A Report for

The National Integrated Pest Management Initiative

IMPLEMENTATION OF A MULTI-STATE IPM PROGRAM FOR WIDELY SCATTERED APPLE GROWERS IN THE MID-MISSISSIPPI RIVER WATERSHED

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Summary:
Apple production in the mid-south and midwest is a small but vital industry with most of the production marketed directly to the consumer. Few apple production regions exist in this region, rather growers are widely dispersed and much of the production is direct marketed to the consumer. To maintain profitability growers must effectively manage a large number of very serious apple pests. Traditionally, apple production has relied almost exclusively on pesticides to control pests. A typical orchardist controlling pests according to a calendar spray schedule may need 15 to 20 pesticide applications during the course of the season. Most of these applications contain both fungicides and insecticides.

A 3-day workshop was help in Indianapolis in November 1995 to address the benefits of and constraints to implementing apple IPM regionally. In attendance were 46 persons that includes university extension and research personnel, apple growers, apple IPM consultants, apple industry representatives, and a representative of the USDA Natural Resources Conservation Service. Seminars were presented on the state of the IPM science for managing the key production pests of apples. This report represents the outcome of that workshop and outlines a plan for coordination of research and implementation of apple IPM for widely scattered apple growers in Arkansas, Illinois, Indiana, Iowa, Kansas, Kentucky, Missouri, Ohio, and Tennessee.

Short and long term research priorities were established that would provide additional IPM strategies to manage fire blight, apple scab, sooty blotch, fly speck, plum curculio, and codling moth more effectively and with less pesticide usage. Extension activities and educational tools were proposed that would facilitate greater communication and cooperation between states and facilitate increased adoption of IPM by growers not yet involved. This includes the use of regional pilot studies/demonstrations, written materials, and development of an internet discussion list for university, industry, and growers in the region.

Additionally, participants at the workshop defined the components of an "entry level" IPM program for commercial apple production in the midwest. This is a basic system, and as such, all of these components must be used in order for orchard to be considered using IPM. The basic components of intermediate level and biologically intensive apple IPM systems were also defined. A survey was sent to apple growers in Arkansas, Illinois, Indiana, Iowa, Kentucky, Missouri, and Ohio to assess their use of these IPM tools, intensity of pesticide usage, and their pest and production problems.

Potential economic impacts from the implementation of this project would be significant. On-farm trials have shown that adoption of current IPM technologies can reduce pesticide costs and cut applications by one third. New IPM technologies developed and adoption of more intensive IPM practices would create additional savings in pesticide usage and cost to the grower.

Problem:
Apple growers in Arkansas, Kansas, Kentucky, Illinois, Indiana, Iowa, Missouri, Ohio, and Tennessee are confronted with a number of serious pest problems including apple scab, fire blight, cedar apple rust, powdery mildew, summer fruit rots (including sooty blotch, fly speck, and fruit rots), codling moth, apple maggot, plum curculio, spotted tentiform leafminer, aphids, and the European red mite. For the

most part, apple growers in these states are widely scattered. There are few consultants to assist growers in decision making within the region. Most are growing fruit in the absence of any neighboring orchards. Because of this isolation, they frequently face orchard and pest management decisions with less help from industry and advisors than growers in other states. This isolation prohibits growers from sharing expensive weather monitoring equipment.

Generally, this region is less than ideal for apple production. Cool, wet spring and warm, wet fall weather is typical for this region. These weather patterns provide favorable conditions for spring (apple scab, cedar apple rust, fire blight) and summer apple diseases (sooty blotch and flyspeck). Most popular cultivars and rootstocks in use are susceptible to fire blight. Each of these diseases can seriously limit production if not managed effectively.

There are differences in pest complexes among the states. For example, apple maggot can be a serious problem east of Missouri, oblique banded leafroller a problem in Ohio and eastward, and spotted tentiform leafminer is rarely a problem south of the Ohio river. There are also important differences in the natural enemy complex among these states. Codling moth remains on of the key insect pests. While mating disruption for codling moth is being used in other apple regions in the US, more than 1/3 of the orchards in this region are too small to attempt mating disruption. Despite codling moth's importance, less than half the growers use pheromone trapping to make informed decisions to manage it.

