption of hybrid varieties. Improved varieties such as FTE-12, Duke, and Sunny, though costly ($400 to $800 per pound), are higher yielding, concentrate production and produce larger and firmer fruit than traditional varieties.

Another change in production practices occurred in South Florida as a result of the freeze experienced in the 1977/78 season. Since then, most tomato growers in Dade County have acquired sprinkler irrigation systems specifically designed to better protect their crop during periods of below freezing temperatures. When the temperature falls below 32 degrees Farenheit, and wind speed is below 10 miles per hour, the sprinklers are turned on. This has the effect of increasing the ambient temperature slightly, thereby reducing frost damage. If wind speed is above 10 miles per hour, turning on the sprinklers apparently increases frost damage.

Increasing use of lazer leveling of fields has also contributed to increases in tomato yields by providing greater uniformity of soil moisture. Lazer leveling is done mostly on new fields or on fields where field ditches need to be remade.

Another significant change has occurred in harvesting. Most tomatoes grown in Florida are picked in the "mature green stage" with only around 10 percent picked when "ripe". Concentrated production brought about by the wide spread use of hybrid varieties has resulted in reduced pickings. Fields once picked 3 to 5 times, depending on the conditions of the market and the field, are now only picked 2 to 3 times. Ground grown tomatoes are picked 1 to 2 times.

Costs

Cost budgets were developed for fresh winter market tomato production in Dade County, Southwest Florida and Palmetto-Ruskin production areas of Florida (tables 3-5). The Dade County budget represents ground tomatoes produced for harvesting during the months of December to April. The budget for Southwest Florida represents staked tomatoes produced for the market of October to May. The budget for Palmetto- Ruskin represents staked tomatoes produced for the May to June market.

The per carton cost of producing, packing and marketing Florida tomatoes has not increased much as compared to the previous study estimates. The biggest jump in total cost occurred in the Southwest with a 7

Table 3: Mature Green Ground Tomatoes: Production and Marketing Costs in Dade County, Florida, 1984/85

Item		Cost
Preharvest		$/Acre
Frost protection		104.03
Land rent		180.00
Fertilizers		311.13
Pesticides		594.76
Other material inputs		
Plastic mulch		162.50
Seed		125.00
Other		59.00
Tractor & other labor		338.90
Machinery requirements		360.82
Miscellaneous inputs		4.00
Supervision		156.81
Administrative cost		107.86
Interest cost		108.03
Total preharvest		2,612.83
Yield per acre:	1,000 25-lb. cartons	$/Carton
Total preharvest		2.61
Harvest		
Picking		0.63
Hauling		0.07
Total harvest		0.70
Production cost		3.31
Packing & marketing		
Packing		1.74
Carton box		0.58
Selling		0.15
Total packing & marketing		2.47
Total cost		5.78

Table 4: Mature Green Staked Tomatoes: Production and Marketing Costs in Southwest Florida, 1984/85

Item	Cost
Preharvest	$/Acre
Land rent	240.00
Crop insurance	150.00
Fertilizers	453.43
Pesticides	462.65
Other material inputs	
Plastic mulch	273.90
Transplants	166.25
Other	78.93
Tractor & other labor	446.04
Machinery requirements	471.27
Supervision	191.97
Administrative cost	132.05
Interest cost	137.99
Total preharvest	3,204.48
Yield per acre: 1,100 25-lb. cartons	$/Carton
Total preharvest	2.91
Harvest	
Total pick & haul	0.80
Production cost	3.71
Packing & marketing	
Packing	1.50
Carton box	0.60
Selling	0.15
Total packing & marketing	2.25
Total cost	5.96

Table 5: Mature Green Staked Tomatoes: Production and Marketing Costs in Palmetto-Ruskin, Florida, 1984/85

Item		Cost
Preharvest		$/Acre
Land rent		83.00
Fertilizers		275.25
Pesticides		501.96
Other material inputs		
Plastic mulch		130.00
Transplants		135.00
Other		123.44
Tractor & other labor		440.24
Machinery requirements		511.41
Supervision		154.02
Administrative cost		104.70
Interest cost		108.28
Total preharvest		2,567.29
Yield per acre:	1,200 25-lb. cartons	$/Carton
Total preharvest		2.14
Harvest		
Pick & haul		0.83
Production cost		
Packing & marketing		
Packing		1.42
Carton box		0.53
Selling		0.15
Total packing & marketing		2.10
Total cost		5.07

percent increase from $5.59 to $5.96 per 25 pound carton (table 6). Total costs per carton increased by only 1 and 3 percent for Dade County and Palmetto-Ruskin tomatoes, respectively.

Tomato yields have had a significant impact on the preharvest cost of a 25 pound carton in the three major production areas. Dade County and Palmetto-Ruskin tomato preharvest costs decreased from the previous study estimates by 7 and 5 percent, respectively. The Southwest had a slight increase of 2 percent in preharvest costs per carton over the same period.

Pesticides, machinery, labor and fertilizer are the major preharvest cost items in all three areas. Pesticide costs are higher in the Dade County area while fertilizer costs are highest in the Southwest. Labor and machinery costs are about the same in the Southwest and Palmetto-Ruskin where staked tomatoes are grown while lower in Dade County where ground tomatoes are grown.

Land rent rates were estimated at $50 per acre in the Palmetto-Ruskin area and $120 and $150 per acre in the Southwest and Dade County, respectively. Less land is required to grow a net acre of tomatoes in Dade County than in the Southwest and the Palmetto-Ruskin area. The overhead irrigation system used in Dade County uses less land than the seepage irrigation system used in the Southwest and Palmetto-Ruskin areas. Irrigation wells are usually located in the middle of the field roads which take up slightly over 15 percent of the area. It is estimated that in the Southwest only 50 percent of the land required to grow tomatoes is actually used for growing the crop, while the rest is made up of irrigation ditches and field roads. In the Palmetto-Ruskin area the situation is similar to the Southwest with only about 60 percent of usable area planted to tomatoes. Because of the land lost to irrigation systems and roads, the net land rent cost required to grown a net acre of tomatoes in Palmetto-Ruskin is $83 compared to $180 in Dade County and $240 in the Southwest.

Harvesting costs per carton have also tended to decrease in Florida. This is the case for Dade County and Southwest Florida where harvesting costs per carton decreased from the 1978/79 estimates by 24 and 10 percent, respectively. Harvesting costs per carton remained constant in Palmetto- Ruskin. The decreases in per unit harvesting costs are attributed mostly to the higher degree of concentration of fruit set in the new hybrid varieties being used compared to the varieties commonly used 5 to 7 years ago.

Packing and marketing costs per carton did experience an increase from the 1978/79 estimates to the 1984/85 estimates. The cost of packing and marketing a carton of tomatoes increased by 14, 22 and 24 percent in Palmetto-Ruskin, Southwest and Dade County, respectively. It now costs $2.10 to $2.47 to pack and market a carton of tomatoes, while for the 1978/79 season it was $1.85 to $2.00, depending on the production area.

Table 6: Cost Comparison of a Carton of Tomatoes between 1978/79 and 1984/85 in Selected Production Areas of Florida

	Preharv.	Harvest	Pack-Mkt	Total
		$/Carton		
Dade County				
1978/79	2.82	0.92	2.00	5.74
1984/85	2.61	0.70	2.47	5.78
Change (%)*	(7)	(24)	24	1
Southwest				
1978/79	2.85	0.89	1.85	5.59
1984/85	2.91	0.80	2.25	5.96
Change (%)*	2	(10)	22	7
Palmetto-Ruskin				
1978/79	2.26	0.83	1.85	4.94
1984/85	2.14	0.83	2.10	5.07
Change (%)*	(5)	0	14	3

* Decreases are represented with a negative percent change, shown in parentheses.

Comparing Costs of Production: Florida and Mexico

A budget for producing and marketing tomatoes in the United States was developed for the state of Sinaloa in Mexico by the University of Missouri. Sinaloa is the major producing areain Mexico for tomatoes marketed in the U.S. The budgets were estimated using the same procedures used in Florida. Growers using the major technology used in Mexico were surveyed to determine the production practices used and budgets were estimated from the information collected. The budget was developed in the same time period as the budgets for Florida. The results of the budget are shown in table 7.

A comparison of the preharvest costs of production in each of the major producing areas of Florida and Mexico are shown in table 8. The results show that Mexican preharvest costs are substantially lower than preharvest costs in Florida. Mexican preharvest costs were estimated at $1.68 per 25 pound carton. By comparison, Florida preharvest costs were estimated at $2.61, $2.91 and $2.14 in the Dade, Southwest and Palmetto-Ruskin areas, respectively.

