Ken Pohronezny and Van H. Waddill
University of Florida Institute of Food and Agricultural Sciences
Tropical Research and Education Center, Homestead

David J. Schuster
University of Florida Institute of Food and Agricultural Sciences
Gulf Coast Research and Education Center, Bradenton

Ronald M. Sonoda
University of Florida Institute of Food and Agricultural Sciences
Agricultural Research and Education Center, Ft. Pierce

Integrated Pest Management for Florida Tomatoes

Tomato (*Lycopersicon esculentum* Mill.) is economically the most important vegetable crop grown in Florida. In a recent season, 40,500 acres (16,397 ha) were harvested, with a total value of \$266.3 million (1). During that year, tomatoes represented 28.7% of the total economic value of all vegetables produced in the state, or more than four times that of any other vegetable. Most of these tomatoes are produced in the southern half of the peninsula, primarily as "winter vegetables" for the northern United States and Canadian markets. In an environment intrinsically harsh to agriculture, tomato growers have adopted a complex horticultural scheme to produce their crops. Most tomatoes are now grown on raised, plastic-mulched beds (Fig. 1) fumigated with broad-spectrum biocides before planting. Such practices require initial expenditure of about \$1,000/acre (\$2,470/ha).

The climate is subtropical, with predominantly mild temperatures and seasonal periods of high rainfall. The cropping patterns in southern Florida are reversed from those in temperate regions, with the noncropping season in the hot, humid months of June, July, and August. Therefore, the pest mortality associated with northern winters does not occur in Florida. Not surprisingly, under these climatic conditions, pathogens, insects, nematodes, and weeds are a constant concern of growers and in many cases limit production.

A traditional method of dealing with foliar pest problems of Florida tomatoes is to spray every 3–7 days, usually with high-pressure, high-volume ground equipment (Fig. 1). One report states that as much as \$1 of every \$5 spent by Florida tomato growers is for pesticide spray materials (3).

In the mid-1970s, leafminers (*Liriomyza* spp.) (Fig. 2) developed into the number one pest concern of the industry (17,30). As many as 34 insecticide applications were made to a single crop (K. Pohronezny, *unpublished*) in an

Fig. 1. Fungicide being applied from a tractor-mounted, high-volume, high-pressure spray unit to direct-seeded tomatoes growing in plastic-mulched, fumigated, raised beds in Dade County, Florida.

University of Florida Agricultural Station Journal Series No. 6703.

attempt to control this pest. Results were generally poor, apparently because of buildup of pesticide resistance and of pesticide-induced increases in leafminer populations resulting from parasite mortality. At the same time, rapid urbanization in Dade County reduced the availability of land for farming and brought agricultural production and residential communities into closer contact. Subsequently, the social problems associated with the agricultural use of pesticides became more acute.

Diseases, especially bacterial spot (*Xanthomonas campestris* pv. *vesicatoria* (Doidge) Dye) (Fig. 3) and late blight (*Phytophthora infestans* (Mont.) dBy.) (Fig. 4), continued to affect production, resulting in heavy losses in some fields despite the use, in extreme cases, of 60 fungicide sprays on some winter 1977 crops (K. Pohronezny, *unpublished*).

To address the problems associated with pest management in Florida tomatoes, a pilot integrated pest management (IPM) program was established in Dade County in the winter of 1976–1977 and extended to Manatee and Hillsborough counties in 1978. From its inception, the program has been truly interdisciplinary, with components in plant pathology, entomology, nematology, and horticulture. In addition, extension and research have worked in close cooperation to create information for use by the commercial industry. In this article, we summarize the progress of the program over eight winter vegetable seasons, outline some of the major recommendations that have come out of the combined extension and research efforts, and indicate possible future trends in the use of IPM in the southern Florida vegetable-growing areas.

Fig. 2. Leafminer (*Liriomyza* spp.) infestation of tomato leaflet. Live, yellow larva can be seen at end of serpentine mine.

Fig. 3. Heavy bacterial spot (*Xanthomonas campestris* pv. *vesicatoria*) damage to field-grown tomato fruit.

Fig. 4. Late blight (*Phytophthora infestans*) lesion on stem of field-grown tomato.

Sampling Methods and Action Thresholds

The most important feature of the Florida tomato IPM program has been the systematic, twice-weekly scouting of fields and the use of the resultant biological data in farm management decisions. Such important questions as sampling intensity, sample size, and workable action thresholds were addressed by extension specialists, researchers, and county extension agents and were modified over the years as data gaps were identified and filled. The sampling procedures we describe briefly here are similar to those given in greater detail elsewhere (13,16,20).

On the basis of field perimeter measurements, fields are gridded into 2–2.5 acre (0.81–1 ha) square sections. Within each of the grid squares, a 6-ft (1.8-m) section of tomato row (6–12 contiguous plants) is used as the actual sampling unit. Scouts are instructed to select the 6-ft sampling sections without bias (e.g., without undue attention to unthrifty-looking plants).