Throughout these states, apples are not one of the major agricultural commodities. Corn, soybeans, tobacco, forages, and livestock take precedence over apples. Because of this, growers frequently receive less support from county extension personnel. While many county extension educators do not consider apple production as important to their local economy, very few have training or experience with horticultural crops. The relative importance of apples relative to other agricultural commodities is reflected in staffing patterns at state universities and with private industry. Most training and extension support activities for apple growers are at the state level, although strong county extension programs for apples are in place in parts of Ohio.

Apple production remains one of the more pesticide intensive crops in the region. Traditionally, growers have relied on regular applications of pesticides throughout the growing season for protection. While these programs protect against all pests throughout the season and they will provide high quality fruit, typically this has resulted in 15 to 20 pesticide applications per season. Nearly all of these applications will contain an insecticide and a fungicide. Growers often rely on broad spectrum, non-selective organophosphate and carbamate insecticides for control of the key pests codling moth and apple maggot. Insecticides used to control key insect pests have caused additional pest problems by upsetting the natural control of other insects and mites. Supplementary applications may be needed when populations of secondary pests, such as whiteapple leafhoppers and European red mites, increase. The large number of pesticide applications associated with apple production increases the potential for human exposure and impacts to the environment.

Because of this reliance on pesticides, pesticide resistance and resistance management have increased in concern. For example, with only streptomycin available for fire blight management during infection and resistance to streptomycin appearing in some orchards, it has become critical for growers to carefully limit the use of these applications with IPM predictive models. Resistance of European red mites to most registered miticides encourages growers to use thresholds and monitor predator mite levels in order to limit the number of miticide applications. Resistance management is also a serious concern with apple scab, codling moth, spotted tentiform leafminer, and whiteapple leafhopper.

Apple IPM is not new to this region and many growers are regularly using the basic components. However, there are certain constraints that have hindered greater adoption of apple IPM. There is a great diversity of orchards sizes, with growers sharing different attitudes toward risk-taking and cost savings. While smaller orchards may be more willing to try new management systems, orchard size also affects the ability to adopt certain technologies (i.e., purchasing pest predictors or using mating disruption). Within each state there are staffing limitations to support apple IPM in both the public and private sectors. Because apple production is limited in acreage in this region, few states in this region have the resources to maintain strong, balanced research and education programs for apple IPM in the entomology, horticulture and plant pathology disciplines. Some states in the region are actively involved in the development and evaluation of new IPM technologies, others may focus on educational and training efforts to encourage implementation. However, because of budget constraints, different IPM management strategies may be emphasized in certain states based more on the experience and expertise of the researcher or extension specialist than necessarily the needs of the apple industry.

Background Situation:
Apple production in much of the south and midwest can be characterized by two types of growers; a small group of wholesale growers with large apple acreages and a much larger group of growers with smaller acreages that rely on direct sales to consumers. Some of the retail orchards use U-pick to reduce harvesting costs. There is a some of processing of apples with cider produced at many of the orchards. This small but vital industry has high visibility and provides an opportunity to demonstrate agriculture's responsible use of chemicals through IPM technology.

In November 1995, a multi-organizational public-private sector team (appendix 1) met to develop a plan for coordination of research and implementation of apple IPM in the region. During this meeting, the participant addressed research and educational issues related to IPM for widely scattered apple growers in Arkansas, Illinois, Indiana, Iowa, Kansas, Kentucky, Missouri, Ohio, and Tennessee and defined the minimum basic components of an apple IPM system for this region (appendix 2). A survey was sent to apple growers in to assess their level of IPM use, intensity of pesticide inputs, and their major pest and production problems (appendix 3).

Overall many apple growers are currently using many of the IPM components, with nearly 45% using all of the components of an entry level IPM program. A large group of the “non-IPM” growers need to adopt two or fewer IPM practices to enter into the “entry-level” category.