Florida producers spend, on average, more than Mexican producers for land, labor, machinery, fertilizer, chemicals and interest. Mexican growers spend more than Florida growers on seed only. The differences in costs are fairly easy to understand. Land costs in Florida are higher because of the increased competition for land, from both agricultural and nonagricultural sources. Labor costs in Florida are higher because of the higher wage rates paid in Florida. Florida growers paid an average of $4.09 per hour for cultural labor and $5.19 per hour for tractor labor. By comparison, Mexican growers paid an average of $2.54 per day for labor. The difference in total labor costs would have been greater if machinery were not substituted in Florida for some of the labor in the cultural operations performed in Mexico.

Florida spends more for machinery because it does substitute machinery for labor in many of the cultural operations and also because it uses full bed plastic mulch, which is machinery intensive. Fertilizer costs are higher in Florida than Mexico solely because of

Table 7. Vine Ripe Staked Tomatoes: Production and Marketing Costs in Sinaloa, Mexico, 1984/85

Item	Cost
PREHARVEST	$/Acre
Land Rent	64.41
Fertilizer	96.61
Pesticides	215.24
Other Material Inputs	
Seed and Greenhouse	221.66
Other	127.07
Labor	286.73
Machinery Services	198.21
Administrative & Overhead	92.83
Interest Cost	54.72
Total preharvest	$1,357.48
YIELD PER ACRE: 809 25-lb. cartons	$/carton
Total preharvest	1.68
HARVEST	
Picking	0.62
Total harvest	0.62
PACKING	
Labor	0.17
Carton box	0.85
Machinery	0.33
Administrative	0.10
Total packing	1.45
MARKETING	
Crossing costs	
Mexican taxes	0.03
American tariff	0.45
Customs brokers	0.10
Fees	0.06
Transportation	0.88
Selling	0.76
Total marketing	2.28
TOTAL COST	6.03

SOURCE: Forthcoming USDA AER publication, available from the USDA, Economic Research Service.

Table 8. Preharvest costs for producing tomatoes in Florida and Mexico.

Item	Mexico	Dade	Southwest	Palmetto-Ruskin
Land Rent	$64.41	$180.00	$240.00	$83.00
Labor	286.73	495.71	637.91	730.74
Machinery	198.21	295.82	389.27	486.42
Fertilizer	96.61	311.13	453.43	300.25
Chemicals	215.24	594.76	462.65	492.96
Seed	221.66	160.00	166.25	135.00
Interest	54.72	108.03	137.99	108.28
Total Preharv.	$1,535.30	$2,612.83	$3,204.98	$2,567.29
Yield (car./acre)	809	1000	1100	1200
Per unit preharv.	1.90	2.61	2.91	2.14

Table 9. Per unit cost comparisons for tomatoes grown in Florida and Mexico.

Item	Mexico	Dade	Southwest	Palmetto-Ruskin
Preharvest	$1.90	$2.61	$2.91	$2.14
Pick & Haul	0.62	0.70	0.80	0.83
Packing	0.60	1.74	1.50	1.42
Carton	0.85	0.58	0.60	0.53
Total harvest & packing	$2.07	$3.02	$2.90	$2.78
Selling	0.76	0.15	0.15	0.15
Transportation	0.88			
American Tariff	0.45			
Other fees	0.19			
Total Marketing	$2.28	$0.15	$0.15	$0.15
Total Costs	$6.03	$5.78	$5.96	$5.07

higher unit prices for fertilizer. Florida and Mexico apply comparable rates of fertilizer on tomatoes, however, lower prices for fertilizer allow Mexico to spend only 21 to 32 % of the total amount Florida spends (depending on the area). The difference in chemical costs are mostly due to production practice. Florida growers generally follow a routine spray program. Mexican growers typically use a reactionary program, spraying only when problems arise. Finally, interest costs in Florida are higher because of the additional capital needed to fund the preharvest costs. Interest costs were calculated from the amount of capital required in preharvest activities. Florida spends more in preharvest activities and, as a result, must spend more on interest.

Most of the seed used for production of tomatoes in Mexico is developed in the United States. Seed generally costs more in Mexico because it must be obtained from the United States at a premium price.

Yields in Florida were 25 to 50 % higher than yields in Mexico. Because of the higher yields in Florida, unit preharvest costs in Florida were higher than Mexico by only 27, 55 and 73 % in the Palmetto-Ruskin, Dade and Southwest areas, respectively, despite Florida growers spending 67, 70 and 108 % more on total preharvest costs in each of the respective areas.

Table 9 shows the per unit cost comparisons for preharvest, harvest and packing, and marketing between Florida and Mexican growers. The results show that Mexico pays less than Florida for harvesting and packing, but substantially more for marketing their tomatoes. The labor intensive costs in harvesting and packing include the picking, hauling and packing operations. Mexican growers paid an average of $1.22 per 25 pound carton for picking, hauling and packing compared to $2.44, $2.30 and $2.25 per carton for tomatoes produced in the Dade County, Southwest and Palmetto-Ruskin areas, respectively. The cost of the carton was higher in Mexico, however, at $0.85 per carton compared to $0.53 to $0.60 per carton in Florida. Tomatoes are packed in corrugated boxes, most of which are manufactured in the United States. Mexican growers must pay more than Florida growers to pack in corrugated boxes. The total harvest and packing costs were $2.07 per box in Mexico compared to $3.02, $2.90 and $2.78 per box for tomatoes grown in the Dade County, Southwest and Palmetto-Ruskin areas, respectively.

Conclusions

The results on the cost of production indicate that Florida has a competitive advantage in producing tomatoes for the U.S. domestic market. However, these results can not be used to conclude that Florida has a competitive advantage over Mexico in producing and marketing tomatoes in the U.S. domestic market. The revenues received for tomatoes have not been compared for the two areas. Revenues must be compared to find which area has a competitive advantage in marketing tomatoes. A competitive advantage in marketing would result from marketing in a seasonal pattern that yields higher average prices received for all product. A competitive advantage may also result because of a higher quality product being marketed. Both seasonal and quality differences contribute to marketing advantages.

Table 10 shows the market shares that Florida and Mexico controlled in the last 15 years for the October to June and December to April seasons. The results show that Florida has been increasing it's share of the domestic U.S. market. These results indicate that Florida's competitive position in tomatoes has been strengthening in recent years. The results of the cost of production comparisons support this hypothesis.

The primary reason Florida enjoys an advantage in the cost of production is because of the high marketing costs that Mexican growers must pay to market tomatoes in the U.S. domestic market. Mexican growers pay an average of $2.28 per carton for marketing costs compared to only $0.15 per carton for marketing costs in Florida.

A major difference between Florida and Mexico deals with the proportion of costs incurred in preharvest activities. Mexico spends 28 % of it's total cost on preharvest activities, compared to 45, 49 and 42 % spent in preharvest activities in the Dade County, Southwest and Palmetto-Ruskin areas, respectively.

Table 10. Market shares for Florida and Mexico in the U.S. fresh winter tomato market, October to June and December to April periods.

Years	Oct. to June* Florida	Oct. to June* Mexico	Dec. to April Florida	Dec. to April Mexico
	(%			)
1970-74	34	39	42	54
1974-79	41	37	45	50
1979-84	50	27	53	44

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TOMATO PRODUCTION PRACTICES IN WEST MEXICO

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In early March 1984 a study group visited Nogales, Sonora, and vegetable growing areas in Sinaloa state Mexico. The tour was conducted by the University of Arizona and had members from eight states, Washington D.C., Brazil and Saudi Arabia. The purpose of the tour was to follow the production and movement of Mexican produce from seeding in Sinaloa to the boarder crossing at Nogales, Arizona. By knowing what your competition is doing, you can gain insight of what to expect from them and, in the long run, can become more competitive.

Over the last 20 years, Florida tomato growers have sought protection of their crop through the USDA and more recently the courts. However, early in 1984 a U.S. judge ruled that distributors of Mexican produce were innocent of unfair competition. Florida growers will likely keep seeking protectionist policies, but other factors may have more of an effect on the strengths or weaknesses of the Florida and Mexican competitors. These factors include technological advances,the value of the peso, and climatic trends.

Florida tomato growers increased their per-acre yields by about 60 percent in the 1970's by technological adoptions such as the use of plastic mulch. This new technology has not been applicable to Mexico and directly helped Florida increase its share of the U.S. winter tomato sales during that decade.

Mexico devaluated the peso sharply in 1981 and 1982 and boosted Mexican exports. That, plus winter freezes in Florida, have helped the Mexican vegetable distributors gain back part of the U.S. market that they had lost to Florida.

In reviewing the Mexican tomato industry in early 1984 in Sinaloa and later in the Baja, one things seems apparent, that for the most part the Mexican tomato farmer runs a large sophisticated operation. Many things appear similar except the soil type, the use of plastic mulch and labor. The Mexicans, as previsouly mentioned, do not use plastic mulch, but they do use labor, alot of it. Much of our technical labor is expensive and harvest labor, although piecework, can make upwards to $100 on a good day. On the other hand, Mexican labor was making 640 pesos per day or about $3.85 in 1984.

