

Chapter 1. Executive Summary and Major Research Findings

South Florida vegetable producers face intense pest pressure and volatile markets. The performance of pest management systems, the weather, and market prices are the three major factors determining whether a grower makes a profit in a given production cycle. Pest management is extremely important because of its impact on crop yield and quality, not just because of the direct cost of pesticides and pest management practices and services.

Out of necessity, farmers in South Florida utilize a range of Integrated Pest Management (IPM) practices. The use of scouting and adherence to thresholds in making pesticide spray decisions is nearly industry-wide, as is attention to minimizing the risk of resistance development. Growers have also adopted many preventive practices, both before and during a crop cycle, with the goal of suppressing populations as low as possible when pests are most vulnerable.

Steady progress has been made since the late 1980s toward softer, more prevention-based, multitactic IPM systems, as documented in tomatoes (Chapter 2) and peppers (Chapter 3). The registration of the systemic insecticide imidacloprid (Admire) in the early 1990s made possible important changes in pesticide use patterns that limited early and mid-season impacts on beneficials and helped avoid late season flare-ups and secondary pest problems. Imidacloprid has also been important in managing new insect pests including the silverleaf whitefly (SLW) and the melon thrips.

In recent years there has been a steadily increasing flow of new chemistry into South Florida vegetable systems. Glades Crop Care, Inc. has completed several trials with new biopesticides that work through novel modes of action and offer growers the chance to diversify their suppression-based efforts. Chapter 4 provides an overview of some of the most promising new materials and describes how Glades Crop Care, Inc. hopes to work them into production systems. The strobilurin fungicides promise to be particularly significant, providing growers badly needed alternatives to relatively higher-risk fungicides that have been under regulatory pressure for many years.

Regulatory pressures have also been driving change in South Florida vegetable production. The first big impact came in the late 1980s and early 1990s. During that period the Environmental Protection Agency (EPA) gradually reduced the maximum pounds of the EBDC fungicides allowed in a production cycle from over 50 to just under 15 pounds of active ingredient per acre. Many growers had to cut their EBDC use by at least half to comply with the new label restrictions. Fortunately, before these restrictions, many growers had begun focusing their programs on prevention practices. This was necessary, since tank mixes of copper compounds and EBDCs had lost much of their effectiveness against bacterial diseases, even at the high application rates common during the early 1980s.

Passage of the Food Quality Protection Act (FQPA) in 1996 has accelerated EPA actions targeting high-risk insecticides, especially the organophosphates (OPs) and carbamates. These families of chemistry include many of the most important insecticides used in the Florida agricultural sector. Largely because of worker-protection concerns and the desire to avoid secondary pest problems, most South Florida growers have already made strides to reduce reliance on OPs and carbamates.

Despite progress in the transition toward fuller implementation of multitactic, prevention-based IPM, intensive fruit and vegetable production in this region remains heavily dependent on access to pesticides. When populations flare unexpectedly because of the weather, resistance, or emergence of a new strain, growers have no choice but to intervene with pesticides. For this reason, rapid loss of products could place South Florida vegetable production in serious jeopardy. Inability to quickly bring down populations of any of our key pests can lead to serious economic damage in just a few days. Growers can not withstand such losses, especially if they occur across a high percentage of fields planted.

With our grower-clients, we have already achieved significant changes in pest management systems, reducing reliance on high-risk pesticides to just a fraction of the use common just 10 years ago, as documented in Chapters 2, 3, and 5. Glades Crop Care, Inc. has developed an IPM measurement methodology to help growers understand where their pest management systems lie upon an IPM continuum ranging from chemical-intensive systems to high-level, bio-intensive IPM. The system helps growers understand the steps needed to move incrementally along the continuum. It also provides a solid empirical basis for capturing the positive linkages between IPM adoption and reducing reliance on high-risk pesticides. Chapter 5 applies these measurement concepts to the evolution of tomato and pepper pest management systems set forth in Chapters 2 and 3. Some important insights emerge and are highlighted in the balance of this chapter.

Experience and Individual Philosophies Vary Greatly

Data are presented that show that different managers often reach very different spray decisions when facing nearly identical pest complexes, even when managing those pests with the benefit of the same information and advice. Some growers are far more risk averse than others.

