Southeastern Tomato Growers Adopt Integrated Pest Management

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SUMMARY. Multidisciplinary integrated pest management (IPM) teams from seven states in the southeastern United States (Alabama, North Florida, Georgia, Kentucky, North Carolina, South Carolina, and Tennessee) met to develop standards for adopting IPM in fresh-market tomato (*Lycopersicon esculentum* L.) production. Teams were composed of growers, private consultants, extension personnel, and faculty. IPM practices available for use on tomatoes in the southeastern United States were identified and a survey to assess the current level of adoption of IPM practices was developed. The survey also allowed growers to identify insect, disease, and production problems; beneficial technology and research developments; and other information relevant to IPM adoption. In northern Florida, Georgia, Kentucky, North Carolina, and South Carolina, IPM adoption by tomato growers was classified as medium or

high on >75% of the fresh-market tomato acreage surveyed. It appears these states may have met the federal mandate for IPM adoption. Tomato producers listed early blight, late blight, bacterial spot, bacterial speck, and bacterial wilt as the main disease problems; tomato fruit worm, thrips, and aphids as the primary insect problems; and poor weather conditions, government regulation, and labor as their primary production problems. Twenty-six percent of the producers throughout the region felt that the development of insect- and disease-resistant varieties would be most helpful to increase production.

Consumers in the United States are increasingly concerned about the use of pesticides in food production. In testimony before Congress in September 1993, the Clinton administration committed to conducting the research and educational efforts necessary to achieve adoption of IPM on 75% of the Nation's crop acreage by the year 2000 (National Coalition of Integrated Pest Management, 1994; USDA Economic Research Service, 1994). In addition, state and federally funded IPM programs have been active for the past 20 years. In the current mood of accountability to the tax payer, it is appropriate to measure the level of IPM in use today. Some states have begun to use IPM labeling to sell produce, and a system must be developed to certify this type of product.

Fresh-market tomato is an excellent model crop for developing and implementing IPM strategies. Growing conditions, cultural practices, and pests are similar across the southeastern United States. Because tomatoes are a high-input crop, requiring a preharvest investment of up to \$5000/acre, the potential for significant financial savings as a result of using IPM practices may encourage grower adoption regardless of federal mandates.

Methods for evaluating the level of IPM implementation on vegetables are not well developed, perhaps because of the difficulty of defining IPM in a manner that lends itself to quantification. Many definitions of IPM exist. The Consortium for International Crop Protection (CICP), New York State Agricultural Experiment Station, Geneva, and Oregon State's Integrated Plant Protection Center (IPPC), Corvallis, have created a compendium of

IPM definitions (<http://www.ippc.orst.edu/cicp/IPMdefinitions/>). The compendium contains 50 definitions, most of which stress integrating multiple pest control techniques in an economically sound fashion. Although reduced reliance on synthetic pesticides is only occasionally a stated goal, many definitions refer to public health and environmental concerns. The National Coalition of Integrated Pest Management (1994) uses the following definition:

"Integrated pest management is a sustainable approach to managing pests by combining biological, cultural, physical, and chemical tools in a way that minimizes economic, health, and environmental risks."

This definition, like many others, outlines a philosophy of IPM and leaves a precise definition of the biological, cultural, physical, and chemical tools to the reader.

Previous surveys used to assess the level of IPM adoption in the United States on vegetables and other crops have considered few IPM production practices in identifying IPM users (i.e., use of crop rotation, scouting, parasites, and biochemical or microbial agents) and placed growers into user and nonuser categories (Fernandez-Cornejo et al., 1994; Vanderman et al., 1994). As Boutwell and Smith (1981) noted, at some point, all producers within a given commodity have been exposed to and influenced by IPM techniques and practices. At this point growers are no longer characterized by the use or nonuse of IPM, but instead by the percentage of available IPM practices they adopt.

Vanderman et al. (1994) first classified acreage according to whether farmers used scouting and economic thresholds to make pesticide treatment decisions. These acres were classified as "under IPM." The definition further divided IPM acres according to the number of additional IPM tactics used. For vegetables, a producer was considered a low IPM user if only scouting and economic thresholds were used. A medium level of IPM involved using one or two additional management practices, and a high level of IPM was defined as using scouting and economic thresholds plus three or more other management practices. One limitation of this approach is that the IPM tactics in each crop management program are generally considered to be

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Table 1. Integrated pest management (IPM) survey developed for use on southeastern tomato producers. Producers responded with never, sometimes, often, and always to each question.