The cheap cost of labor relates well with methods of production and harvest. This seems to be changing slightly each year and it seems like there may be a shift towards mature green production as opposed to the traditional vine ripe operations. This means a shift in variety, generally towards one which can withstand the long trip from Sinaloa to the boarder in Nogales. Now, planting is done from containerized transplants which are normally hand seeded in flats. The plants are set in the field by hand in 15 meter blocks with roadways every 100 meters. Approximately 3500 to 4000 plants are used per acre. Generally, the farmers tend to over fertilize. The crops are forrow irrigated with water that is controlled by the government. The plants are staked and the plants are sprayed continuously as necessitated by weather conditions.

At harvest time the fields are harvested every other day, and in hot weather, every day, sometimes twice a day. The plants are harvested continuously until they die. Each crew has about 30 pickers which harvests 10 to 15 acres a day. The tomatoes are dumped into bulk containers when harvested. Yields can range to about 40,000 pounds per acre or 1600 boxes per acre. Farm size is large, and a 4000 acre farm can have in excess of 8000 workers. The fresh winter vegetable production in Sinaloa employs about 250,000 workers. Each of the larger growers have their own packing facility. The tomato harvest runs from December through May, peaking in March and April.

The farming area in Sinaloa, from Culican to Los Mochis, is the southern edge of the Sonoran Desert. It gets less winter rain but more summer rain than the portion of the same desert in Arizona. Low rainfall means less plant disease, however when it does rain fields may become impossible to get into because of the soil type. Winter days are warm and frosts are more rare than in Florida. Most of the irrigation water comes from rivers and canals that run westward out of the Sierra Madre mountains.

Most of the crop (90%) is vine ripe although the volume of mature green is increasing. In Sinaloa there were 15 vine ripe and two mature green packing sheds in 1984. In the Baja most are mature green operations.

The latest change is the increase in the numer of farmer cooperatives or ejidos. These have been started by groups of farmers pooling their land and efforts to grow crops. The land was given to the farmers as part of the government's land reform program. The overall effect that the ejidos will have as competition to Florida is unknown at present. Their financial backing, production practices, and marketing system is quite crude at present.

THE 1984-85 TOMATO SEASON

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The Organizational Meeting of the Florida Tomato Committee was held at Marco Island, Florida, in September 1984. The initial regulations recommended to the Secretary of Agriculture were slightly different from those in effect for the 1983-84 season. The new regulations required all tomatoes to be run over sizing equipment and all containers had to be packed at the registered handler's facility. Containers, net weight and size dimensions all remained the same.

The Committee met again in October in LaBelle, Florida, to review a study evaluating the elimination of 7x7 and off-grade tomatoes and what effect this would have on net income. It was agreed that no action would be taken to eliminate 7x7 or off-grade tomatoes, but it was unanimously recommended to the Secretary of Agriculture that representation on the Committee be changed. This was approved; and beginning in 1985-86, Districts 1 and 3 will have three members and three alternates, District 2 will have two members and two alternates,and District 4 will have four members and four alternates.

On January 20-22, Florida was devastated with another freeze. District 1 had temperatures of 26-30 degrees. Fields that were irrigated and frozen faired quite well. There was some survival of young plants and older fields produced sucker crops. In District 2, fields with fruit set to mature fruit were severely damaged. Young plant damage was light to moderate. District 3 had temperatures of 22-32 degrees which totally wiped out older crops with young plants surviving. District 4 with 18-22 degree readings lost 75 percent of everything planted. Heavy replanting in District 3 occurred after the freeze and the harvest of this acreage coincided with the harvest of the spring crop in District 4. For all practical purposes, the season ended on June 15 with only a few people packing any tomatoes after that date.

Total harvested acres in Florida were 44,729 compared to 45,400 the previous season and 43,386 harvested in 1982-83. Districts 2 and 3 had increases of 80 and 903 acres, respectively. Districts 1 and 4 were down 1,607 and 47 acres, respectively, giving a net decrease of 671 acres. There were 1,441 acres less of ground tomatoes and 770 acres more of staked tomatoes planted this season. The ratio remains about 1/3 ground and 2/3 staked. Total shipments were 52,471,073 25-lb. equivalents compared to 45,493,783 the previous season.

Total shipments were 6,977,290 25-lb. equivalents more than the previous season even though there were 671 less acres planted. This is directly attributable to the weather conditions that were very favorable throughout most of the season. Bumper crops were produced in the fall and spring resulting in disasterously low prices during these periods. The freeze in January severely damaged more than 7,000 acres of tomatoes. Had it not occurred, prices in late January, February, March and early April would also have been very cheap. In late April, May and early June, many fields were picked only once or twice and then only large fruit were picked. With a decent market, several million more boxes would have been shipped.

Harvesting of the fall crop began in Districts 3 and 4 in mid-October with District 2 starting about three weeks later and District 1 starting the middle of December. Total shipments from all districts exceeded one million packages by the first week of November and continued at this level for the next 12 weeks, dropping to 750,000 on the week ending January 26. Salvage operations for the next two weeks were 800,000 and 1.1 million. Shipments ranged between 100,000 and 868,000 packages for eight weeks and then exceeded one million 25-lb. equivalents per week for the next nine weeks with three of these weeks exceeding three million per week and four exceeding two million.

District 2 started harvesting the second week of November and continued shipping good volume through the second week of February. Supplies for the next seven weeks were light, returning to normal volume April 6 and continuing through mid-May. Acreage planted for harvest was up two percent over the previous season and total shipments were up 3.7 percent. Losses from the freeze were estimated at 35 percent so shipments would have been much larger if the weather had been good. Weekly shipments from this district exceeded 100,000 25-lb. equivalents for 19 weeks during the season and ten of these weeks had shipments that exceeded 200,000 25-lb. equivalents.

District 1 started picking the middle of December and finished May 12. Weekly volume remained steady throughout this period except for a couple of weeks following the freeze and a couple of weeks in mid-March which was also the result of the January freeze. Total acreage planted for harvest was down approximately 12-1/2 percent and shipments were down a corresponding 11.8 percent. Again this points out how fortunate south Florida was on the nights of January 20-22 when most of the balance of the state experienced sub-freezing temperatures.

District 3 began shipping tomatoes the middle of October and total weekly shipments were running a little above normal volume when they were zapped by the January freeze. Virtually all tomatoes in this district with any fruit on them were totally wiped out. Following four weeks of salvage operations, shipments dropped to almost nothing for the next six weeks and only reached normal shipments for five weeks during the balance of the season. The official records show harvested acres to be up 903 acres over the previous season but this information is misleading. Any salvage following the freeze was counted as acres harvested with low yields. Official estimates indicate about 1,850 acres were lost as a result of the freeze, but 7,000 acres might be a more accurate figure. Total shipments were up 30 percent over the previous season which indicates the excellent growing conditions that existed following the freeze.

District 4 started harvesting in mid-October and reached shipments totaling more than 600,000 25-lb. equivalents by the second week. Fall acreage was down seven percent but shipments were up by 25 percent. More than seven million 25 lb. equivalents were shipped from District 4 during the fall season. This points out how good the growing conditions were and it also explains why prices were so cheap. Some of the tomatoes packed and shipped in District 4 are actually grown in District 3 and vice versa.

Harvest of the spring crop in District 4 started in late April which is about normal. Total acres harvested were up about three percent but shipments were up a whopping 21 percent. During their nine-week spring season, shipments from District 4 totalled more than 13.5 million 25-lb. equivalents but slightly more than 12.1 million of these were shipped in a six-week period. Quality was excellent but prices were so cheap many fields were picked only once or twice and then only larger sizes were picked. From an economic standpoint, this was without a doubt the worst season ever experienced in this area.

The total 52,471,073 25-lb. equivalents were shipped over a 35-week period. Twenty-two of these weeks had shipments exceeding one million packages with eight weeks showing more than two million and three of these showing more than three million 25-lb. equivalents. the total shipments were up 6,977,290 25-lb. equivalents or about 15 percent over the previous season.

The total value of the crop was about 314.4 million dollars, compared to 310.6 million the previous season. The average price was $5.99 per 25-lb. equivalent for the entire season, compared to $6.83 per 25-lb. equivalent for the 1983-84 season and $7.54 for 1982-83. Short supplies folowing the January freeze helped raise the season's average price. Many tomatoes were sold for less than costs of production with some not even returning picking and packing costs. Tables Two, Three, Four and Five show the variations in average price between the districts. It's easy to see a wide variation in price between the different districts.