For example, tomato Farm DE based its worm control program on the use of *Bacillus thuringiensis* Berliner (*B. t.*), while the grower at Farm ~U refused to use it because he felt it was not effective. The result was that Farm ~U used significantly more methomyl, permethrin and spinosad to control worms than Farm DE, where methomyl and chlorpyrifos were used sparingly to control SLW and clean up older worm larvae that were not susceptible to *B. t.* Data presented in Chapter 5 capture the impacts of these

decisions on the pounds of pesticides applied and the toxicity units¹ associated with insecticide applications.

Some growers are willing to experiment with novel approaches, often well before problems emerge with the performance of their current pest management system, or regulatory actions compel the change. The capacity to change differs across individuals, as does the ability to effectively incorporate new tactics and chemistry into control programs. The longer the time period to experiment with novel approaches, the more likely that effective new practices and techniques will be discovered and worked into commercial programs without causing significant disruptions in overall system performance. This observation reinforces the importance of phasing in restrictions on pesticide use patterns and reductions in tolerances, especially in cases where alternatives are few and relatively unproven.

Differences across individuals dictate the need for different approaches by crop consultants in working with clients. Our method for measuring IPM along a continuum of systems has proven an effective tool with growers regardless of where they currently fall along the continuum. Some growers want to progress along the continuum toward more prevention-based systems that work with generally softer materials. By describing the additional practices in place on farms currently in the biointensive IPM zone, growers obtain a concrete idea of how they must change their systems, and what the process of change is going to cost in terms of changes in selection of pesticides and developing new skills and expertise.

Other growers want to keep their systems as simple as possible and are content to deal with the adverse impacts of chemical-intensive systems. For these growers, the measurement tools are still useful in monitoring changes in the effectiveness of the system. Slippage in efficacy, because of resistance or secondary pest problems, will be readily apparent in the basic measures of pesticide application per acre and the total toxicity units per acre.

Diversity in Pesticide Use Patterns is Not Necessarily Related to Stability

Through analyzing pesticide use and IPM practice data over time in tomato and pepper production across different types of systems, we tested the hypothesis that the diversity of a pest management system is positively correlated with the reliability and robustness of the system. Our focus was on the suppression of insect pests and in particular, on the use of insecticides as the dominant tool for suppressing populations that threaten to exceed damage thresholds.

In South Florida vegetable systems, most major insect pests will quickly and profoundly exceed damage thresholds in the absence of a number of practices designed to

¹ Toxicity units are a measure of the potential toxic impact of pesticide applications and are based on pounds applied and mammalian acute LD-50s, as described in Chapter 5.

suppress their populations. Since the 1960s, growers have depended largely on insecticides to avoid major crop losses. This tactic often worked well but, over time, created significant indirect costs and triggered resistance and shifts in pest complexes.

Our data show consistently that diversity in insecticide use is actually driven by the intensity of chemical use. The more farmers spray, the more diversity they need in their insecticide rotations to avoid resistance. We developed an insecticide diversity index, the value of which was highest on farms using relatively hard pesticides and relatively few preventive practices.

Prevention remains the backbone of effective systems and begins with a vital step: assuring that transplants are clean. A range of related preventive phytosanitary practices are essential to limit the instances when insects or diseases are spread from field to field by equipment or workers.

Our data suggest, however, that natural biocontrol-based processes carry a major share of the burden in suppressing insect pests on farms that have progressed into the biointensive zone along the IPM continuum. The grower creates a biotic environment in their fields where these processes can thrive by eliminating pesticides to the full extent possible, and implementing practices that promote the diversity and activity of beneficial organisms. Better tools and methods are needed to capture these natural processes fully. With such tools and new insights, we will be able to work through with grower-clients how changes in IPM practices and pesticide use patterns might affect the relationship between pests, beneficials, and crop production. As our ability improves in projecting the impact of such changes on beneficial organisms, we will develop novel scouting techniques and a new generation of action thresholds. In the future, the actions triggered by a given threshold may have little or nothing to do with the application of a pesticide and the ways we monitor efficacy will also have little to do with today's standards of performance.

FQPA Impacts and Future Vulnerability

We do not expect major disruptions or problems in managing insect pests as a result of implementation of the Food Quality Protection Act (FQPA). South Florida vegetable growers have ample tools now to manage insect pests, even if the EPA phases out several higher-risk OPs and carbamates over the next five years.