1. Using recommended cultural practices
 - a. Do you avoid planting in fields with a history of severe weed, insect, or disease pressure?
 - b. Do you use soil tests or foliar analyses to determine fertility needs?
 - c. Do you use drip irrigation?
 - d. Do you use plastic or organic mulch?
 - e. Do you select varieties with disease or insect resistance?
 - f. If you grow your own transplants, do you use certified seed?
 - g. If you grow your own transplants, do you use commercially treated seed?
 - h. If you purchase transplants, do you purchase from a reputable dealer?
 - i. Do you rotate between years or between plantings with a crop other than tomato, potato, pepper, or eggplant?
 - j. Do you prune or tie plants when the foliage is dry (not in the early morning or after rain)?
 - k. Do you destroy old crop debris within a week of harvest?
 - l. Do you consider the potential of weedy field borders and drive rows to harbor pests and make an effort to eliminate weeds in these areas?
2. Application techniques
 - a. Do you use a high-volume hydraulic sprayer with drop nozzles for fungicide or insecticide application?
 - b. Do you fully calibrate spray equipment at the beginning of each season?
 - c. Do you check spray equipment for uniformity of nozzle output before each use?
 - d. Do you use at least 40-gal/acre spray volume with each fungicide or insecticide application?
 - e. Do you read the label of all pesticides applied to your crop each year?
 - f. Do you use pesticides that are recommended for use on specific pests?
 - g. Do you identify the type of insects or diseases in your field before applying pesticides?
 - h. Do you use the lowest labeled insecticide rate for control of insects?
 - i. Do you test water pH and adjust pH when necessary to avoid pesticide breakdown in the spray tank?
3. Specific pest management practices
 - a. Do you maintain records of field history and pest problems?
 - b. Do you use reflective mulch to control aphids and viruses?
 - c. Do you scout fields for insect pests once a week or more?
 - d. Do you scout fields for plant diseases once a week or more?
 - e. Do you use treatment thresholds (when available) for insect control?
 - f. Do you plant nonhost crop borders for control of viral diseases?
 - g. Do you adjust planting dates to avoid insect pests?
 - h. Do you use biological or environmentally friendly insecticides (i.e., *B.t.* neem, insecticidal soap, insecticidal oil, etc.)?
 - i. Do you purchase and release beneficial insects (i.e., *Trichogramma* egg parasites)?
 - j. Do you use weed maps to target herbicide applications?
 - k. Do you clean equipment before moving to new fields?
 - l. Do you make sure organic mulching material is free of weed seed?
 - m. Do you use banded applications of herbicides?
 - n. Do you use mechanical cultivation or hand hoeing to remove weeds?
 - o. Do you target postemergence herbicides against small weeds?
 - p. Do you use pheromone traps to monitor for tomato fruitworm or other insect pests?
 - q. Do you use mating disruption (pheromone products) to control tomato pinworm?
 - r. Do you inject or band fertilizers within the plant bed?
 - s. Do you apply fertilizer by drip irrigation?
 - t. Do you test soils for nematodes annually?
 - u. Do you rogue (remove) plants with symptoms of viral diseases?
 - v. Do you shrink or stretch fungicide applications depending on weather conditions?
 - w. Do you use disease forecasting (TOM-CAST) for timing fungicide applications?

Important questions!!!

- How many acres of tomatoes do you farm?
 If your fields are scouted for pests, who does the scouting?
 How many fungicide applications do you make per crop?
 How many insecticide applications do you make per crop?
 How many herbicide applications do you make per crop?
 What are your key disease problems?
 What are your key insect problems?
 What are your key production problems?
 What development in plant protection or pest management would help you the most?

equally important. In reality, the importance and practicability of specific IPM tactics varies by crop, region, and relative pest pressure. Thus, in defining IPM for specific commodities, all available IPM tactics should be identified and weighted based on importance and usefulness in the crop management program for a given region. Boutwell and Smith (1981) first suggested weighting insect management practices in IPM evaluation. This idea was further developed by workers in Massachusetts, who included horticultural practices, plant nutrition, and control methods for insect, disease, and weed pests in guidelines used to document whether the crop has been grown using an IPM system (Hollingsworth et al., 1992a, 1992b, 1996).