During the 1984-85 season, there were more than twelve different commercial varieties planted. Sunny, Duke, F.T.E. No. 12, FloraDade and Hayslip accounted for 96 percent of the total acreage. Some of the other varieties planted were Freedom, Mountain Pride, Castle 1035, Count, F.T.E. 20 and BHN 26. The Florida Tomato Exchange is continuing research efforts to find a new super variety for Florida and several seed companies are working toward the same objective.

The continuing regulations allowing commingling of only 5x6 and larger tomatoes, requiring all tomatoes shipped out of state to be in new boxes coupled with the new regulations requiring the tomatoes to be run over sizing equipment and be packed at the registered handler's facility, and requiring the name and address of the registered handler on the carton went a long way toward solving the problems of theft and the shipment of cull tomatoes all over the United States. A few refinements in these regulations in the future will close the loop holes and further control these serious problems.

The Committee's activities in controlling container weights and designated diameters of tomato sizes have been profitable for the Florida Tomato Industry. It is also doubtful that Mexican producers would impose restrictions on themselves voluntarily if the Florida Tomato Marketing Order was not in effect. The need for continued use of these controls plus consideration of additional regulations on domestic shipments during periods of market glut are essential if profitable returns are to be expected by the Florida Tomato Industry.

The producers of Florida tomatoes must continue to work together to provide the ultimate consumer with a more palatable product. New varieties will be developed and the consumer must be educated in the proper methods of ripening and preparation. Increased per capita consumption of fresh Florida tomatoes could cure many of the problems of overproduction. Joint efforts of the Florida Tomato Committee and the Florida Tomato Exchange are channeled in this direction.

SUGGESTED HERBICIDES FOR TOMATOES

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Herbicides must be applied at exactly the correct rate and time to selectively control weed growth in a vegetable crop. Obtain consistent results by reading the herbicide label and other information about the proper application and timing of each herbicide. To avoid confusion between commercial formulations, suggested rates listed in this guide are stated as pounds active ingredient per acre (lbs. ai./acre) unless otherwise indicated. Apply lower rates for sandy and rockland soils with low organic matter and clay contents. Not all labled herbicides are suggested due to either a lack of Florida data, or due to data indicating a degree of crop injury when applied under Florida conditions. When limited data is available the materials are suggested for use on a trial basis. Read each herbicide label for specific weeds controlled.

TOMATOES

Herbicide	Labelled crops	Time of application	Rate (lbs.ai./acre)
Chloramben (Amiben)	Tomatoes (established)	Postemergence or posttransplant	3.0

Granular formulation may be applied to cultivated non-mulched transplanted or established direct seeded tomatoes. Plants should be at the 5-6 leaf stage. Apply only when foliage is dry. Will not control established weeds.

Herbicide	Labelled crops	Time of application	Rate (lbs.ai./acre)
	Tomatoes	post planting or post transplanting	3.0

A special Local needs 24 (c) Label for Florida. Apply once per crop season after existing weeds in row middles have been removed. Lable states control of many annual grasses and broadleaf wees. Among these are crabgrass, goosegrass, lambsquarter, wild mustard, black nighthade, pigweed, purslane, common ragweed and Florida beggarweed.

Herbicide	Labelled crops	Time of application	Rate (lbs.ai./acre)
DCPA (Dacthal)	Established tomatoes	Posttransplanting after crop establishment (non-mulched)	6.0 to 8.0
		Mulched row middles after crop establishment	6.0 to 8.0

Controls germinating annuals. Apply to weed free soil 6-8 weeks after crops is established and growing rapidly or to moist soil in row middles after crop establishment. Note label precautions of replanting non registered crops wihtin 8 months.

Diphenamid (Enide)	Tomatoes	Pretransplant Preemergence Postemergence Posttransplant Incorporated	3.0 to 4.0

Controls germinating annuals. Apply to moist soil 1 week before or within 4 weeks after transplanting crop. Incorporate 0.5 to 2 inches. May be applied as directed band over "plug" planting or to mulched row middles. Label states control of many grasses and broadleaf weeds including spiny ameranth, bermudagrass, goosegrass, seedling johnsongrass, lambsquarter, pigweed, purslane, Fla. pusley and others.

Metribuzin (Sencor Lexone)	Tomatoes	Postemergence Posttransplanting after establishment	0.25 to 0.5

Controls small emerged weeds after transplants are established or direct seeded plants reach 5-6 true leaf stage. Apply in single or multiple applications with 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.

Herbicide	Labelled crops	Time of application	Rate (lbs.ai./acre)
Metribuzin (Sencor Lexone)	Tomatoes	Directed spray in row middles	0.25 to 1.0

Apply in single or multiple applications with a minimum of 14 days between treatments and maxiumum 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, ameranthus sp., Florida pusley, common ragweed, sicklepod, and spotted spurge.

Napropamid (Devrinol)	Tomatoes	Preplant incorporated	1.0 to 2.0

Apply to well worked soil that is dry enough to permit thorough incorporation to a depth of 1-2 inches. Incorporate same day as applied. For direct seeded or transplanted tomatoes.

	Tomatoes	Surface treatment	2.0

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.

Paraquate (Ortho paraquat Gramoxone)	Tomatoes	Premergence Pretransplant	0.5 to 1.0

Controls emerged weeds. Use a non-ionic spreader and thoroughly wet weed foliage.

	Tomatoes	Post directed spray in row middle	0.5

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.

Herbicide	Labelled crops	Time of application	Rate (lbs.ai./acre)
Trifluralin (Treflan)	Tomatoes (except Dade County)	Pretransplant incorporated	0.75 to 1.0

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.

	Seeded Tomatoes (except Dade County)	Post directed	0.75 to 1.0

For direct seeded tomatoes, apply at blocking or thinning as a directed spray to the soil between the rows and incorporate.

TOMATO NEMATICIDES FOR 1985-1986 IN FLORIDA

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Tomatoes can be damaged by several plant nematodes in Florida, including root-knot, reniform, sting, and stubby-root. Risk of crop losses to any of these may be reduced by crop rotation (farming "new" land), but the value of the crop practically dictates that chemical nematicides be used, even on most new land. On old vegetable land, nematicides are definitely necessary for efficient crop production.

Most Florida tomatoes are grown on some form of the full-bed plastic mulch system, in which one of the multi-purpose fumigants is an integral part of the program. Historically, product choice has often been dictated by the pests other than nematodes for which control was desired, since most fumigants provide excellent nematode control in this system. For instance, methyl bromide is the most active of the fumigant ingredients against nutsedges (Cyperus spp.), so has often been preferred for that reason. Some growers who felt that they had little problem with nutsedge or could control it satisfactorily by other means have used Vapam or multi-purpose fumigants based on dichloropropene, such as Vorlex. Less expensive fumigant and non-fumigant nematicides are also registered for some situations in Florida tomato production.

MULTI-PURPOSE SOIL FUMIGANTS registered for Florida tomatoes are listed in Table 1. These products can help control several classes of pests, depending on product, rate, and application procedure chosen. Rates shown here are guidelines to most common uses of the products. Consult product labels to be sure of legal uses. All of these products are more effective when covered with a plastic tarp; methyl bromide products must be covered to keep that volatile active ingredient in the ground long enough to effectively control the target pests.

Since bed widths and spacing are highly variable, rates are given on a broadcast acre basis. The actual amount of chemical used per acre of field depends on the portion of the field area which is actually occupied by the beds: if beds are 30 inches wide and are spaced 60 inches apart, center-to-center, the treated area is 50% of the total field area, so 50% of the broadcast rate of product would be needed; for 36-inch beds spaced 5 feet apart, the field requires 36/60 = 60% of the broadcast rate.

The selection of multi-purpose fumigant products (Table 1) has not changed much in recent years, in contrast to less expensive fumigants. Indeed, methyl bromide is apparently less at risk of abrupt regulatory

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Table 1. MULTI-PURPOSE SOIL FUMIGANTS FOR FLORIDA TOMATOES. Note that rates are expressed in terms of broadcast treatments; see text above for explanation of calculation of actual amounts to apply per field acre, depending on bed area and spacing.

PRODUCT	ACTIVE INGREDIENTS	BROADCAST RATE/ACRE
Chlor-O-Pic	chloropicrin	35-78 gal. without tarp; 11-15 gal. when tarped
Terr-O-Gas 67, many others	methyl bromide/ chloropicrin mixtures, often in 2:1 ratio but available in many proportions	rate usually provides 180-240 lb methyl bromide/acre; use label rates
Vapam, Busan 1020	metam-sodium	40-60 gal. when tarped; 80-100 gal. with water seal
Vorlex	dichloropropene (the active ingredient of Telone II) + MITC, a tear gas similar to chloropicrin	30-50 gal.