In Arkansas, Kansas, Kentucky, Illinois, Indiana, Iowa, Missouri, Ohio, and Tennessee apple IPM programs have been implemented to varying degrees. However, without the large volume of production in any one state, individual university resources to implement a balanced research/extension apple IPM program have been limited. While some states may have strong extension apple IPM programs, others may direct more of their efforts toward apple IPM research. Among the different disciplines involved, this balance may even vary within states. University downsizing has left some key research or extension positions unfilled in some states. Producers in these states are at a disadvantage with respect to development of locally generated information and its transfer as compared with growers in the larger apple production states of Michigan, Pennsylvania, New York, and Washington. Information generated by and disseminated from these areas may or may not directly address the local needs of our apple producers.

The aim of the project will be to provide growers with practical IPM systems to manage pests and reduce pesticide usage for apple production, while maintaining or increasing orchard profitability and fruit quality. An apple IPM implementation team consisting of university researchers and extension specialists, growers, and individuals from private industry will be assembled to address this goal. The project team will assist in the development, delivery, and implementation of IPM by apple growers through coordination research, training and educational, and support efforts in this region. By consensus, the project team has identified specific regional research, educational, and implementation needs, related these needs to existing programs, and set future priorities.

Predictive apple infection models for scab, fire blight, and to a lesser extent, cedar apple rust have been worked out. These models allow growers to apply disease control chemicals only when absolutely necessary. There is a need to develop additional models for foliar diseases such as powdery mildew and frog-eye leaf spot; fruit diseases such as black rot, white rot, sooty blotch/flyspeck, blotch, and bitter rot; and stem diseases such as collar rot or nursery infections of crown gall or southern stem blight.

More consumers buy apples than any other fruit. Apples are especially important in that 94% of consumers bought apples in the last year. However, according to the 1992 Packer Fresh Trends, 82% of consumers believe that growers can reduce chemicals during production without quality loss.

IPM based thresholds, predictive models, and non-pesticidal management tactics are currently available and beginning to be used by growers for management of insect and mite pests. However, there is the need to continue to develop and evaluate more biologically-intensive management such as mating disruption for insect pests, use of selective insect growth regulators and enhancing the action of natural enemies of pests.

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Recent disease and insect predictive IPM technology advances permit growers in specific sites to significantly reduce pesticide use for apple scab, fire blight, codling moth, and San Jose scale control by use of specialized weather and pest monitoring tools. For example, by carefully monitoring the weather, a grower can determine if leaf wetness and temperature conditions favor apple scab infection. With the advent of effective after-infection fungicides that can eradicate early stages of apple scab infections, the grower now has flexibility in choosing when to spray for this disease. The grower need only spray with eradicative fungicides when the disease has been active, rather than on a constant preventive schedule. This can greatly reduce the number of fungicide applications for apple scab control, particularly during drier periods.

There are no eradicative bactericides for fire blight control. However, site-specific environmental monitoring prior to bloom indicate levels of inoculum and the potential for disease incidence during the critical bloom period. This information is used to determine the need for sprays during bloom. Varietal and rootstock resistance also play a major role in fire blight management.

There is a need to get appropriate localized weather information to growers in a timely and inexpensive way so they can make informed decisions about disease management options. New weather monitoring and prediction approaches involving satellite, radar, geographic information systems, and predictive models may be available for apple growers. Research is needed to determine whether commercial services such as "Sky Bit" can provide weather information to growers as effectively as ground-based instruments.

For several diseases, the pathogen lies dormant on apple tissues until conditions are right for infection, or the pathogen waits in a latent state following infection. For some diseases, the pathogens are carried on plant material from the nursery to the grower. Research on improved detection systems is needed so that disease-free nursery stock can be assured.

Despite the success of scab-immune apples, research on developing apple cultivars resistant to the many other diseases is still needed. Development of new biocontrol agents and new chemistry for apple disease management should still be considered a high priority.

