Final Narrative Report

Michigan Apple Integrated Pest Management Implementation Project

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This report was prepared by the Michigan Apple IPM Implementation Project Coordinator (David Epstein), Project Co-Coordinator (Dr. Daniel Waldstein), and Project Manager (Dr. Charles Edson), on behalf of the Project Management Team, Michigan Apple Committee, and the Michigan IPM Alliance. Contributions were also made to this report by Dr. Larry Gut, Dr. Susan LaVigne, Jean Haley and Dr. Jeff Connor.

Significant contributors to the Michigan Apple Integrated Pest Management Implementation Project have been made over the years by a large number of individuals including apple growers, consultants, processors, and other apple industry representatives, as well as many at Michigan State University. A special thanks to the Michigan Apple Committee and the Michigan IPM Alliance for their steadfast support and partnership in this effort.

Executive Summary for Final Narrative Report

Project Goal

The goal of the Michigan Apple IPM Implementation Project (MAIPMIP) is the widescale (state-wide) implementation of an economically viable and environmentally sound pest management and production system that will significantly reduce reliance on broad spectrum pesticides and reduce the potential for residues on both raw and processed products.

Project Objectives

Objective I. - Implementation of the new system is expected to reduce the overall use of organophosphate (OP) insecticides by 50 - 75% in each year of the project and overall fungicide use by 15% on the acreage in the system, depending pest pressure and weather conditions.

Objective II. - Adoption of the system in Year One is expected to be on 500 acres; Year Two - 3000 acres; Year Three - 8000 acres.

Objective III. - The project will train field staff (consultants, field men, full-time orchard staff) in the implementation of the system so that the information providers for 75% of the growers are trained by the end of the project.

Accomplishments of the MAIPMIP

The following three tables provide an overview of major achievements of the MAIPMIP as they pertain to each objective.

Table 1. Objective I: major achievements.

Sub-objectives	Major Achievements
Use of mating disruption (MD)	• Significant increase in the number of growers who use MD for control of codling moth, leafrollers, oriental fruit moth • Moderate increase in the number of growers who use MD for control of borers • Significant impacts of the project on trap placement, number of traps per acre, trap maintenance and lure replacement.
Use of reduced-risk materials	Increased use between entrance and exit surveys: • 36% more growers use SpinTor • 23% more growers use Confirm • 20% more growers use Bts Increased use of new materials registered after start of project: • 83% of growers report using Intrepid • 20% of growers report using Avaunt • 13% of growers report using Esteem • 5% of growers report using Actara (registered summer 2001)

Table 1. Continued.

Sub-objectives	Major Achievements
Use of predictive models	• 55% of growers report using predictive models as a direct result of the project • 84% of growers report establishing biofix at 1st sustained capture (industry standard is 5 moths per trap)
Organophosphate use	• 49% reduction in Year 1 • 25% reduction in Year 2 • 30% reduction in Year 3
Fungicide use	• 3 fungicide use workshops were conducted to help growers improve spray timing, resistance management, and use of predictive models • Increased use of strobilurin fungicides
Pesticide residues	• No orchard average exceeded EPA tolerances for the year sampled. • The residue testing was specific to each site. When a compound was used; samples were tested. • Only one block had residue reported without a recorded use. All other residues detected were associated with recorded uses. • Repeatable residues detected over the four years were from the following compounds: Imidan, Captan, EBDC's and late season use of Guthion, Lorsban and Carbaryl. • Organophosphate use and residues were reduced over three years for this group of growers.
Fruit injury	• Maintained or reduced fruit injury on IPM acreage compared to grower's on-farm conventional programs
Economics	• Maintained or increased economic viability of IPM acreage compared to conventional program, depending on control methods and percent of fruit being sold to fresh market

Table 2. Objective II: Increased grower participation and acreage enrolled.

Project Year	Number of Growers	Acreage Enrolled
1999	43	850
2000	63	2,833
2001	103	8,300

Table 3. Objective III: major achievements.

Sub-objective	Major Achievements
Training & Outreach	• Created the MAIPMIP Industry Network, comprised of 106 growers, 24 consultants and field scouts, and 26 extension personnel, and 5 processors and packers • Conducted 8 training workshops attended by 289 growers, consultants, and extension personnel • Participated in 67 meetings, workshops, and conferences attended by over 9400 participants in 2000-2001 • Created MAIPMIP website: www.cips.msu.edu/maipmip/ • Made thousands of phone calls and on-farm visits with growers and consultants • Significantly impacted on-farm monitoring practices by increasing frequency, monitoring for beneficials, and time spent per monitoring trip • Improved overall pest management skills of participating growers • Seven additional pest management scouts were hired by consultants in 2001 • Conducted baseline survey of 39 participating growers in 1999 and 2000 • Conducted exit survey of 50 growers in 2001-2002
Educational Materials	• Pocket manual for IPM scouting and decision-making developed; 1500 copies distributed • Produced 4 educational fact sheets on mating disruption, monitoring, and Leafroller biology; distributed at grower meetings and in grower seasonal packets • Annual educational tours for federal and state regulatory personnel (US EPA, USDA, MDA, and DEQ) at participating MAIPMIP farms in 1999, 2000, and 2001 • Contributed 6 articles to 3 Gerber IPM newsletters devoted to the MAIPMIP; 500-600 copies distributed to growers and industry • Seasonal summaries of field data containing individual grower scouting reports, chemical spray applications, economic analysis, and pre-harvest fruit quality evaluations distributed yearly to participating growers