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action now than it was in 1984. The manufacturers are presently conducting a battery of tests on its behavior in soil, its potentional to reach groundwater, and its carcinogenic potential. Preliminary and unofficial reports from all of those tests are said to be favorable to retention and possibly even expansion of soil fumigation uses of methyl bromide.

The Florida tomato industry should not complacently assume that its fumigants are again safe from further restriction. The recent history of pesticide regulatory actions should teach us all that sudden, unanticipated events can drastically alter the status of any material. Objective, scientific evaluation of data may have less to do with the fate of a product than poorly informed, emotionally charged public opinion. There are people actively seeking to abolish the use of this entire class of compounds; any incident that might give notoriety and emotional weight to their cause could rapidly alter the status of methyl bromide and its chemical relatives such as Telone products, Vorlex, and chloropicrin. There is presently a USDA task force assessing the potential impact of loss of any or all of the soil fumigants. That study is not yet complete, but the effect of losing methyl bromide and other halogenated hydrocarbon fumigants on the Florida tomato industry is already clear: at best, it would force a complete re-structuring of pest control practices; at worst, much of the industry might be forced to leave Florida. Those who want to stay in the business here should seriously investigate alternative means of managing nematodes, with the realization that most other existing nematicides are either more difficult to use effectively, less effective, or both, as they are currently used.

FUMIGANT NEMATICIDES. Moderately-priced soil fumigants intended primarily or entirely for nematode control have essentially disappeared from peninsular Florida. North Florida growers may continue to have Telone II and Telone C-17 available for their use, but most of the Florida tomato industry does not presently have that option. The long-term fate of these dichloropropene-based products depends on the results of studies of its fate in soil and water and its carcinogenic potential that are not yet completed.

Where tomatoes are grown in less intensive culture without use of plastic mulch and only nematode control is desired, Telone II can still provide economical, reliable nematode control where it is still available. It is relatively cheap and easy to apply with simple pump or gravity-flow regulators and is registered for use in production of most vegetables. It is thus economically feasible and often the only practical nematicide for small market-garden operations.

VYDATE. Foliar application of Vydate L on a regular schedule of 2-4 pts/acre in at least 100 gallons of water/acre, at 1-2 week intervals, seems to suppress nematode activity in tomatoes. This may provide a reasonable means to prevent significant nematode damage to a second crop planted on plastic-mulched beds without disturbing the beds for fumigation. It should not be depended upon to provide primary nematode control where a significant infestation is anticipated. Consult product labelling for specific application guidelines.

TOMATO PLANT DISEASE
CHEMICAL CONTROL GUIDE

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Crop	Chemical	Rate/A	Minimum days to harvest	Pertinent Diseases listed on label	Pertinent Diseases not listed on the label but also controlled	Special Remarks
Tomato	Benlate	1/2 - 1 lb.	NTL	Gray mold Leaf mold White mold (Sclerotinia) Phoma leaf spot	Target spot Rhizoctonia fruit rot	Field & Greenhouse.
	Botran 75 W	1 lb/100 gal water	NTL	Botrytis stem canker		Seedlings or newly set transplants may be injured by drenching. Greenhouse use only.
	Bravo 500	2 1/4 - 4 1/4 pts.	NTL	Early blight Late blight Gray leaf spot Leaf mold Septoria leaf spot Gray mold Black mold Rhizoctonia fruit rot Bacterial spot (when combined with Kocide 101, Tri-basic Copper Sulfate, or CP-Basic Copper TS-53-WP)	Phoma leaf spot Target spot Rhizoctonia fruit rot Bacterial speck (when used as indicated for bacterial spot)	Do not use with Copper Count-N in concentrated spray mixtures.
	Manzate 200 Flowable	1.3 - 2.5 qts.	5	Same as Dithane M-45		

Crop	Chemical	Rate/A	Minimum days to harvest	Pertinent Diseases listed on label	Pertinent Diseases not listed on the label but also controlled	Special Remarks
Tomatoes (Cont'd)	Dithane FZ	Field 0.8-2.4 qts greenhouse 4.5-6.1 fl oz/5000 sq ft	5	Leaf mold Early blight Late blight Gray leaf spot Septoria leaf spot Bacterial spot (use 1.2 qts combined with copper fungicides as in Dithane M-45)	See Dithane M-45	Do not use on young plants in greenhouse to avoid injury.
	Dithane M-45	1 1/2 - 3 lbs.	5	Late blight Early blight Gray leaf spot Leaf mold Bacterial spot	Leaf mold Phoma leaf spot Target spot Bacterial spot & Bacterial speck (When combined with Kocide 101, Tri-basic Copper Sulfate, or CP-Basic Copper TS-53-WP)	
	Dithane M-22	1-3 lbs.	5	Early blight Late blight Septoria leaf spot Gray leaf spot Leaf mold	See Dithane M-45	Field or greenhouse. Do not use on young tender plants under glass.
	Dithane M-22 Special	1-3 lbs.	5	Early blight Late blight Gray leaf spot Septoria leaf spot Bacterial spot	See Dithane M-45	To avoid injury do not use on young plants in greenhouse.

Crop	Chemical	Rate/A	Minimum days to harvest	Pertinent Diseases listed on label	Pertinent Diseases not listed on the label but also controlled	Special Remarks
Tomatoes (Cont'd)	Manzate	1 1/2 - 2 lbs.	5	Early blight Late blight Septoria leaf spot Gray leaf spot	See Dithane M-45	Do not use on young plant in greenhouse as injury may occur.
	Manzate D	1 1/2 - 2 lbs.	5	Early blight Late blight Septoria leaf spot Gray leaf spot	See Dithane M-45	Do not use on young plants in greehhouse as injury may occur.
	Manzate 200	1 1/2 - 3 lbs.	5	Early blight Late blight Gray leaf spot Gray leaf mold Bacterial spot	See Dithane M-45	
	Manzate Flowable	Field 1.2-2.4 qts. Greenhouse 4.5-6.1 fl oz/5000 sq ft	5	Early blight Late blight Septoria leaf spot Gray leaf spot	See Dithane M-45	Field and greenhouse. Do not use on young seedlings in greenhouse as injury may occur.
	Manex	1.2-1.6 qts.	5	Leaf mold Early blight Late blight Gray leaf spot Septoria leaf spot	Target spot Phoma leaf spot	Field or greenhouse.

Crop	Chemical	Rate/A	Minimum days to harvest	Pertinent Diseases listed on label	Pertinent Diseases not listed on the label but also controlled	Special Remarks
Tomatoes (Cont'd)	Difolatin 80 Sprills (Mechanically harvested tomatoes only)	1 1/2 - 3 lbs.	NTL	Early blight Late blight Gray leaf spot Septoria leaf spot Fruit rot	Target spot Phoma leaf spot Leaf mold	Fruit spotting may occur when applied during high temperatures or drought stress.
	Dyrene (not for use in greenhouse)	2-5 lbs.	NTL	Botrytis Early blight Late blight Septoria leaf spot		If temperatures exceed 85^0 F do not use more than 1 lb if tank mixed with a copper fungicide.
	Kocide 101	2-4 lbs.	NTL	Early blight Bacterial speck Bacterial spot	See Dithane M-45	Minimum days to harvest is 5 if used with a Dithane or Manzate fungicide.
	Kocide 606	2 2/3 - 5 1/3 pts.	NTL	Early blight Bacterial speck Bacterial spot	See Dithane M-45	Same as Kocide 101
	Tri-basic Copper Sulfate	2-4 lbs.	NTL	Bacterial spot Bacterial canker Early blight Late blight Leaf mold Septoria Stemphyllium leaf spot	See Dithane M-45	Same as Kocide 101

Crop	Chemical	Rate/A	Minimum days to harvest	Pertinent Diseases listed on label	Pertinent Diseases not listed on the label but also controlled	Special Remarks
Tomatoes (Cont'd)	CP-Basic Copper TS-53 WP	2-4 lbs.	NTL	Same as Tri-basic Copper sulfate	See Dithane M-45	Same as Kocide 101.
	JMS Stylet Oil	3 qts.	NTL	Potato virus Y Tobacco etch virus Pepper mottle virus	Tomato yellows	Must be applied with gound rig at 400 psi using Tee Jet TX5 SS nozzles. **READ LABEL**
	Ridomil 2E[1] (Soil application)	2-4 pts. (Broadcast only)	PPI treatment for plant beds	Pythium damping off in plant beds Late blight Phytophthora stem canker		Not a necessary treatment for Pythium if beds are fumigated prior to seedling and recontamination of fumigated soil is avoided. Not for use in greenhouses.
	Ridomil 2E[1] (Soil application)	4-8 pts.[2] (Broadcast rate)		Pythium damping off for field	Phytophthora stem canker Late blight	Same as entry above.