Pheromone trapping in combination with pest-specific degree-day accumulations derived from weather monitoring equipment is used to indicate the need for additional scouting or management activities. Formal pest monitoring procedures and economic thresholds are used to monitor codling moth, apple maggot, spotted tentiform leafminer, San Jose scale, aphids, leafhoppers, mites, and leafrollers.

Despite the success of mating disruption for management of codling moth in the Northwest, mating disruption has had mixed results in this region. Additional research is still needed to maximize the effectiveness of this strategy. There is the need to develop new biological control agents and more selective chemistry to manage the key insect pests.

The clientele targeted through this project include apple growers and other related industry personnel. This IPM project will address concerns of pesticide reduction, sustainability of apple production in the region, and resistance management.

The likelihood of adoption of apple IPM by growers is favorable. Apple IPM offers growers in this region some immediate advantages including reductions in production costs and pesticide usage, and if pesticides are needed, they will be used when they will be most effective. During grower demonstrations over a two year period in Kentucky, the use of IPM generated notable savings among the orchards. Growers with comparison blocks saved an average of $71 per acre using IPM and reduced the total number of applications from 15 to 12, fungicide sprays from 15 to 12, and insecticide and miticide sprays from 12 to 8. No losses in yield or quality due to IPM were observed. In fact, mite injury was reduced in blocks managed by IPM. Widespread adoption of IPM technology in the south and midwest would help to make apple production more competitive with other regions, while reducing fungicide and/or insecticide usage and easing potential risks to applicators, farm workers, and the environment.

Project scope:
The proposed project will combine and expand individual state Apple IPM efforts into a regional effort to include Arkansas, Kansas, Kentucky, Illinois, Indiana, Iowa, Missouri, Ohio, and Tennessee. It is anticipated that this interdisciplinary project will address all pests of apple in the region, including weeds, diseases, insects, and mites. While production practices are similar and most of the apple pests are endemic to the entire region, there are some significant difference among states with respect to the composition and intensity of specific apple pests that will also be addressed.

The objective of the Apple IPM planning grant is to assemble a multi-organizational public-private sector team to address regional apple IPM that will:

1. Develop a plan for coordination of research and implementation of apple IPM in the region.
2. Address research and educational issues related to IPM for widely scattered apple growers in Arkansas, Illinois, Indiana, Iowa, Kansas, Kentucky, Missouri, Ohio, and Tennessee.
3. Plan and hold an apple IPM symposium/workshop to discuss the benefits of and constraints to implementing apple IPM regionally.

Many of the states in the proposed project have no formal IPM programs, workshops, or publications. Frequently, apple IPM concepts are informally taught to growers at more generalized county, regional and statewide fruit meetings. Most of the states in the region are conducting research on various aspects or components of apple IPM.

In Missouri, a few growers are regularly monitoring for pests and applying insecticides only when needed. Some growers have experimented with mating disruption for codling moth, but the results have been erratic. About fifteen Show Me plant DISEASE forecasting systems™ will be evaluated for disease management in apples, grapes, field crops, and turfgrass. The system uses the Show Me Weather Machine to monitor weather, an IBM-compatible computer equipped with a radio receiver, and the Show Me Plant Disease Forecaster™ software to forecast disease infection periods for 11 plant diseases and codling moth infestations. Current studies include evaluating the use of remote weather data and precision farming practices. An interactive multimedia guide, "Identification and control of common apple diseases in Missouri" is distributed on the University of Missouri Xplor extension CD ROM.

In Iowa, IPM is being implemented through on-going farm trials with 20 cooperators for apples, strawberries, tomatoes, and cucurbits. These apple trials include the use of weather monitoring and predictive systems for disease management, and regularly monitoring, pheromone trapping, scouting thresholds, and degree day models for insect and mite management. Long term trials of scab-immune apple cultivars are being conducted. Bulletins on tree fruit and small fruit IPM for homeowners are being developed.

In Indiana, while no formal apple IPM program exists, IPM information for apples in distributed through county and statewide fruit meetings. However, there is an active research program for European red mites on apples. This program has addressed various aspects of mite management including the effects of various orchard management practices on European red mite predators. Indiana has been a key player in the development of scab resistant apple cultivars.