Loss of all insecticides in both families of chemistry, however, would be devastating and lead to an immediate, major jump in use of synthetic pyrethroids, which would in turn trigger many new problems with secondary and/or late-season pests. Likewise, the adverse impacts of losing several materials will depend on how quickly the process unfolds. Catastrophic losses could occur if growers lose several key products within a 24 month period. Fortunately, there is no evidence suggesting that such a scenario will occur. USDA pesticide residue data show generally acceptable frequency

and levels of most OPs and carbamates based on how these products are currently used in Florida agriculture.

The recent decision to revoke the chlorpyrifos tolerance on tomatoes will lead to a significant reduction in the toxicity units associated with this crop, largely because of the pattern and levels of residues in Mexican tomatoes. The loss of this insecticide for Florida tomato production will have minimal impact. After the revocation of the chlorpyrifos tolerance, methamidophos will emerge as the dominant risk-driver in this crop, accounting for the majority of the toxicity units associated with residues found in fresh market tomatoes by the USDA (see Chapter 5).

Four important tomato insecticides are in jeopardy as the FQPA implementation process moves ahead: the carbamates, oxamyl and methomyl; the OP, methamidophos; and endosulfan. Serious problems will arise only if the EPA quickly phases out these insecticides. It is likely that, after the cumulative assessment of carbamate dietary exposures and risks, some degree of dietary risk reduction will be necessary. Methomyl will no doubt bear a portion of the reduction, since it is now by far the most commonly found carbamate in food. Fortunately, our experience with insecticide use patterns and residue levels confirms that significant reductions in the frequency of residues and mean residue levels can be achieved through extensions in pre-harvest intervals or reduced numbers of applications per crop cycle.

Generally, growers have more options for dealing with Lepidopteran insect pests. In tomatoes, the most difficult challenge is the SLW, both because it is a tough pest to manage and it transmits Tomato Mottle Virus and Tomato Yellow Leaf Curl Virus. Some growers rely on methamidophos for SLW control, in large part because methamidophos is a cost-effective synergist when applied in tank mixes including a synthetic pyrethroid. On most farms, one or two applications of a methamidophos-synthetic pyrethroid tank mix prove effective for late season whitefly control. Although not addressed in this project, the reliance on methamidophos for management of the devastating virus disease, Tomato Spotted Wilt Virus, and its vector, the western flower thrips, is even more profound among vegetable growers in northern Florida and southern Georgia.

If methamidophos were lost to south Florida growers, reliance would increase on mid-season foliar applications of imidacloprid. This would in turn place in jeopardy an active ingredient that plays a critical role in our bio-intensive tomato IPM program. The loss of methamidophos might not be an immediate problem. Yet, serious consequences could emerge in a few years as a result of the increase in imidacloprid use and the extension of the selection pressure imposed by imidacloprid on target pests. Managing resistance to imidacloprid would definitely require applications of additional active ingredients, would increase control costs, and might possibly trigger new dietary residues of concern. Similar examples are discussed in the chapter on pepper pest management involving the prospect that an FQPA-driven action might lead to a switch in insecticide

use patterns triggering unintended consequences including resistance, secondary pests, or both.

Our findings strongly support the need for EPA to take resistance management into account when crafting risk mitigation measures. We are confident that ways can be found to include methamidophos in our tomato insect management program without resulting in significant residues. We recognize that pesticide product labels will need to become much more complicated, explicit, and region-specific if a high-risk insecticide such as methamidophos is to be retained for limited applications when justified to avoid resistance to other valuable materials. Perhaps methamidophos use on tomatoes is a good candidate for the prescription use option suggested in a recent report by the Council for Agricultural Science and Technology (Coble et. al., 1998).²

Disease management in most Florida vegetable crops remains highly dependent on the EBDCs. At present, any significant further label limits on the use of these fungicides in tomatoes or peppers could place growers in serious jeopardy. We are encouraged by the results obtained with new SAR chemistry designed to trigger or reinforce plant defense mechanisms (see Chapter 4). We are also convinced that years of patient work are needed to determine how, when and where these new technologies can be incorporated into our systems.