1 Do not apply more than 12 pints Ridomil 2E/season.
2 PPI (via mechanical device) or POPI (via irrigation) broadcast or banded.

Crop	Chemical	Rate/A	Minimum days to harvest	Pertinent Diseases listed on label	Pertinent Diseases not listed on the label but also controlled	Special Remarks
Tomatoes (Cont'd)	Ridomil 2E[1] (Soil application)	4 pts.[2] (Broadcast rate)		Phytophthora or Pythium fruit rots	Late blight	Same as entry above.
	Ridomil MZ-58[3] (Foliar spray)	1 1/2 - 2 lbs.	5	Late blight	Phytophthora stem canker Pythium fruit rot	Only Dithane M-45, Manzate 200, Manzate or Dithane M-22 may be tank mixed with Ridomil MZ-58. Do not apply more than 2 lbs/A of Manzate or Dithane fungicides with Ridomil MZ-58.

1 Do not apply more than 12 pints ridomil 2E/season.

2 Soil surface 4-8 weeks before harvest followed by irrigation. If plastic used on beds, apply as a band next to bed in middles if roots have developed beyond plastic. Ridomil translocates upward in plant from root. If plastic not used, band on soil below drip line.

3 High rate is equivalent to 40% of Mancozeb a.i. in Dithane M-45 or Manzate 200.

LEGAL INSECTICIDES

FOR CONTROL OF INSECTS

ON

TOMATOES

July 1985

Prepared by Freddie A. Johnson, Professor, Extension Entomologist, Institute of Food and Agricultural Sciences, University of Florida, Gainesville, Florida 32611

TOMATOES (REVISED 7-18-85)

INSECT	INSECTICIDE	FORMULATION	RATE/ACRE	MIN. DAYS TO HARVEST
ants	allethrin (Pyrellin SCS)	1% liquid (EC)	1-1 1/2 pts.	see label
aphids	allethrin (Pyrellin SCS)	1% liquid (EC)	1-1 1/2 pts.	see label
	aliphatic petroleum (JMS-Stylet Oil)	97.6% EC	see label.	see label
	azinphosmethyl (Guthion)	2 S (EC)	2-3 pts.	0
	demeton (Systox)	2 EC	1-1 1/2 pts./ 100 gal.	3
	diazinon	4 EC	1/2 pt.	1
	dimethoate (Cygon, Defend)	4 EC	1/2-1 pt.	7
	disulfoton (Di-Syston)	15 G	8-23.4 oz./1000 ft. row (any row space)	30
	endosulfan (Thiodan) (green aphid aphid)	3 EC	2/3 qt.	1
	lindane (Isotox-lindane)	25 WP	1 lb.	do not apply after fruits start to form
	malathion	5 EC	1 pt./100 gal.	1
	methamidophos (Monitor)	4 EC	1 1/2-2 pts.	7
	methomyl (Lannate, Nudrin)	1.8 L	2-4 pts.	1 - 2 pts. 2 - 2+ pts.

TOMATOES

INSECT	INSECTICIDE	FORMULATION	RATE/ACRE	MIN. DAYS TO HARVEST
aphids (cont.)	methoxychlor + diazinon (Alfa-Tox)	30% liquid (EC)	2 1/2 qts.	1
	mevinphos (Phosdrin)	4 EC	1/4-1/2 pt.	1
	methyl parathion	4 EC	1-3 pts.	15
	monocrotophos (Azodrin)	5 S (EC)	7/8 pt.	21
	parathion	4 EC	1-2 pts.	10
	phosphamidon	8 EC	1/2 pt.	10
	pyrethrins + piperonyl butoxide (Pyrenone) (green peach aphid)	66% liquid (EC)	2-6 oz./100 gal.	0
armyworms (also see other specific types of armyworms)	allethrin (Pyrellin SCS)	1% liquid EC	1-1 1/2 pts.	see label
	carbaryl (Sevin)	5 B	40 lbs.	0
	diazinon	4 EC	3/4-1 pt.	6
	fenvalerate (Pydrin) (Southern, Sugarbeet Western Yellow-Striped)	2.4 EC	5 1/3-10 2/3 ozs.	1
	methomyl (Lannate, Nudrin)	1.8 L	1-2 pts.	1
	methyl parathion	4 EC	1-3 pts.	15

TOMATOES

INSECT	INSECTICIDE	FORMULATION	RATE/ACRE	MIN. DAYS TO HARVEST
armyworms (cont.)	parathion (up to 3rd instar)	4 EC	1-2 pts.	10
	trichlorofon (Dylox, Proxol)	5 B	20 lbs.	28
(fall armyworms)	carbaryl (Sevin)	80 WP	1 1/2-2 1/2 lbs.	0
	diazinon	4 EC	3/4-1 pt.	1
	methomyl (Lannate, Nudrin)	1.8 L	2 pts.	1
	methoxychlor (Marlate)	50 WP	2-6 lbs.	1 - 3 1/2 lbs. 7 - 3 1/2+ lbs.
	methoxychlor + diazinon (Alfa-Tox)	30% liquid (EC)	2 1/2 qts.	1
(southern armyworms)	diazinon	4 EC	3/4-1 pt.	1
	fenvalerate (Pydrin)	2.4 EC	5 1/3-10 2/3 ozs.	1
	methomyl (Lannate, Nudrin)	1.8 L	2-4 pts.	1 - 2 pts. 2 - 2+ pts.
	permethrin* (Ambush) (Pounce)	2 EC 3.2 EC	3.2-12.8 ozs. 2-8 ozs.	up to day of harvest
(beet armyworms)	fenvalerate (Pydrin) (Sugarbeet armyworm)	2.4 EC	5 1/3-10 2/3 ozs.	1
	methomyl (Lannate, Nudrin)	1.8 L	2-4 pts.	1 - 2 pts. 2-2+ pts.
	permethrin* (Ambush) (Pounce)	2 EC 3.2 EC	3.2-12.8 ozs. 2-8 ozs.	up to day of harvest

(for tomatoes to be used for fresh market only - do not use on cherry tomatoes)

TOMATOES

INSECT	INSECTICIDE	FORMULATION	RATE/ACRE	MIN. DAYS TO HARVEST
(yellow striped armyworms)	azinphosmethyl (Guthion)	2 S (EC)	3-6 pts.	14
	endosulfan (Thiodan)	3 EC	1 1/3 qts.	1
	fenvalerate (Pydrn) (Western Yellow Striped)	2.4 EC	5 1/3-10 2/3 ozs.	1
banded cucumber beetle	azinphosmethyl (Guthion)	2 S (EC)	1 1/2-2 pts.	0
	diazinon	4 EC	3/4-1 pt.	1
	lindane (Isotox-lindane) larvae	25 WP	1-2 lbs.	Preplant (soil)
beetles	allethrin (Pyrellin SCS)	1% liquid (EC)	1-1 1/2 pts.	See label.
blister beetle	cryolite (Kryocide)	96 WP	15-30 lbs.	wash fruit
	endosulfan (Thiodan)	3 EC	2/3 qt.	1
	methoxychlor (Marlate)	50 WP	2-7 lbs.	1 - 3 1/2 lbs. 7 - 3 1/3+ lbs.
	methoxychlor + diazinon (Alfa-Tox)	30% liquid EC	2 1/2 qts.	1
	parathion	4 EC	1-2 pts.	10

TOMATOES

INSECT	INSECTICIDE	FORMULATION	RATE/ACRE	MIN. DAYS TO HARVEST
cabbage looper	<u>Bacillus thruingiensis</u> Bactospeine, Bactur, Dipel, Sok, Stan-Guard, Thuricide)	See individual labels.		0
	cryolite (Kryocide)	96 WP	15-30 lbs.	wash fruit
	endosulfan (Thiodan)	3 EC	1 qt.	1
	fenvalerate (Pydrin)	2.4 EC	5 1/3-10 2/3 ozs.	1
	methomyl (Lannate, Nudrin)	1.8 L	2-4 pts.	1 - 2 pts. 2 - 2+ pts.
	methomyl (Lannate, Nudrin)	1.8 L +	1-2 pts.+ 1/2 lb.	1 - 2 pts. 2 - 2+ pts.
	methyl parathion	4 EC	2-3 pts.	15
	monocrotophos (Azodrin)	5 S (EC)	1 5/8 pts.	21
	permethrin* (Ambush) (Pounce)	2 EC 3.2 EC	3.2-12.8 ozs. 2-8 ozs.	up to day of harvest
Colorado potato beetle	azinphosmethyl (Guthion)	2 S (EC)	1 1/2 pts.	0
	carbaryl (Sevin)	80 WP	2/3-1 1/4 lb.	0
	disulfoton (Di-Syston)	8 EC	1.2-3.5 fl. oz./ 1000 ft. row (any row spacing) or 1-3 pts./A (38" row spacing)	30