In Ohio, a small number of growers widely scattered throughout Ohio practice apple IPM on their own based on information obtained through Ohio State University as well as other sources. On a more formal level, there is an apple IPM program in its fifth year in a 5-county area of north central Ohio that involves 15 growers, 2 scouts, and coordination by one extension agent. While there is more interest and demand in Ohio for apple IPM, the key is having a knowledgeable resource person locally available, such as a extension agent.

In Arkansas, demonstration projects have been used to show apple growers how to conserve mite predators for biological control. The biology and management of the predator mite, *Amblyseious fallacis*, has been studied in several commercial orchards where biological control of spider mites has been achieved. A goal of the research program is to develop, demonstrate, and help County Extension Agents implement fruit tree IPM practices that lead to a more sustainable and low input fruit crop management program.

In Kentucky, on-going work confirms the economic benefits of apple IPM. Since 1991, about 40 widely-scattered commercial apple growers have begun using IPM practices, or at least components of IPM, in their orchards. Formalized winter meetings, in-season training workshops, a grower oriented IPM manual, and an instructional video are methods used to educate and train apple IPM to growers. A component of the Kentucky program is to train growers to become IPM self reliant. Growers are trained to scout their own orchards, maintain IPM records, and run predictive models on their own. Apple growers in the program have on average been able to reduce pesticide usage by about one third, and when compared to an adjacent orchard block maintained by the traditional preventive spray schedule, the IPM managed trees showed no difference in fruit quality, orchard diseases, or insect infestations. This has provided a cost savings of $146 per acre for growers on average. Grower acceptance has been encouraging with few growers dropping from the program.

Process:
The real strength of the project will be to assemble the combined expertise of the research/extension

specialists with grower and industry representatives throughout the region to integrate local apple IPM implementation efforts into a region-wide program. It will be important to maintain broad representation including public and private organizations, during all stages of this project. The IPM implementation team will consist of key university specialists, apple growers and other apple industry personnel from throughout the region, and representatives of the USDA Natural Resources Conservation Service. The composition of the proposed team is intended to stimulate public and private sector involvement. A preliminary list of those expressing interest in becoming actively involved with the planning grant is outlined in the following section.

An apple IPM implementation planning workshop will be organized and the planning team will meet to devise an implementation strategy for the region. In order to maintain a clear focus on this goal, as well as promote team building among the different groups involved, the structure of this workshop will be designed by Dr. Ron Hustedde, a sociologist and needs assessment specialist. Techniques will be used to encourage cooperative team building while ensuring a balance among those involved. An initial objective of this one-day workshop will be to identify common ground, opportunities, and incentives for greater adoption of apple IPM as well as constraints to its implementation. Existing Apple IPM programs among the states in the region will be studied carefully during this workshop. Specific research, education, training, and incentives needs relating the adoption of IPM by widely scattered apple growers in Arkansas, Illinois, Indiana, Iowa, Kansas, Kentucky, Missouri, Ohio, and Tennessee will be assessed and prioritized by the proposed implementation team.

An outcome of the workshop will be the development of the framework of a plan for coordination of research and implementation of apple IPM in the region. Based on the prioritized needs, steps will be outlined that will ensure the development of the project. Indicators that can be evaluated to monitor future progress of the IPM implementation project include the level of grower involvement and adoption of recommended biologically intensive IPM practices, reductions in pesticide use, fruit yields and quality, and an economic assessment of apple production using IPM. The team will establish milestones to measure the progress of the project.

As part of the workshop, a one-day symposium will be used to share broad areas of expertise as well as discuss the benefits of and constraints to implementing apple IPM regionally. The symposium, held just prior to the planning workshop, will be an opportunity to generate thought and enthusiasm surrounding the project, evaluate its feasibility and to begin to build the teams necessary to initiate planning. It will be attended by the IPM implementation team as well as other university researchers and extension specialists, private consultants and key industry personnel, and growers from the states involved. At this symposium, five expert speakers would be invited from outside of the region to address issues of apple production, integrated pest management technologies, marketing of IPM grown produce, and sociological factors affecting apple IPM. States participating in the project will provide apple IPM research/education/training reports during the symposium.