The purpose of this study was to develop a definition of IPM for tomato growers in seven states in the southeastern United States and to determine the levels of adoption of tomato IPM practices in each region. Growers were asked to identify their major pest and production concerns. In addition, information was gathered that will be used to increase IPM adoption and target future research and educational programs.

Methodology

As part of the USDA–Land-grant University IPM Initiative Program, state IPM teams from the southeastern United States met at Auburn University in November 1995. Teams from Alabama, northern Florida (Calhoun, Okaloosa, and Santa Rosa counties located in the panhandle), Georgia, Kentucky, North Carolina, South Carolina, and Tennessee were com-

posed of extension specialists, extension agents, researchers, growers, and private consultants. Before meeting at Auburn University, representatives from cooperating states sent lists of practices they felt were important components of a tomato IPM program. These lists were compiled into survey form and presented at the meeting for discussion. A final survey was then developed for use in the region.

The survey had three sections (Table 1). The first section included cultural practices that reduce pest populations, promote plant health, or both. Pesticide application techniques and methods were included in the second section, and practices targeted against specific pests were included in the third section. Growers were also asked to identify key disease, insect, and production problems and specific developments in plant protection or pest management that would be most helpful in crop management programs.

Unique situations in participating states were accommodated by assigning weights to each IPM practice (survey question) based on its perceived importance and practicability by the state team members (i.e., 1 = low importance; 4 = high importance). For example, in Alabama, high importance was given to IPM practices concerned with maintaining pesticide application equipment, application practices, insect and disease scouting, and practices that controlled viral diseases. Respondents received points based on the frequency with which each practice was used (i.e., never = 0, sometimes = 1, often = 2, and always = 3). For each question the weight value was multiplied by the frequency value. These products were summed for all

questions to arrive at the total survey score. Each respondent was assigned a percentage score based on the percentage of total possible points achieved. A score of 0% to 50% was considered a low level of IPM use, 51% to 75% a medium level of use, and 76% to 100% was considered a high level of IPM use.

The survey was distributed to tomato growers by mail, at county vegetable production meetings, and at relevant state association meetings. This resulted in a purposive sample of growers who farmed ≈34 % of the region's acreage. Estimates of the total fresh-market tomato acreage in each state were made by each state team. All states except Kentucky reported survey results on fresh-market tomatoes. Kentucky results include fresh-market and processing tomatoes.

Results and discussion

A total of 158 tomato growers responded to the survey (Table 2). There was considerable variation in farm size throughout the region, with farms averaging 213 acres in northern Florida to 6.8 acres in Kentucky. The number of fungicide and insecticide applications varied throughout the region as well, although the number of herbicide applications was similar. Growers applied fungicides and insecticides most frequently in northern Florida and least often in Tennessee.

The results of this survey indicate that, in five of the seven southern states, >75% of the respondents' fresh-market tomato acreage is in the medium or high IPM category (Table 2). Respondents in Georgia, Kentucky, North Carolina, northern Florida, and South Carolina have met or exceeded

Table 2. Results of the survey used to determine the level of integrated pest management (IPM) implementation in tomato production in the southeastern United States.

State	Growers (no.)	Total acreage ² (%)	Mean farm size (acres)	Mean score on survey (SD)	Percentage in medium and high IPM category		Mean no. of applications (SD)		
					Growers	Acreage	Fungicide	Insecticide	Herbicide
Alabama	25	13.0	22.1	57.0 (±12.7)	65	66	9.7 (±4.1)	9.8 (±4.1)	2.0 (±1.3)
Georgia	15	54.0	69.5	68.0 (±9.5)	100	100	14.6 (±4.6)	13.2 (±6.2)	1.5 (±0.7)
Kentucky ³	29	11.0	6.8	65.8 (±11.1)	93	99	10.2 (±5.1)	7.2 (±4.9)	1.3 (±0.9)
North Carolina	35	25.0	13.3	54.3 (NA) ⁴	66	94	11.6 (±6.9)	8.0 (±5.2)	1.7 (±1.9)
north Florida ⁴	12	54.4	213.3	74.6 (±6.9)	100	100	19.5 (±7.9)	16.4 (±7.4)	1.9 (±0.6)
South Carolina	18	70.0	132.2	71.7 (±13.0)	94	99	11.8 (±4.2)	9.9 (±4.2)	1.8 (±0.7)
Tennessee	24	13.7	31.8	53.5 (±11.8)	67	63	8.3 (±3.9)	8.2 (±4.1)	2.0 (±0.9)

²Total acreage for each state was estimated by the state team.