TOMATOES

INSECT	INSECTICIDE	FORMULATION	RATE/ACRE	MIN. DAYS TO HARVEST
Colorado potato beetle (cont.)	disulfoton (Di-Syston)	15 G	8-23.4 oz./1000 ft. row (any row spacing) or 6.7-20 lbs./A (38" row spacing)	30
	endosulfan (Thiodan)	3 EC	2/3 qt.	1
	fenvalerate (Pydrin)	2.4 EC	5 1/3-10 2/3 ozs.	1
	methoxychlor (Marlate)	50 WP	2-6 lbs.	1 - 3 1/2 lbs. 7 - 3 1/2+ lbs.
	parathion	4 EC	1-2 pts.	10
	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
	phosphamidon	8 EC	1/2 pt.	10
	pyrethrins + piperonyl butoxide (Pyrenone)	66% liquid (EC)	2-6 oz./100 gal.	0
corn earworm (See also tomato fruitworms)	azinphosmethyl (Guthion)	2 S (EC)	3-6 pts.	14
crickets	carbaryl (Sevin)	5 B	40 lbs.	0
	trichlorfon (Dylox, Proxol)	5 B	20 lbs.	28

TOMATOES

INSECT	INSECTICIDE	FORMULATION	RATE/ACRE	MIN. DAYS TO HARVEST
cutworms (cont.)	allethrin (Pyrellin SCS)	1% liquid (EC)	1-1 1/2 pts.	see label
	carbaryl (Sevin)	80 WP	2 1/2 lbs.	0
	carbaryl (Sevin)	5 B	40 lbs.	0
	diazinon	14 G	14-28 lbs.	preplant
	diazinon	4 EC	2-4 qts.	preplant
	fenvalerate (Pydrin)	2.4 EC	5 1/3-10 2/3 ozs.	1
	lindane (Isotox-lindane)	25 WP	1-2 lbs.	preplant (soil)
	methomyl (Lannate) (varigated cutworm)	1.8 L	2 pts.	1
	permethrin* (Ambush) (Pounce) (granulate cutworm)	2 EC 3.2 EC	3.2-12.8 ozs. 2.8 ozs.	up to day of harvest
	trichlorfon (Dylox, Proxol) (survace feeding cutworms)	5 B	20 lbs.	28
darkling ground beetles	carbaryl (Sevin)	5 B	40 lbs.	0
Drosophila (fruit flies)	azinphosmethyl (Guthion)	2 S (EC)	1 1/2-2 pts.	0
	diazinon	4 EC	1/2-1 1/2 pts.	1
	malathion	5 EC	2 1/2 pts.	1
	naled (Dibrom)	8 EC	1 pt.	1

TOMATOES

INSECT	INSECTICIDE	FORMULATION	RATE/ACRE	MIN. DAYS TO HARVEST
European corn borer	azinphosmethyl (Guthion)	2 S (EC)	2-3 pts.	0
	carbaryl (Sevin)	80 WP	1 1/4-2 1/2 lbs.	0
flea beetles	azinphosmethyl (Guthion)	2 S (EC)	2-3 pts.	0
	carbaryl (Sevin)	80 WP	2/3-1 1/4 lbs.	0
	carbophenothion (Trithion) (potato flea beetle)	8 EC	1/2-1 pt.	7
	cryolite (Kryocide)	96 WP	15-30 lbs.	wash fruit
	disulfoton (Di-Syston)	8 EC	1.2-3.5 fl. oz./ 1000 ft. row (any row spacing) or 1-3 pt./A (38" row spacing)	30
	disulfoton (Di-Syston)	15 G	8-23.4 oz./1000 ft. row (any row spacing) or 6.7-20 lb./A (38" row spacing)	30
	endosulfan (Thiodan)	3 EC	2/3 qt.	1
	fenvalerate (Pydrin)	2.4 EC	5 2/3-10 2/3 ozs.	1
	methyl parathion	4 EC	1-3 pts.	10 - 1 pt. 15 - 1+ pt.
	methoxychlor (Marlate)	50 WP	2-6 lbs.	1 - 3 1/2 lbs. 7 - 3 1/2+ lbs.

TOMATOES

INSECT	INSECTICIDE	FORMULATION	RATE/ACRE	MIN. DAYS TO HARVEST
flea beetles (cont.)	methoxychlor + diazinon (Alfa-Tox)	30% liquid (EC)	2 1/2 qts.	1
	naled (Dibrom)	8 EC	1 pt.	1
	parathion	4 EC	1-2 pts.	10
	Penncap-M	2 EC	2-4 pts.	15
	phosphamidon	8 EC	1/2 pts.	10
	pyrethrins + piperonyl butoxide (Pyrenone)	66% liquid (EC)	2-6 oz./100 gal.	0
garden symphylans	fonofos (Dyfonate)	10 G	20 lbs.	preplant, broadcast
grasshoppers	azinphosmethyl (Guthion)	2 S (EC)	2-3 pts.	0
	carbaryl (Sevin)	5 B	40	0
	fenvalerate (Pydrin)	2.4 EC	5 1/3-10 2/3 ozs.	1
	mevinphos (Phosdrin)	4 EC	1/2-1 pt.	1
	parathion	4 EC	1-2 pts.	10

TOMATOES

INSECT	INSECTICIDE	FORMULATION	RATE/ACRE	MIN. DAYS TO HARVEST
hornworms (tomato hornworms)	azinphosmethyl (Guthion)	2 S (EC)	3-6 pts.	14
	Bacillus thuringiensis Bactospeine, Bactur, Dipel, Stan-Guard, Sok, Thuricide)	See individual labels.		0
	carbaryl (Sevin)	80 WP	1 1/4-2 1/2 lbs.	0
	cryolite (Kryocide)	96 WP	15-30 lbs.	wash fruit
	endosulfan (Thiodan)	3 EC	2/3-1 1/3 qts.	1
	fenvalerate (Pydrin)	2.4 EC	2 2/3-5 1/3 ozs.	1
	methomyl (Lannate)	1.8 L	2-4 pts.	1 - 2 pts. 2 - 2+ pts.
	naled (Dibrom)	8 EC	1 pt.	1
	Penncap-M	2 EC	4 pts.	15
	permethrin* (Ambush)	2 EC	3.2-12.8 ozs.	up to day
	(Pounce)	3.2 EC	2-8 ozs.	of harvest
	trichlorfon (Dylox, Proxol)	80 SP	20 oz.	21

TOMATOES

INSECT	INSECTICIDE	FORMULATION	RATE/ACRE	MIN. DAYS TO HARVEST
lacebugs	carbaryl (Sevin)	80 WP	1 1/4-2 1/2 lbs.	0
leafhoppers	allethrin (Pyrellin SCS)	1% liquid EC	1-1 1/2 pts.	see label
	azinphosmethyl (Guthion)	2 S (EC)	2-3 pts.	0
	carbaryl (Sevin)	80 WP	2/3-1 1/4 lbs.	0
	carbophenothion (Trithion) (potato leafhopper)	8 EC	1/2-1 pt.	7
	disulfoton (DiSyston)	8 EC	1.2-3.5 fl. oz./ 1000 ft. row (any row spacing) or 1-3 pts./A (38" row spacing)	30
	disulfoton (Di-Syston)	15 G	8-23.4 oz./1000 ft. row (any row spacing) or 6.720 lbs./A (38" row spacing)	30
	dimethoate (Cygon, Defend)	4 EC	1/2-1 pt.	7
	methoxychlor (Marlate)	50 WP	2-6 lbs.	1 - 3 1/2 lbs. 7 - 3 1/2+ lbs.