As a sample is approached, the number of flying insects is estimated. Several methods for sampling leafminers have been tried. Currently, most commercial scouts are counting the live, or live and dead, leafminer larvae on all the shoots (0–2 true leaves), the terminal three leaflets (trifoliolate) of the third fully expanded leaf from the top of a stalk (ground tomatoes) or the top of a staked plant (three true leaves to bloom), or the terminal trifoliolate of the fourth fully expanded leaf (postbloom) on a six-plant sample. The action threshold for leafminer has evolved to a mean field density of 0.7 live larvae per trifoliolate. This threshold seems more workable than one based on total mines (16). These same leaflets are used to count aphids and eggs of Lepidoptera.

Tomato pinworm (*Keiferia lycopersicella* Walsingham) is the key insect pest of the crop. The likelihood of direct damage to the fruit when this insect is present necessitates intensive sampling and a low action threshold. Early in the program, estimation of tomato pinworm was based on sampling of upper leaves, but recent work (J. E. Pena, 1983 Ph.D. dissertation, University of Florida, Gainesville) indicates that sampling in the lower canopy is a better indicator of total damage. Useful action thresholds for tomato pinworm are 0.67 larvae per plant or 0.83 larval foliar injuries per plant.

The same six plants are used for inspecting for other insects, particularly lepidopterous larvae. Action thresholds used for lepidopterous larvae are one larva per plant prebloom and one larva or egg per field (i.e., detection) postbloom.

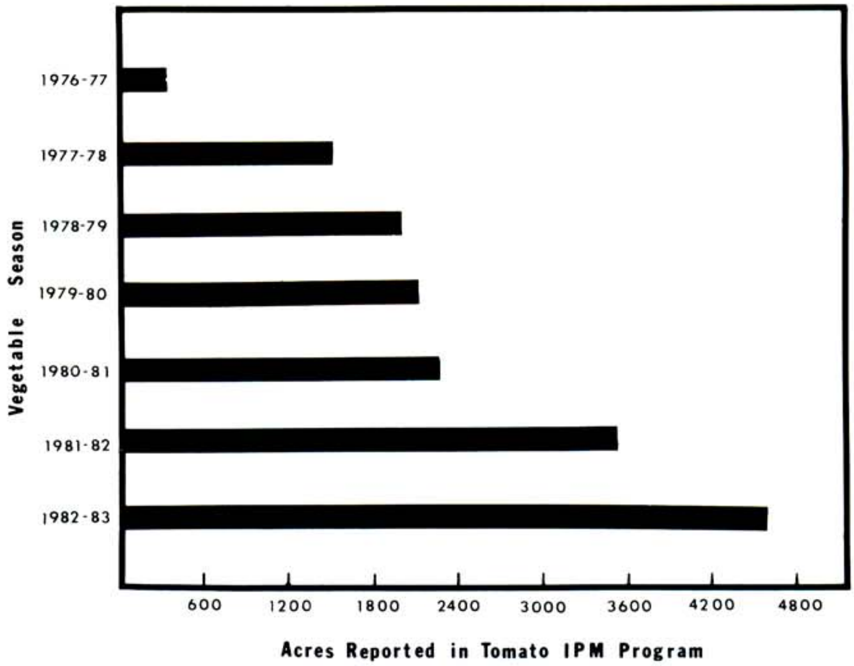


Fig. 5. Acres reported in Extension Service and privately supported tomato IPM programs in Florida from 1976 to 1983.

Table 1. Incidence of selected pests in commercial tomato fields during one cropping season (1978–1979) of pilot phase of integrated pest management program in Dade County, Florida

Pest	Affected plant organ	Pest incidence (%)[a]	
		Fall crop,[b] 1,227 samples	Winter/spring crop,[c] 1,212 samples
Disease			
Bacterial spot or	Leaves	11.0	20.5
bacterial speck	Fruit	0.5	3.7
Late blight	Leaves	0	0
Early blight	Leaves	≤0.1	0
Sclerotinia stem rot	Shoots	≤0.1	0.2
Damping-off	Shoots	0.8	0
Insect			
Leafminer	Leaves	70.0	46.4
Tomato fruitworm	Leaves	3.2	0.2
Armyworm	Leaves	6.4	2.0
Aphid	Leaves	0.9	0.7
Tomato pinworm	Leaves	0.4	0.7
	Fruit	≤0.1	4.0
Cabbage looper	Leaves	1.2	0

[a]Percentage of samples with at least one disease lesion or one insect.
[b]In cotyledon stage by 15 October 1978.
[c]In cotyledon stage after 15 October 1978.