³Kentucky included processing and fresh-market tomatoes in its results.

⁴Calhoun, Okaloosa, and Santa Rosa counties.

Table 3. Mean number of pesticide applications (SD) on farms which were scouted by growers or crop consultants, and on farms scouted by an integrated pest management (IPM) program scout sponsored by the South Carolina Tomato Association.

State	Mean no. fungicide applications on farms scouted by			Mean no. insecticide applications on farms scouted by		
	Grower	Consultant	SC IPM program scout	Grower	Consultant	SC IPM program scout
Georgia	11.7 (± 2.9)	19.7 (± 4.5)	---	12.3 (± 7.0)	17.0 (± 6.2)	---
North Carolina	12.0 (± 7.6)	11.3 (± 2.3)	---	8.4 (± 5.5)	10.3 (± 0.5)	---
northern Florida ^y	4.7 (± 0.3)	21.9 (± 5.3)	---	3.3 (± 2.5)	18.4 (± 5.5)	---
South Carolina	16.3 (± 3.2)	17.5 ^z	9.1 (± 2.8)	10.7 (± 2.1)	17.5 ^z	8.4 (± 2.7)

^yCalhoun, Okaloosa, and Santa Rosa counties.

^zOne grower in this group.

the State IPM teams' criteria for practicing IPM and have met the federal mandate of IPM on 75% of the tomato cropland.

It is interesting to note that a high score on the IPM survey was not necessarily reflected in a low average number of fungicide and insecticide applications (Table 2). For example, northern Florida and Georgia reported 100% of the respondents in the medium or high IPM category and also reported the highest average number fungicide and insecticide applications. IPM does not necessarily result in lower pesticide use. In some cases growers may be under-managing pest problems and IPM will actually result in increased pesticide usage.

The survey results also suggest another possible explanation for lack of correlation between high survey scores and reduced pesticide use. Information on the personnel who scouted tomato fields was available from Alabama, Georgia, northern Florida, North Carolina, and South Carolina. In Alabama, all scouted fields were scouted by the grower. Fields in North Carolina, Georgia, and northern Florida were scouted by growers or crop consultants (Table 3). Except for fungicide applications in North Carolina, more fungicide and insecticide applications were applied on fields scouted by consultants than on fields growers had scouted. South Carolina has an established IPM program on

tomatoes, and fields were scouted by growers, crop consultants, or IPM scouts. The mean number of fungicide and insecticide applications was lowest in fields scouted by an IPM scout (9.1 and 8.4 applications, respectively), followed by fields scouted by growers (16.3 and 10.7, respectively), and highest on the farm scouted by a consultant (17.5 and 17.5, respectively).

Other factors, such as farm size, were also correlated with increased pesticide application, and fields in some regions of the southeastern United States may require more pesticides than those in others. However, these results suggest that crop consultants may be using very conservative thresholds in their disease and insect scouting pro-

Table 4. Percentage of respondents within each state and within the region that identified these factors as problems.

	Alabama	Georgia	Kentucky	North Carolina	Northern Florida ^z	South Carolina	Tennessee	Regional
Diseases								
Early blight	12	20	55.2	42.9	8.3	55.6	66.7	41.3
Late blight	4	13.3	17.2	31.4	0	27.8	29.2	20.0
Bacterial spot	8	0	10.3	2.9	66.7	66.7	12.5	18.7
Bacterial wilt	0	13.3	10.3	5.8	33.3	16.7	4.2	9.7
Bacterial speck	0	0	6.9	2.9	0	33.3	8.3	7.1
TSWV ^y	8	40	0	0	58.3	11.1	0	10.9
Insects								
Tomato fruit worm	20.0	13.3	31.0	48.6	25.0	50.0	20.8	31.7
Aphids	40.0	20.0	13.8	20.0	0	22.2	33.3	22.8
Thrips	8.0	46.7	0	25.7	58.3	38.9	4.2	20.9
Stinkbug	16.0	6.7	31.0	8.6	8.3	38.9	8.3	17.1
Pinworm	8.0	40.0	0.0	8.6	50.0	50.0	8.3	17.7
Whitefly	0	13.3	0	11.4	50.0	0.0	12.5	9.5
Army worm	0	33.3	0	2.9	16.7	0	4.2	5.7
Production								
Weather	32.0	20.0	20.7	17.2	33.3	38.9	33.3	26.6
Government regulation	0	6.7	0	0	8.3	5.6	52.1	9.8
Labor	0	0	13.8	0	8.3	22.2	16.7	8.2
Irrigation	0	6.7	24.1	8.7	0	0	4.2	7.6
Diseases	8.0	13.3	0	2.9	16.7	11.1	12.5	7.6