Table 1. Percentage of apple acreage and growers practicing IPM in Midwestern and Midsouth states as determined through a 1996 grower survey of production practices.

State	Acres managed using IPM[1]	Acres managed using Non-IPM	Apple growers using IPM	Apple growers using Non-IPM
Arkansas	3	151	1	13
Illinois	1226	1594	24	61
Indiana	493	340	14	43
Iowa	10	116	1	10
Kentucky	232	168	13	21
Missouri	1173	887	8	14
Ohio	1432	2070	27	61
Other[2]	188	842	3	12
Total Acreage	4756 (44%)	6167 (56%)	91 (28%)	235 (72%)

[1] IPM is defined as those acres which are managed using at least a minimum set of IPM components (eg., the "entry level" IPM components for commercial apple production, Appendix 2). Because apple maggot is not endemic to the entire region, use of red spheres and yellow cards for monitoring was not considered necessary for to a minimum IPM program.

[2] Other includes surveys returned without return address or postmark and from states outside the survey area (eg., Florida, Texas, Mississippi). Surveys returned from outside the area surveyed were assumed to have been completed by growers vacationing in other states.

Table 2. Average pesticide usage per acre per season and usage per grower per season among Midwestern and midsouthern states.

State	Acres	No. of Growers	Applications / grower / season Fung.	Ins.	Herb.	Applications / acre / season Fung.	Ins.	Herb.
Arkansas	183	14	7.3	7.5	2.2	7.7	6.9	1.6
Illinois	2820	85	10.7	9.6	1.9	12.6	9.9	2.1
Indiana	833	57	11.2	9.5	1.7	13.2	10.5	1.8
Iowa	126	11	9.4	9.1	1.6	12.2	12.3	1.2
Kentucky	404	34	11.7	8.9	1.7	13.4	9.4	1.7
Missouri	2060	22	10.0	9.1	2.4	9.6	8.8	2.4
Ohio	3502	88	10.9	9.1	1.5	10.0	8.1	1.5
Other	1034	15	10.5	8.1	1.9	10.0	8.2	1.7
Total	11,012	326	10.7	9.2	1.8	11.0	9.0	1.9

Table3. Summary of responses by apple producers to the Apple IPM Survey

Integrated Pest Management Component	**Number of Responses**	**Mean Score**	**Percentage Using the Component**
Regular monitoring of the orchard for pests and diseases	308	2.37	98.7
Manage orchard floor to reduce pest and disease problems. This includes weed management, soil testing for nutrient analysis, and water management	308	2.18	96.4
Sanitation (removal) of fruit mummies, twig and branch cankers and scabbed apple leaves while trees are dormant	313	1.81	85.9
Use of weather-based forecasting for fire blight disease management decisions	317	1.29	70.7
Use of weather-based forecasting and/or eradicant-only fungicide programs for apple scab management	310	1.58	76.5
Maintain IPM records that includes orchard and pest history, scouting and pesticide use	303	1.67	78.5
Use foliar analysis for nutrient management	303	0.91	54.8
Use an integrated mite management program that includes choosing pesticides that conserve mite predators	285	2.02	86.3
Use of pheromone trapping and degree day monitoring for codling moth management	298	1.01	46.6
Use of yellow sticky cards or red spheres for apple maggot management	300	0.54	26.1
Regularly calibrate and maintain spray equipment	301	2.11	97.0
Evaluate fruit quality as a measure of pest management effectiveness and as a guide for future decisions	303	2.19	96.7
Prune trees to increase air movement, light penetration and for sanitation to control fire blight. This results in reducing disease pressure and increases spray coverage	308	2.75	99.7
Integrated management of all insect and mite pests including	307	1.61	83.1

the use of university recommended scouting procedures and treatment thresholds			
Avoid cultivars that are highly susceptible to apple scab and fire blight	316	1.54	81.9
Use of spot treatments, reduced pesticides rates and alternate middle spraying to manage pests when appropriate	307	1.60	86.6
Use mating disruption for codling moth control	304	0.25	11.8
Use of resistant cultivars for apple scab, fire blight, cedar apple rust, and powdery mildew	308	1.16	71.4
Restrict pesticide usage to bio-rational alternatives	280	0.92	56.7

Table 4. Frequency of key disease problems reported by apple producers.