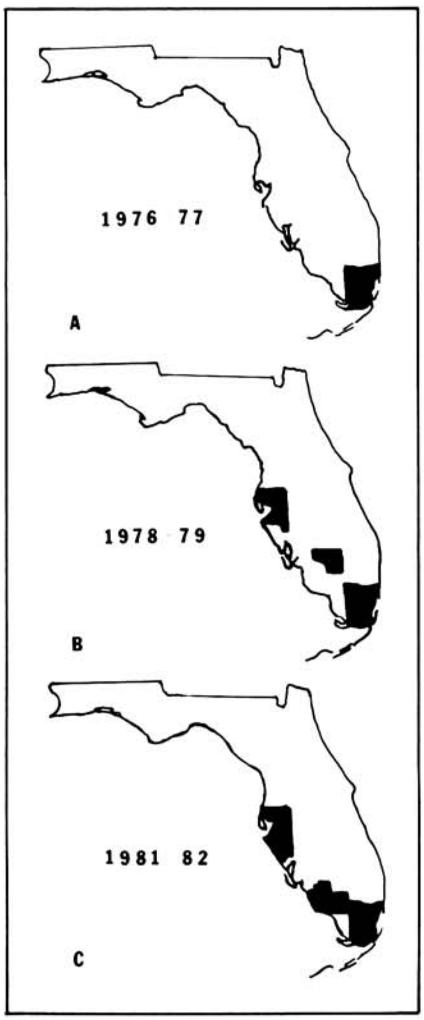


Fig. 6. Increases in acreage reported in tomato IPM programs. Counties with at least 50 acres in the programs were (A) Dade, 1976–1977; (B) Dade, Hillsborough, Manatee, and Hendry, 1978–1979; and (C) Dade, Hillsborough, Manatee, Sarasota, and Collier, 1981–1982.

Foliar diseases are assessed with the Horsfall-Barratt grading system. Diseases or insects that cause whole plant loss are assessed as a percentage of the stand affected. Because "scout-and-spray" tactics do not provide adequate control of several important foliar diseases, especially late blight (8), growers are advised to spray on a 5–7 day schedule with a broad-spectrum fungicide.

As they move from sample site to sample site, scouts are encouraged to make general observations of disease and insect occurrence and of relative abundance of weeds. Since most of the tomato crop is grown on fumigated beds, nematodes and other soilborne pests are usually well controlled. If decisions about nematode control need to be made, however, growers are urged to base those decisions on the status of the previous crop or a combination of preplant soil samples and bioassays (12).

Data collected by scouts are used by farm managers to make treatment decisions based on extension service guidelines. For example, if scouts in the field determine the mean leafminer density to be 0.5 live larvae, the grower considers the recommended threshold, current markets, and other factors in deciding to treat or not to treat.

Program Progress

During the first year (1976–1977) of the pilot tomato IPM program in Dade County, 365 acres (148 ha) were scouted once a week. The program was funded entirely by the University of Florida Institute of Food and Agricultural Sciences, with monies provided to the state by the U.S. Department of Agriculture Extension Service. In 1978, Dade County growers assumed full costs for scouting, and a pilot program was also established in Manatee and Hillsborough counties (20). Today, about 4,700 acres (1,902 ha) of tomatoes are monitored twice weekly by extension-trained scouts (Fig. 5) on farms located in most southern Florida tomato-growing areas (Fig. 6). Funding is handled completely in the private sector, leaving extension personnel free to concentrate on educational programs. Most of the acreage is being scouted by employees of private pest management companies that contract with grower clients, although some large farming operations have hired specialists whose primary responsibilities are field scouting.

The large number of observations recorded by scouts in the years of the pilot program were stored and analyzed on the mainframe computer at the Northeast Regional Data Center in Gainesville, using custom data management software. Data summaries proved useful in a number of ways, not the least of which was a systematic documentation of the occurrence and relative abundance of the major pests affecting tomato production. For instance, when presence/absence in samples is used as a measure of the 1978–1979 season in Dade County (Table 1), leafminer was the most common pest. Leafmines were found in 70 and 46.4% of the fall and winter/spring crop samples, respectively. Counts averaged 2.7 and 2.0 mines per trifoliolate in the fall and winter/spring crop samples, respectively. In most fields, average leafmine densities rarely exceeded action thresholds (13,16). Most direct insect damage to fruit was caused by southern armyworm (*Spodoptera eridania* (Cramer)), beet armyworm (*S. exigua* (Hubner)), and tomato fruitworm (*Heliothis zea* (Boddie)).

Bacterial speck (*Pseudomonas syringae* pv. *tomato* (Okabe) Young, Dye, & Wilkie) and bacterial spot were the most common diseases recorded by scouts (Table 1); because these two diseases are often hard to differentiate in the field, scouting data were combined. Bacterial foliage damage was found in 11 and 20.5% of the fall and winter/spring crop samples, respectively. The grand mean for Horsfall-Barratt ratings of foliar bacterial diseases was 1.3 for the fall crop and 1.5 for the winter/spring crop. Bacterial diseases were quite clumped in distribution, however, with some fields severely damaged. For example, in one winter/spring field with an average Horsfall-Barratt rating of 5 (12–25% of the tissue lost or damaged), the most severely diseased sample had a rating of 8 (more than 75% of the tissue lost or damaged). Similarly, the most severely diseased field in the fall crop had a maximum rating of 7 (more than 50% of the tissue lost or damaged) and an average field rating of 5. These scouting reports and research showing the adverse impact of bacterial spot on tomato yield, fruit quality, and size (15) support the commonly held opinion that bacterial spot and other foliar bacterial diseases are the most widespread and potentially most harmful diseases facing Florida's producers.