^zCalhoun, Okaloosa, and Santa Rosa counties.

^yTomato spotted wilt virus.

grams; this may result in the consistently higher levels of pesticide use on consultant-scouted farms.

Clearly, the IPM program in South Carolina has reduced pesticide use (Table 3). The program began in 1978 with start-up funds from a federal extension IPM program and was relinquished to the South Carolina Tomato Association several years ago (R. Griffin, personal communication). The association now administers the program, assesses growers scouting fees, hires scouts, and performs other duties. Although growers participating in the program have reduced numbers of fungicide and insecticide applications, it remains to be seen if this program could be adopted by other states. The South Carolina program is maintained by a strong tomato growers' association, and the average farm size is fairly large (132.2 acres, Table 2). In Alabama, tomato farms are small (22 acres), widely dispersed, and without benefit of a tomato association. A single scout in Alabama would have to scout a wide area to have sufficient acreage to pay a reasonable salary. In Alabama and other states with similar circumstances, it may be more practical to educate the growers in scouting techniques than to attempt to develop and train an independent scouting industry. In areas where crop consultants are already established, IPM education programs should target and work with the consulting industry in addition to producers.

Tomato producers identified similar production concerns throughout the southeastern United States (Table 4). Early blight, late blight, bacterial spot, bacterial speck, and bacterial wilt were identified by growers as key disease problems. Tomato spotted wilt virus (TSWV) was identified primarily in Georgia and Florida. Tomato fruit worm, aphids, thrips, stinkbug, and pinworm were identified as primary insect problems. Producers throughout the southeastern United States identified poor weather as their primary production problem, followed by government regulation and labor problems.

Although growers may not always correctly identify their pest problems, the pest problems identified by growers in most states were also iden-

tified as major problems by state IPM team members. In Alabama, few growers identified cucumber mosaic virus (CMV) as a key disease concern, even though an epidemic of this disease has seriously impacted tomato production in the northern tomato-producing counties (Sikora et al., 1993). It is interesting to note that many IPM practices used to control this disease are aimed at controlling aphid vectors. Forty percent of the Alabama respondents identified aphids as a key insect pest (Table 4).

Only 51% of those asked to identify beneficial developments in plant protection or pest management responded to this question (growers in Kentucky and Tennessee were not asked this question). The largest percentage of respondents (26%) felt that introducing more disease- and insect-resistant varieties would be the most helpful. Less government regulation was listed by 5% of the respondents. The broad range of other suggestions, from controlling individual diseases or insects to information on pollinators (bees), suggested that, besides developing resistant varieties, there was little consensus among growers. It is interesting to note that only one grower suggested developing a methyl bromide replacement even though the U.S. Clean Air Act (Section 602) passed in 1990 requires that this ozone-depleting substance be withdrawn from use by 2001. These results indicate that IPM workers, researchers, and specialists will have an important leadership role in directing future developments in IPM.

IPM teams in each state assigned higher weights to the IPM practices they felt were most important in their state. This created a flexible survey tool, easily adapted to each state. Douce et al. (1983) suggested a more objective approach and proposed using factor analysis to reduce the number of IPM practices to a reasonable number and to determine appropriate weights for the factors. We felt that members of the state teams had considerable expertise, which was easily incorporated into the survey using our methodology and which would have been ignored by factor analysis.

In the process of creating this survey, the state IPM teams outlined a

clear definition of IPM in fresh-market tomato production. Survey results established a baseline that can be used to measure the success of programs designed to increase IPM adoption. The survey also provided an opportunity for growers throughout the region to identify pest problems of importance to them. Results of the survey will be used to develop extension and research programs in the southeastern United States.

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