Key Problem	Frequency	Key Problem	Frequency
Apple scab	159	Collar rot	11
Fire blight	123	Bitter pit	11
Sooty blotch	94	Cork spot	10
Fly speck	87	White rot	7
Powdery mildew	31	Blister spot	4
Cedar apple rust	27	Bot rot	2
Black rot	13	Alternaria	1

Table 5. Frequency of key insect and mite problems reported by apple producers.

Problem	Frequency	Problem	Frequency
E. Red Mite	146	Stink / plant bugs	12
Codling moth	81	Leafrollers	5
Spotted Tentiform Leafminer	46	Grasshoppers	3
Plum curculio	41	Oriental fruit moth	2
Whiteapple leafhopper	26	Shot-hole borer	1
Aphids	25	Sawflies	1
San Jose scale	25	Yellowjackets	1
Apple maggot	24	Thrips	1
Japanese beetle	13		

Table 6. Frequency of key production problems reported by apple producers.

Problem	Frequency	Problem	Frequency
Labor	53	Hail damage	6
Weather	43	Rootstocks	6
Thinning	33	Mice	5
Fruit size	28	Tree fertility	5
Pruning	16	Tree growth	5
Time/timing	14	Old age	4
Deer	13	Poor equipment	4
Fruit color	12	Wind damage	4
Fruit drop	12	Birds	3
Biennial bearing	12	Winter injury	3
Water management	12	Lack of cold storage	3
Excessive regulations	9	Lack of pollination	3
Weeds	7	Sunscald	2
Marketing apples	7		

Appendix 1. Mid-south and midwest apple IPM Team Members in attendance at the Oct 31 - Nov 2 workshop in Indianapolis, IN.

Data Removed.

Appendix 2. Minimum, intermediate, and high-level components of Midwest Apple IPM Systems.

The following components, as a whole, define an "entry level" IPM program for commercial apple production in the midwest. This is a basic system, and as such, all of these components must be used in order for orchard to be considered using IPM.

<u>Minimum Components of "Entry Level" Apple IPM</u>

- Regular monitoring of the orchard.
- Orchard floor management to reduce pest and disease problems that includes weed management, soil testing for nutrient analysis, and water management.
- Sanitation of fruit mummies scabbed apple leaves.
- Use of weather based forecasting for disease management decisions for apple scab and fire blight.
- IPM record management that includes orchard and pest history, scouting and pesticide use records.
- Foliar analysis for nutrient management.
- An integrated mite management program.
- Use of pheromone trapping and degree day monitoring for codling moth management.
- Use of yellow sticky cards and red spheres for apple maggot management.
- Calibrate and maintain spray equipment.
- Pruning trees to increase air movement, aid in reducing disease, allow for thorough spray coverage and for sanitation to control fire blight, cankers, and fruit rots.

<u>The additional components for an intermediate level IPM system</u>

- Integrated management of all arthropod pests including the use of university recommended scouting procedures and treatment thresholds.
- Avoiding cultivars that are highly susceptible to diseases.
- Use of spot treatments, reduced pesticides rates and alternate middle spraying when appropriate.

<u>The additional components for a high level, or biologically intensive, IPM system</u>

- Mating disruption for codling moth control.
- Monitoring and treatment thresholds for plum curculio.
- Use of resistant cultivars for apple scab, fire blight, cedar apple rust, and powdery mildew.
- Pesticide usage restricted to bio-rational alternatives.

Appendix 3. Midwest Apple Survey of Ipm Usage

Indicate which of the following practices you use in the management of your crop.