Other diseases found occasionally included early blight (*Alternaria solani* (Ell. & G. Martin) Jones & Grant), damping-off (*Rhizoctonia solani* Kühn and *Pythium* spp.), and Sclerotinia stem rot (*Sclerotinia sclerotiorum* (Lib.) dBy.) (Table 1). Sporadic occurrences of other diseases during 1978–1979 were fruit soil rot (*R. solani*), southern blight (*Sclerotium rolfsii* Sacc.), and brown root rot (*Pyrenochaeta lycopersici* Schneider & Gerlach). Root-knot nematode (*Meloidogyne* spp.) was found on some plants grown in fumigated beds by the end of the second commercial harvest. Similar pest spectra have been reported on tomato in other Florida counties in other years (20).

IPM scouts have brought to our attention several outbreaks of new or unusual diseases in the various tomato-growing areas of the state, including bacterial speck and Fusarium crown rot.

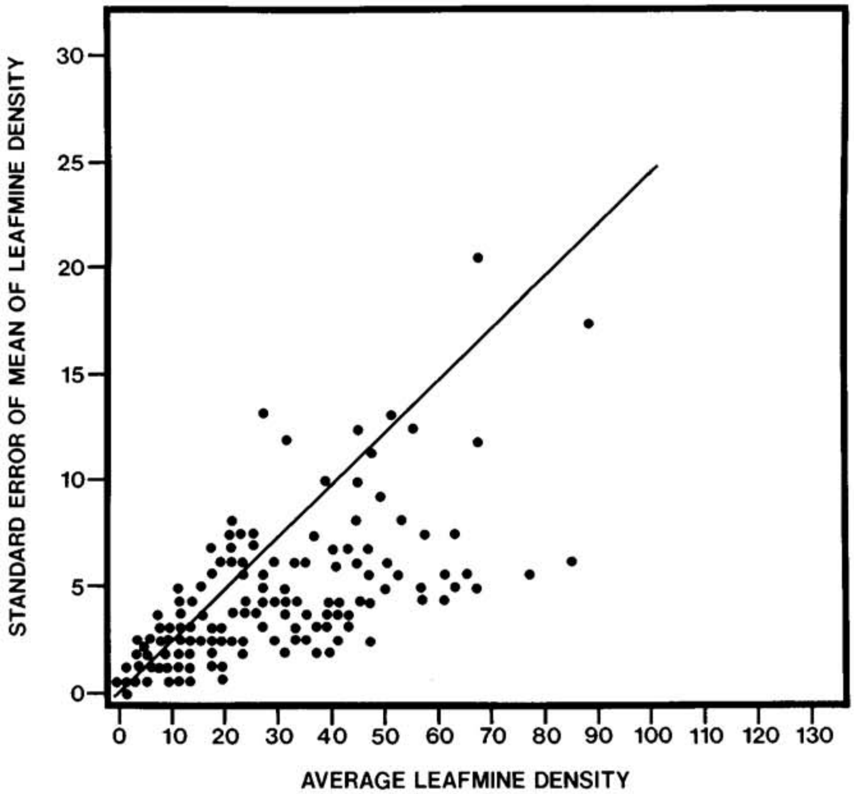


Fig. 7. Plot of the standard error (SE) of the mean of leafminer density vs. the mean leafmine density ($\bar{x}$) for commercial field data, 1978–1979, Dade County. Line in scatter diagram represents the fit of 25% RV value, where RV (%) = SE/$\bar{x}$ (100) (25), indicating that most leafminer density estimates were within precision limits considered acceptable for scouting programs.

Sampling Scheme Validation

Computer storage and analysis of scouting data aided verification of the adequacy of the sampling scheme for several pests, especially leafminers. For example, relative variation (RV) for leafminer counts was calculated for all visits to all fields, using the formula (25)

$$\mathrm{RV}\ (\%) = \mathrm{SE}/\bar{x}\ (100),$$

where SE = standard error of the mean and $\bar{x}$ = mean leafmine density for each field on each sampling date. SE was then plotted versus its corresponding $\bar{x}$. An RV value of 25% has been considered within acceptable limits of precision in entomological surveys (18). In Figure 7, SE has been plotted versus the corresponding $\bar{x}$ for all the 1978–1979 data, and the line for RV = 25% has been fitted to the scatter diagram. The large majority of points fall below the line. Results were similar in Hillsborough and Manatee counties (20). Thus, farm managers can place a high degree of confidence in the reliability of estimates of mean leafminer densities based on scouting information.

Conserving Leafminer Parasites

For most of the 1960s and the early 1970s, insecticides provided good, albeit one-dimensional, control of leafminers. Most of these insecticides were similar in chemical structure and biological mode of action, however, and resistance to new materials developed rapidly. At the same time, insecticide-induced mortality of the natural insect enemies of the leafminer was high.