TOMATOES

INSECT	INSECTICIDE	FORMULATION	RATE/ACRE	MIN. DAYS TO HARVEST
leafhoppers (cont.)	methyl parathion	4 EC	1-2 pts.	15
	mevinphos (Phosdrin)	4 EC	1/2-1 pt.	1
leafminers	allethrin (Pyrellin SCS)	1% liquid (EC)	1-1 1/2 pts.	see label
	azinphosmethyl (Guthion)	2 S (EC)	1 1/2-2 pts.	0
	carbophenothion (Trithion)	8 EC	1/2-1 pt.	7
	diazinon	4 EC	1/2 pt.	1
	diazinon	50 WP	1/2 lb.	1
	dimethoate (Cygon, Defend)	4 EC	1/2-1 pt.	7
	disulfoton (Di-Syston)	8 EC	1.2-3.5 fl. oz./ 1000 ft. row (any row spacing) or 1-3 pts/A (38" row spacing)	30
	disulfoton (DiSyston)	15 G	8-23.4 oz./1000 ft. row (any row spacing) or 6.7-20 lbs./A (38" row spacing)	30
	ethion	4 EC	1 pt.	2
	fenvalerate (Pydrin)	2.4 EC	10 2/3 ozs.	1

TOMATOES

INSECT	INSECTICIDE	FORMULATION	RATE/ACRE	MIN. DAYS TO HARVEST
leafminers (cont.)	lindane (Isotox-linedane)	25 WP	1 1/2 lbs.	Do not apply after fruit starts to form.
	methamidophos (Monitor) (adults)	4 EC	1 1/2-2 pts.	7
	methoxychlor + diazinon (Alfa-Tox)	30% liquid (EC)	2 1/2 qts.	1
	monocrotophos (Azodrin)	5 S (EC)	1 5/8 pts.	21
	naled (Dibrom)	8 EC	1 pt.	1
	oxamyl (Vydate L)	2 EC	2-4 pts./100 gal.	1
	parathion	4 EC	1-2 pts.	10
	Penncap-M	2 EC	2-4 pts.	15
	permethrin* (Ambush) (Pounce)	2 EC 3.2 EC	3.2-12.8 ozs. 2-8 ozs.	up to day of harvest
	phorate (Thimet)	15 G	15 oz./1000 ft. row (min. 38" spacing)	at planting
	phosphamidon	8 EC	1/2 pt.	10
	trichlorfon (Dylox, Proxol)	80 SP	20 oz.	21
loopers	allethrin (Pyrellin SCS)	1% liquid (EC)	1-1 1/2 pts.	see label

TOMATOES

INSECT	INSECTICIDE	FORMULATION	RATE/ACRE	MIN. DAYS TO HARVEST
loopers (cont.)	methomyl (Lannate, Nudrin)	1.8 L	2-4 pts.	1-2 pts. 2-2+ pts.
mites	allethrin (Pyrellin SCS)	1% liquid (EC)	1-1 1/2 pts.	see label
	carbophenothion (Trithion) (russet, tropical & two-spotted mites)	4 EC	1-2 pts.	7
	demeton (Systox)	2 EC	1-1 1/2 pts./100 gal.	3
	dicofol (Kelthane)	1.6 EC	1-2 qts.	2
	disulfoton (Di-Syston)	8 EC	1.2-3.5 fl. oz./ 1000 ft. row (any row spacing) or 1.3 pts. (38" row spacing)	30
	disulfoton (Di-Syston)	15 G	8-23.4 oz./1000 ft. row (any row spacing) or 6.7-20 lbs./A (38" row spacing)	30
	ethion (tropical, two-spotted, and tomato russet mites)	4 EC	1 pt.	2
	methyl parathion	4 EC	1-2 pts.	15
	mevinphos (Phosdrin)	4 EC	1/2 - 1 pt.	1
	naled (Dibrom)	8 EC	1 pt.	1

TOMATOES

INSECT	INSECTICIDE	FORMULATION	RATE/ACRE	MIN. DAYS TO HARVEST
(tomato russet mite)	endosulfan (Thiodan)	3 EC	1 1/3 qts.	1
	malathion	25 WP	2-4 lbs.	1
	methyl parathion	4 EC	1-3 pts.	15
	parathion	4 EC	1-2 pts.	10
	sulfur (Kolospray)	81% WP	7 lbs.	0
	sulfur (Magneticide)	6 F	1/2-1 gal.	0
(spider mite)	malathion	5 EC	1 1/2 pts./100 gal.	1
mole crickets	diazinon	15 G	7 lbs.	preplant
	diazinon	4 EC	1 qt.	preplant, broadcast
pinworm (tomato pinworm)	allethrin (Pyrellin SCS)	1% liquid (EC)	1-1 1/2 pts.	see label
	azinphosmethyl (Guthion)	2 S (EC)	3-6 pts.	14
	carbaryl (Sevin)	80 WP	1 1/4-2 1/2 lbs.	0
	cryolite (Kryocide)	96 WP	15-30 lbs.	wash fruit
	fenvalerate (Pydrin)	2.4 EC	5 1/3-10 2/3 ozs.	1

TOMATOES

INSECT	INSECTICIDE	FORMULATION	RATE/ACRE	MIN. DAYS TO HARVEST
pinworm (tomato pinworm) cont.	methamidophos (Monitor) (suppression of low populations)	4 EC	1 1/2-2 pts.	7
	methomyl (Lannate, Nudrin)	1.8 L	2-4 pts. (ground application only)	1 - 2 pts. 2 - 2+ pts.
	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
plant bugs	allethrin (Pyrellin SCS)	1% liquid (EC)	1-1 1/2 pts.	see label
	carbaryl (Sevin)	80 WP	1 1/4-2 1/2 lbs.	0
	methyl parathion	4 EC	2 pts.	15
	parathion	4 EC	1-2 pts.	10
potato flea beetle	carbophenothion (Trithion)	8 EC	1/2-1 pt.	7
potato psyllid	carbophenothion (Trithion)	4 EC	1-2 pts.	7
	endosulfan (Thiodan)	3 D	33 lbs.	1
	methyl parathion	4 EC	1-3 pts.	15
	parathion	4 EC	1-2 pts.	10
salt marsh caterpillar	trichlorfon (Dylox, Proxol)	5 B	20 lbs.	28

TOMATOES

INSECT	INSECTICIDE	FORMULATION	RATE/ACRE	MIN. DAYS TO HARVEST
sowbug	carbaryl (Sevin)	5 B	40 lbs.	0
stinkbugs	azinphosmethyl (Guthion) (green stinkbugs)	2 S (EC)	1 1/2-2 pts.	0
	carbaryl (Sevin)	80 WP	1 1/4-2 1/2 lbs.	0
	endosulfan (Thiodan)	3 EC	1-1 1/3 qts.	1
	parathion	4 EC	1-2 pts.	10
	phosphamidon	8 EC	1/2 pt.	10
	pyrethrins + piperonyl butoxide (Pyrenone)	66% liquid (EC)	2-6 oz./100 gal.	0
thrips	azinphosmethyl (Guthion)	2 S (EC)	2-3 pts.	0
	lindane (Isotox-lindane)	25 WP	1 lb.	Do not apply after fruit starts to form.
	parathion	4 EC	1-2 qts.	10

TOMATOES

INSECT	INSECTICIDE	FORMULATION	RATE/ACRE	MIN. DAYS TO HARVEST
tomato fruitworm (same specifics as corn earworm and fruitworm)	azinphosmethyl (Guthion)	2 S (EC)	3-6 pts.	14
	carbaryl (Sevin)	80 WP	1 1/4-2 1/2 lbs.	0
	cryolite (Kryocide)	96 WP	15-30 lbs.	wash fruit
	fenvalerate (Pydrin)	2.4 EC	5 1/3-10 2/3 ozs.	1
	methamidophos (Monitor)	4 EC	1 1/2-2 pts.	7
	methomyl (Lannate, Nudrin)	1.8 L	2-4 pts.	1 - 2 pts. 2 - 2+ pts.
	methoxychlor + diazinon (Alfa-Tox)	30% liquid (EC)	2 1/2 qts.	1
	monocrotophos (Azodrin)	5 EC	1 5/8 pts.	21
	naled (Dibrom)	8 EC	1 pt.	1
	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
tuberworm	azinphosmethyl (Guthion)	2 S (EC)	2 1/4-3 pts.	0
weevils	allethrin (Pyrellin SCS)	1% liquid (EC)	1-1 1/2 pts.	see label.
whitefly	azinphosmethyl (Guthion)	2 S (EC)	1 1/2-2 pts.	0
	endosulfan (Thiodan)	3 EC	2/3 qt./100 gal.	1

TOMATOES

INSECT	INSECTICIDE	FORMULATION	RATE/ACRE	MIN. DAYS TO HARVEST
whitefly (cont.)	fenvalerate (Pydrin)	2.4 EC	5 1/3-10 2/3 ozs.	1
	parathion	4 EC	1-2 pts.	10
	phosphamidon	8 EC	1/2 pt.	10
white grubs	lindane (Isotox-lindane)	25 WP	1-2 lbs.	preplant (soil)
wireworms	diazinon	14 G	21-28 lbs.	preplant
	diazinon	2 B	50 lbs.	none listed
	diazinon	14 G	70 lbs.	preplant, broadcast
	diazinon	4 EC	10 qts.	preplant, broadcast
	fonofos (Dyfonate)	10 G	20 lbs.	preplant, broadcast
	lindane (Isotox-lindane)	25 WP	1-2 lbs.	preplant (soil)

INSECT	INSECTICIDE	FORMULATION	RATE/ACRE	MIN. DAYS TO HARVEST
wireworms (cont.)	parathion	10 G	30-40 lbs.	preplant, broadcast & disc 3 wks. preplanting
	parathion	4 EC	5 qts.	apply to soil surface pre-planting & work 6-9" into soil.

*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.