We are also aware that many of the promising new reduced risk fungicides work through a highly targeted mode of action, raising the risk of resistance. Accordingly, if EPA decides that risk mitigation measures must be imposed on the EBDCs, the agency should project likely substitution patterns and build into product labels explicit requirements to follow recommended, proven resistance management practices. Accomplishing this goal will prove a major challenge, since pesticide labels are rarely explicit in terms of resistance management. We are encouraged by the greater attention paid to resistance management on the labels for the bioinsecticide spinosad and the strobilurin fungicide azoxystrobin.

Prevention through System Innovation Remains the Key for Success

Our findings demonstrate that growers are successfully reducing reliance on higher-risk pesticides through greater emphasis on prevention coupled with increasingly complex, multitactic IPM systems. Typically, success depends first on a set of practices that avoid the introduction and early-season spread of pest problems. This is followed in importance by the careful use of pesticides designed to not adversely impact plant health or populations of beneficial organisms. While today's higher-risk materials will not be needed or used as heavily as in the past, the willingness of growers to innovate will depend on access to effective pesticides to deal with explosions of potentially damaging pests, which can occur, even in the most complete and sophisticated bio-intensive IPM


² *Feasibility of Prescription Pesticide Use in the United States*

Chair: Harold D. Coble, Department of Crop Science, North Carolina State University, Raleigh. IP9, August 1998

program. At such times, we may need to apply products such as the EBDCs, methomyl, and methamidophos to quickly bring populations under damage thresholds.

Paradoxically, the less frequently such high-risk materials are applied, the greater the benefits that will follow each application. This will require a major change in thinking and practices by growers, crop consultants, researchers and the pesticide industry. The longer the South Florida vegetable industry has to work out new management tactics and systems that include the judicious use of higher-risk materials, the more likely the transition along the IPM continuum will progress smoothly and benefit all.

New tools and attention to the measurement of IPM system performance and the linkages between IPM and pesticide use and dietary exposures are needed to document progress already achieved and monitor the pace of future accomplishments. By openly assessing progress toward widely accepted goals, we hope the South Florida vegetable industry will be given the time needed to complete the transition to prevention-based multitactic IPM systems. The most innovative growers in the State are now proving that such systems are commercially viable, but more time is needed to refine them and build confidence in them statewide.





Chapter 2. The Evolution of Tomato Pest Management Systems and Impacts on Pesticide Use and Reliance

Change is the only constant in the history of pest management technology and pesticide use in the production of South Florida vegetable crops. Biological adaptation of pest complexes has been perhaps the dominant cause of change. Pest problems are constantly evolving because of the emergence of resistance and new strains of established pests and diseases, and the introduction of exotic species. These changes have, in turn, been shaped, if not directly triggered by past pest management efforts. In particular, pesticide use patterns in the 1970s and 1980s imposed extremely heavy selection pressure on pest populations.

Today the nature of selection pressure imposed on pest populations has clearly changed both qualitatively and quantitatively. In general, the modes of action of newer materials are more specific and narrow. Other things being equal, the risk of resistance to highly active low-dose compounds with a specific, biochemical mode of action is greater than the risk associated with many older products that work through a complex mix of modes of action. For example, if the new strobilurin fungicides were used today as intensively as the EBDC's and copper compounds were used in the early 1980s, we would be fortunate to keep them in the program for two or three years.

Tomato pest management systems have changed for the good in other important ways that tend to lessen the risk of resistance. Our systems are more prevention-oriented and include many more practices, beginning with the growth and management of transplants through all agronomic stages, crop scouting, staking, pruning, harvest, and handling of the crop, as well as post-harvest management of residues and possible sources of disease inoculum or habitat for insects. Our increased focus on prevention is spreading out the control burden, reducing the frequency of spikes in populations at times when crops are threatened, and lessening the selection pressure imposed by any single practice or pesticide.

Our systems also reflect increasingly complex decision-processes in which several people typically participate to one degree or another. Different operations have varying degrees of tolerance for risk, and long-term experience (and habit) plays a surprisingly major role in how pests are managed across farms in a given region. The diversity of approaches and systems in place also can and often does accelerate innovation.

Factors Shaping IPM Systems and Decision-making on the Farm

For a variety of reasons Florida tomato pest management systems have entered a critical period of accelerated transition. Part of the pressure comes from the loss of materials because of the Food Quality Protection Act (FQPA) and the methyl bromide phase out.