Data gathered from commercial fields show that the routine use of broad-spectrum insecticides reduces parasitism of leafminer larvae. These observations verify our contention that the leafminer crises of the mid-1970s resulted at least partially from high leafminer parasite mortality in fields heavily sprayed with insecticides. During the 1977–1978 season, to test the parasite mortality hypothesis, live leafminer larvae were gathered from Dade County fields, some in which the tomato IPM program was implemented and some in which traditional spray practices were used. Larvae were returned to the laboratory and held in cartons until adult fly or parasite emergence 3 weeks later.

Parasitism rates were much lower (av. 16%) in fields receiving 10 or more spray applications of broad-spectrum insecticides than in fields receiving fewer than 10 applications (av. 44%) (Table 2). Because caterpillar control was equal with both spray regimes, we assumed that leafminer control could be enhanced by using an IPM approach. Therefore, we recommend that growers use twice-weekly scouting, apply treatments for leafminer and other insect pests at threshold levels only, and utilize caterpillar control insecticides (e.g., endosulfan and tank mixes of *Bacillus thuringiensis* and methomyl in reduced rates [22]) that have less effect on leafminer parasites. Subsequent to demonstration of the benefits of conserving parasites, some growers have reduced their use of broad-spectrum insecticides by one-third.

Table 2. Effect of broad-spectrum insecticide application frequency on parasitism of leafminer (*Liriomyza* spp.) in nine commercial tomato fields during 1977–1978 in Dade County, Florida

Fewer than 10 applications			Ten or more applications		
Field	Percent parasitism[a]	Number of applications	Field	Percent parasitism[a]	Number of applications
1	44	3	6	15	10
2	53	2	7	16	19
3	51	3	8	31	24
4	48	2	9	3	24
5	24	6			
Average	44	3.2		16	19.3

[a] Number of laboratory-reared leafminer pupae from which adult parasites emerged divided by number of pupae reared. (Data from *Citrus and Vegetable Magazine*, March 1979; used with permission of Kyle Publishing Co., Tampa, FL.)

Stimulation of Research and Extension Programs

When the pilot extension IPM program was initiated, gaps in the data base needed to make the best recommendations were readily apparent. A complete list of all the contributions made around the state to fill data gaps is beyond the scope of this article, but we will mention a few that have been readily adapted to the field.

Nematode management. Preplant decision making about the need for nematode control can be greatly enhanced by the use of a simple bioassay for root knot nematode (12). This test should be done in conjunction with standard soil sample tests for other parasitic nematodes.

Expanded pesticide evaluations. The establishment of a viable IPM program on tomatoes has stimulated an interest in and a need for pesticide research beyond routine efficacy screening. This effort has emphasized insecticides and has included the effects on parasitic insects (21,22,28), the effects on specific insect life stages (19,22), and the efficacy of "cleanup" sprays (21,22,29). This information has permitted better selection and timing of insecticide applications and thus improved the integration of chemical control into the IPM programs.

Resistance to streptomycin. Widespread resistance to streptomycin among Florida isolates of *X. campestris* pv. *vesicatoria* was documented in 1962 (26). It was hypothesized that reversion to a susceptible wild type might occur during the next 20 years, assuming diminished streptomycin use. However, recent field studies (23) have shown that resistance to streptomycin is still quite widespread in the bacterium, suggesting that streptomycin is not a viable choice for control of bacterial spot.

Reduced fungicidal activity of copper/maneb tank mixes. Growers sometimes spray heavily and routinely with tank mixes of copper and maneb or mancozeb, especially when pressure from foliar bacterial diseases is high. However, the possible problems associated with foliar fungal disease outbreaks when there is heavy dependence on copper/maneb tank mixes have been known for some time (5). Instances of severe damage from late blight (16) and target spot (9) on crops under copper/maneb regimes have been documented. Extension educational programs have renewed emphasis on the need to use maneb alone or to alternate maneb with chlorothalonil when foliar fungal diseases are more threatening than bacterial diseases.

Modern horticultural practices and pest control. A study of the interplay of horticultural practices and pest control (4) showed that bacterial spot and tomato pinworm are more damaging when overhead irrigation is used than when drip irrigation is used. The same study showed that when two rows per bed were used, disease and insect problems were not increased and yields were substantially increased. Fusarium wilt and Verticillium wilt are potentially two of the most damaging diseases of Florida tomatoes. However, their impact, as well as that of several other diseases, has been minimized by the use of resistant varieties. Disease resistance continues to be an important component of the integrated management of diseases in the state. Cultural practices that are important in pest management include use of pathogen-free seed, disease-free transplants, and crop rotation.