Always	**Usually**	**Seldomly**	**Never**	**Integrated Pest Management Component**	**Want more information**
				Regular monitoring of the orchard for pests and diseases	
				Manage orchard floor to reduce pest and disease problems. This includes weed management, soil testing for nutrient analysis, and water management	
				Sanitation (removal) of fruit mummies, twig and branch cankers and scabbed apple leaves while trees are dormant	
				Use of weather-based forecasting for fire blight disease management decisions	
				Use of weather-based forecasting and/or eradicant-only fungicide programs for apple scab management	
				Maintain IPM records that includes orchard and pest history, scouting and pesticide use	
				Use foliar analysis for nutrient management	
				Use an integrated mite management program that includes choosing pesticides that conserve mite predators	
				Use of pheromone trapping and degree day monitoring for codling moth management	
				Use of yellow sticky cards or red spheres for apple maggot management	

				Regularly calibrate and maintain spray equipment	
				Evaluate fruit quality as a measure of pest management effectiveness and as a guide for future decisions	
				Prune trees to increase air movement, light penetration and for sanitation to control fire blight. This results in reducing disease pressure and increases spray coverage	
				Integrated management of all insect and mite pests including the use of university recommended scouting procedures and treatment thresholds	
				Avoid cultivars that are highly susceptible to apple scab and fire blight	
				Use of spot treatments, reduced pesticides rates and alternate middle spraying to manage pests when appropriate	
				Use mating disruption for codling moth control	
				Use of resistant cultivars for apple scab, fire blight, cedar apple rust, and powdery mildew	
				Restrict pesticide usage to bio-rational alternatives	

How many acres of apples do you farm? ______________________

Approximately how many fungicide/bactericide applications do you make per season? ___________________

Approximately how many insecticide applications do you make per season? ___________________

Approximately how many herbicide applications do you make per season? ___________________

What are your key disease problems?

What are your key insect (or mite) problems?

What are your key production problems?

Table3. Summary of Responses to the Apple IPM Survey

IPM Component	**Number of Responses**	**Mean Score**	**% Using Component**
Regular monitoring of the orchard for pests and diseases	308	2.37	98.7
Manage orchard floor to reduce pest and disease problems. This includes weed management, soil testing for nutrient analysis, and water management	308	2.18	96.4
Sanitation (removal) of fruit mummies, twig and branch cankers and scabbed apple leaves while trees are dormant	313	1.81	85.9
Use of weather-based forecasting for fire blight disease management decisions	317	1.29	70.7
Use of weather-based forecasting and/or eradicant-only fungicide programs for apple scab management	310	1.58	76.5
Maintain IPM records that includes orchard and pest history, scouting and pesticide use	303	1.67	78.5
Use foliar analysis for nutrient management	303	0.91	54.8
Use an integrated mite management program that includes choosing pesticides that conserve mite predators	285	2.02	86.3
Use of pheromone trapping and degree day monitoring for codling moth management	298	1.01	46.6
Use of yellow sticky cards or red spheres for apple maggot management	300	0.54	26.1
Regularly calibrate and maintain spray equipment	301	2.11	97.0
Evaluate fruit quality as a measure of pest management effectiveness and as a guide for future decisions	303	2.19	96.7
Prune trees to increase air movement, light	308	2.75	99.7

penetration and for sanitation to control fire blight. This results in reducing disease pressure and increases spray coverage			
Integrated management of all insect and mite pests including the use of university recommended scouting procedures and treatment thresholds	307	1.61	83.1
Avoid cultivars that are highly susceptible to apple scab and fire blight	316	1.54	81.9
Use of spot treatments, reduced pesticides rates and alternate middle spraying to manage pests when appropriate	307	1.60	86.6
Use mating disruption for codling moth control	304	0.25	11.8
Use of resistant cultivars for apple scab, fire blight, cedar apple rust, and powdery mildew	308	1.16	71.4
Restrict pesticide usage to bio-rational alternatives	280	0.92	56.7