Ineffectiveness of BLITECAST in predicting tomato late blight in southern Florida. Since "scout-and-spray" was not a useful disease management strategy for Florida tomatoes, especially with respect to late blight (8), we tested the applicability of BLITECAST, a prediction system for potato late blight (11), to southern Florida's tomato crop. BLITECAST is based on measurements of temperature, rainfall, and relative humidity periods at or above 90%. In the first several seasons, scouting observations in commercial fields were used as the basis for establishing the actual date of appearance of tomato late blight in Dade County. Later, scouting observations were supplemented with twice-weekly detailed inspections of plots in a "disease nursery" (no fungicides applied) at the Tropical Research and Education Center in Homestead. Meteorological data were gathered both synoptically and within the crop canopy.

BLITECAST predicted the first occurrence of tomato late blight too early to be of practical value in southern Florida (Table 3). Late blight is traditionally associated with the cool, winter months in Florida when rainfall is usually minimal (10). However, BLITECAST data indicated that outbreaks were likely as early as 17 October (Table 3). The adjustments in spray programs made by experienced growers are more reflective of the time of actual outbreaks of late blight than the dates generated by BLITECAST.

Florida growers must be aware of the potential buildup of *P. infestans* during periods of extended leaf wetness, even in the absence of rain. Therefore, BLITECAST was used as originally described, i.e., late blight sprays were indicated when rainfall/temperature *or* relative humidity/temperature data reached critical levels, whichever occurred first.

There may be several reasons why BLITECAST has not been accurate in southern Florida. BLITECAST assumes that inoculum is always available (11) and that weather conditions are limiting in the subsequent outbreaks of the disease on susceptible crops. The source of primary inoculum in southern Florida is unknown. It is highly unlikely that infected potato fields are the source, since no late blight was observed in area potato fields before or during the tomato late blight epidemics of 1976–1977 and 1977–1978 (*unpublished*).

In southern Florida, lack of correlation between weather patterns in early fall and those in late fall and early winter may also explain some of our results with BLITECAST. BLITECAST assumes a correlation of blight weather from week to week (11). This assumption apparently is valid for the northeastern United States, since BLITECAST is successful there. In southern Florida, however, predicting late fall and early winter weather on the basis of early fall weather is risky indeed. For example, November signals the beginning of the dry season and has a rainfall average 14 cm less than that in October (12). Obviously, recordings of rainfall in October do not establish a pattern likely to be repeated in November. Apparently, if we are to improve spray timing for tomato late blight, we need new approaches to predicting the disease.

Table 3. BLITECAST prediction dates and dates on which tomato late blight first observed in Dade County, Florida

Cropping season	BLITECAST prediction date	Date late blight first observed
1976–1977	17 October	26 December
1977–1978	3 November	20 December
1980–1981	8 November[a]	Not observed
1981–1982	16 November[a]	Not observed
1982–1983	8 December[a]	Not observed

[a]Includes observations in a tomato "disease nursery" (no fungicides applied) at Tropical Research and Education Center in Homestead, FL.

Possible Future Trends

The successful implementation of tomato IPM in the field has made clear the need for rapid, up-to-date information delivery from extension specialists to county agents to growers. The University of Florida Institute of Food and Agricultural Sciences is developing a computer-based information system called the Florida Agricultural Information Retrieval System (FAIRS) (2). Because FAIRS is easy to operate, has rapid update capability, and can be adapted to a number of different hardware configurations, use of the system in tomato IPM will likely increase.

Although statistical analysis of scouting data has shown that the recommended sampling intensity is adequate in most instances, there is no indication that scouts can economize by reducing sampling much below that now used (Fig. 7). Therefore, scouting recommendations may be streamlined best by developing alternatives to some of the current monitoring procedures.

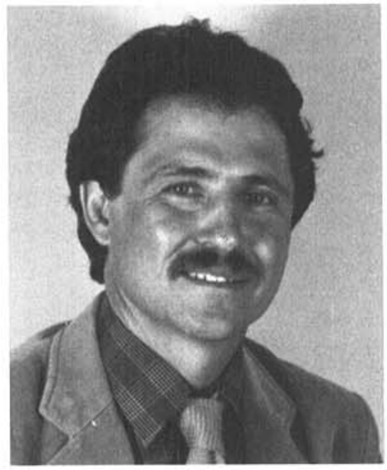
Most initial efforts probably should be directed at leafminers, since up to 50% of a scout's time at any one sampling site may be spent in assessing this pest. We have tried Styrofoam trays to trap prepupae falling from tomato foliage (7) and sticky card traps for leafminer adults (6,27). Neither has proved applicable to large-scale commercial operations in southern Florida. However, a visual rating system (18) for estimating leafminer correlates quite well with actual mine counts. The rating system is much less time-consuming and has been used successfully both in small plots and in large commercial fields visited by scouts in Hillsborough and Manatee counties. The system has increased scouting efficiency and reduced scout "burnout" associated with the tedium of assessing high leafminer densities. More work is needed (e.g., sequential sampling plans) to increase scouting efficiency without losing accuracy.

Current emphasis is on preventive sprays for disease control (14), although the arrival of new classes of fungicides with curative action suggests a reevaluation of "scout-and-spray" strategies (8) for late blight and other foliar diseases. Curative fungicides may be used in conjunction with disease prediction systems adapted specifically to southern Florida.

Extension programs need to concentrate on reinforcing IPM principles. Perhaps extension should emphasize the concept of "bioenvironmental" methods for pest control, as defined by Sonoda et al (24). To use the terminology of Whalon and Croft (31), once growers overcome a period of crisis, "implementation entropy" may be observed, i.e., a period when growers neglect the sound IPM principles learned during the crisis. This has happened to a certain extent in the southern Florida tomato business. With the appearance of several new classes of insecticides effective against leafminers and other insects, some growers have returned to routine insecticide spraying. Sooner or later, such practices probably will contribute to new cases of pesticide resistance and to secondary pest outbreaks. The established IPM programs in the state will be a firm basis from which to deal with the periodic pest emergencies certain to threaten future Florida tomato crops.

Ken Pohronezny

Dr. Pohronezny is associate professor of plant pathology at the University of Florida's Tropical Research and Education Center in Homestead. He received his B.S. degree from Pennsylvania State University and his Ph.D. degree from Ohio State University. Since joining the Florida faculty in 1976, he has been responsible for developing and implementing extension programs in integrated pest management for Florida's winter vegetables. He also maintains an interest from graduate school in the etiology and epidemiology of bacterial diseases of vegetables.

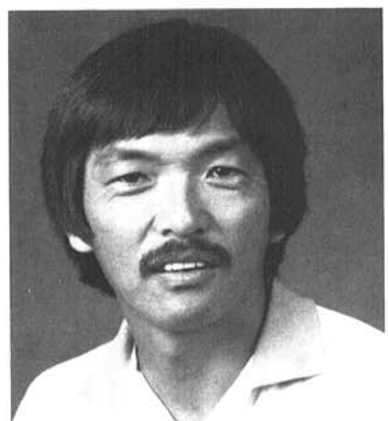


Van H. Waddill

Until recently, when he assumed responsibilities as director of the Everglades Research and Education Center in Belle Glade, Dr. Waddill was professor of entomology at the University of Florida's Tropical Research and Education Center at Homestead. His responsibilities included research on insect problems on vegetables and integration of his findings into pest management schemes. He has also been active in several studies of migratory insects that overwinter in southern Florida. He received his B.S. and M.S. degrees from Texas A&M University and his Ph.D. from Clemson University.

David J. Schuster

Dr. Schuster, professor of entomology at the University of Florida, has been located at the Gulf Coast Research and Education Center in Bradenton since 1975. He received his Ph.D. degree from Oklahoma State University in 1973. He is conducting research to support integrated pest management programs on tomatoes and other vegetable commodities grown on the west coast of Florida, with emphasis on population assessment and action thresholds, chemical control, biological control, and host plant resistance.



Ronald M. Sonoda

Dr. Sonoda is professor of plant pathology at the University of Florida Institute of Food and Agricultural Sciences. He joined the staff of the Agricultural Research and Education Center at Ft. Pierce in 1969, with research responsibilities in diseases of vegetable and tropical forage crops. Recently, those responsibilities have shifted to citrus diseases. He received an A.B. degree in chemistry from California State University, Sacramento, and M.S. and Ph.D. degrees in plant pathology from the University of California, Davis.

Acknowledgments

We extend special thanks to the scouts who participated in the pilot programs in several areas of Florida: Phyliss Daum, Joyce Francis, Wilbur Dankers, Martha Bruce, Debra Smolinski, Kathy Carbiener, Brian Cotterill, and E. Renee Fischer. We also thank Howard Beck for developing the data base management software and Jeanette Viola for computer entry of reams of scouting data.

Literature Cited

1. Anonymous. 1983. Florida agricultural statistics, vegetable summary, 1982. Fla. Crop Livest. Rep. Serv. Orlando. 71 pp.
2. Beck, H. W., Stimac, J. L., and Johnson, F. A. 1984. Florida Agricultural Information Retrieval System FAIRS: Design of a computerized consultation system for agricultural extension. Fla. Coop. Ext. Serv., IFAS, Univ. Fla. 20 pp.
3. Brown, R. B., and Johnson, R. W. 1982. Important farmlands of Florida and trends in their use. Proc. Soil Crop Sci. Soc. Fla. 41:18-24.
4. Bryan, H. H., Waddill, V. H., and Pohronezny, K. 1980. Effects of plant population, irrigation method and IPM on tomato yields, quality, defects and production efficiency. (Abstr.) HortScience 15:428.
5. Conover, R. A., and Gerhold, N. R. 1981. Mixtures of copper and maneb or mancozeb for control of bacterial spot of tomato and their compatibility for control of fungus diseases. Proc. Fla. State Hortic. Soc. 44:154-156.
6. Csizinszky, A. A., and Schuster, D. J. 1982. Yield response of staked, fresh-market tomatoes to reduced use of fertilizers and insecticides. J. Am. Soc. Hortic. Sci. 107:648-652.
7. Johnson, M. W., Oatman, E. R., Wyman, J. A., and Van Steenwyk, R. A. 1980. A technique for monitoring *Liriomyza sativae* in fresh-market tomatoes. J. Econ. Entomol. 73:552-555.
8. Jones, J. P. 1978. Disease thresholds for downy mildew and target spot of cucurbits and late blight of tomato. Plant Dis. Rep. 62:798-802.
9. Jones, J. P., and Jones, J. B. 1984. Target spot of tomato: Epidemiology and control. Proc. Fla. State Hortic. Soc. 97:216-218.
10. Jones, J. P., Weber, G. F., and Kelbert, D. G. A. 1969. Tomato diseases in Florida. Fla. Agric. Exp. Stn. Bull. 731. 88 pp.
11. MacKenzie, D. R. 1981. Scheduling fungicide applications for potato late blight with BLITECAST. Plant Dis. 65:394-399.
12. McSorley, R., and Pohronezny, K. 1981. A simple bioassay as a supplement to soil extraction for detection of root knot nematodes. Proc. Soil Crop Sci. Soc. Fla. 40:121-123.
13. Pohronezny, K., Simone, G. W., and Waddill, V. 1984. A tomato scouting manual with color-illustrated dichotomous keys for insects and diseases in Florida tomato fields. IFAS, Univ. Fla. Coop. Ext. Serv. Spec. Publ. SP-22.
14. Pohronezny, K., and Sonoda, R. M. 1983. Disease control for Florida tomatoes. IFAS, Univ. Fla. Ext. Plant Pathol. Rep. 35. 12 pp.
15. Pohronezny, K., and Volin, R. B. 1983. The effect of bacterial spot on yield and quality of fresh-market tomatoes. HortScience 18:69-70.
16. Pohronezny, K., and Waddill, V. 1978. Integrated pest management—development of an alternative approach to control of tomato pests in Florida. IFAS, Univ. Fla. Ext. Plant Pathol. Rep. 22. 7 pp.
17. Pohronezny, K., Waddill, V. H., Stall, W. M., and Dankers, W. 1978. Integrated control of the vegetable leafminer (*Liriomyza sativae* Blanchard) during the 1977–78 tomato season in Dade County, Florida. Proc. Fla. State Hortic. Soc. 91:264-267.
18. Schuster, D. J., and Beck, H. W. 1983. Visual rating system for assessing *Liriomyza* spp. (Diptera:Agromyzidae) leafmining on tomato. J. Econ. Entomol. 76:1465-1466.
19. Schuster, D. J., and Everett, P. H. 1983. Response of *Liriomyza trifolii* (Diptera:Agromyzidae) to insecticides on tomatoes. J. Econ. Entomol. 76:1170-1174.
20. Schuster, D. J., Montgomery, R. T., Gibbs, D. L., Marlowe, G. A., Jones, J. P., and Overman, A. J. 1980. The tomato pest management program in Manatee and Hillsborough Counties, 1978–80. Proc. Fla. State Hortic. Soc. 93:235-239.
21. Schuster, D. J., Musgrave, C. A., and Jones, J. P. 1979. Vegetable leafminer and parasite emergence from tomato foliage sprayed with oxamyl. J. Econ. Entomol. 72:208-210.
22. Schuster, D. J., Price, J. F., and Everett, P. H. 1981. Insecticides for management of insect pests on tomatoes in Florida. Univ. Fla., IFAS, Bradenton AREC Res. Rep. 1981–1984. 9 pp.
23. Sonoda, R. M., and Pohronezny, K. 1983. Status and potential of pesticide resistance among fungal and bacterial pathogens of vegetable crops in Florida. Proc. Fla. State Hortic. Soc. 96:66-69.
24. Sonoda, R. M., Volin, R. B., Pohronezny, K. L., Marois, J. J., and Mitchell, D. J. 1983. Current status of managing tomato diseases in south Florida by bioenvironmental means. Fla. Sci. 46:111-116.
25. Southwood, T. R. E. 1978. Ecological Methods with Particular Reference to the Study of Insect Populations. Halsted Press, New York. 524 pp.
26. Stall, R. E., and Thayer, P. L. 1962. Streptomycin resistance of the bacterial spot pathogen and control with streptomycin. Plant Dis. Rep. 46:389-392.
27. Tryon, E. H., Jr., Poe, S. L., and Cromroy, H. L. 1980. Dispersal of vegetable leafminer onto a transplant production range. Fla. Entomol. 63:292-295.
28. Waddill, V. H. 1978. Contact toxicity of four synthetic pyrethroids and methomyl to some adult insect parasites. Fla. Entomol. 61:27-30.
29. Waddill, V. H. 1980. Tomato pinworm: Management with insecticides used at reduced rates and on demand. Proc. Trop. Reg. Am. Soc. Hortic. Sci. 24:141-143.
30. Waddill, V. H., and Pohronezny, K. 1979. Tomato IPM: Key to vegetable leafminer control. Citrus Veg. Mag. 42:34-37.
31. Whalon, M. E., and Croft, B. A. 1984. Apple IPM implementation in North America. Annu. Rev. Entomol. 29:435-470.