Summary for the attached Narrative Report

Michigan is annually the second to third leading producer of apples in the United States. The most recent Michigan Department of Agriculture (MDA) statistical survey reported 1,100 apple farms operating on 47,500 acres in the state, producing 850 million pounds of apples with a farm-level value of $75.9 million (Michigan Agricultural Statistics 2000-2001). Over 25 kinds of insects and mites may need to be controlled in Michigan orchards, with at least a dozen insect pests that directly feed on the apples. These pests must be effectively controlled to maintain adequate yields of quality fruit that is acceptable to consumers. Managing this pest complex across the varied conditions and growing systems of Michigan's five apple production regions while reducing organophosphate insecticide inputs presented MAIPMIP with a complex set of challenges.

Implementation and Documentation

The core of the MAIPMIP was the implementation and documentation of selective IPM programs on farms in each of five MI growing regions. The MAIPMIP also established grower standard practice blocks as comparison programs, where available. Based on catalytic funding from MAIPMIP industry partners the Michigan Project Team established 8 demonstration orchards one year in advance of the official start of the project. The MAIPMIP grew from 47 growers participating on 877 acres in 1999 to 106 growers participating on more than 8,300 acres in 2001. Viewed within the current reality of a Michigan apple industry that has lost 18% of its apple acreage and 15% of its farms since 1997, the growth of the MAIPMIP 1999 – 2001 was a significant accomplishment.

Reducing OP Use

The MAIPMIP promoted block-specific orchard scouting, a greater reliance on new, reduced risk insecticide chemistries, and pheromone mating disruption as tactics to reduce OP insecticide use. Project acreage was managed in conjunction with a consultant or scout, engaging most of the private firms that provide these services to Michigan apple growers. Growers selected options that they (and their consultants) felt were appropriate for their specific farm and pest situation. Regional variability provided a powerful impetus for growers in all regions to become involved in the MAIPMIP, so that they could learn first-hand how to effectively implement the new, selective programs on their farms.

Weekly scouting and pesticide use data were collected during the field season and fruit injury evaluations conducted prior to harvest. Economic data were also calculated for each farm. Total organophosphate (OP) use in the selective blocks was reduced by 49, 25, and 30 percent in 1999, 2000, and 2001, respectively. Despite the decreased use of OP's, overall control of key insect pests was as good or better in selective blocks when compared with growers' conventional programs. As growers and consultants gained experience and confidence in implementing the new selective programs, they expanded the use of these programs to non-MAIPMIP acreage. Therefore, during 2000 and 2001 selective insecticide use in cooperating comparison (conventional) blocks was equal to or greater than MAIPMIP selective blocks. Based on a ranging economic analysis performed by MAIPMIP staff, the selective IPM programs were economically competitive with grower standard programs when average or better yields were achieved, particularly when greater than 50% the harvested fruit was destined for fresh markets. Results were distributed to individual growers and the collective results used in recruitment efforts for the subsequent year.

Hands-on Field Training and Education

This project utilized industry support to conduct hands-on field training for growers and consultants who can now implement the new, more complicated and environmentally sound system on a wide scale. The Project Coordinators spent a great deal of time in the field, providing education for growers, discussing strategies, and collecting data. These one-on-one meetings were critical to the training efforts provided by the MAIPMIP. In addition, field workshops and meetings focused on specific implementation issues. An average of 25-40 growers, consultants and extension personnel attended over 50 meetings and workshops during 2000 and 2001. In addition, MAIPMIP results were presented during the Michigan State Horticultural Society meetings (attendance over 2000) and at grower meetings across Michigan during the winter months. New fact sheets and a pocket field guide were produced and distributed and training workshops conducted. Through the MAIPMIP, growers learned the power of information and the necessity of on-site monitoring to make sound management decisions.

Introduction & Background

A Significant Apple State

Michigan is annually the second to third leading producer of apples in the United States. The most recent Michigan Department of Agriculture (MDA) statistical survey reported 1,100 apple farms operational on 47,500 acres in the state, producing 850 million pounds of apples worth a farm-level value of $75.9 million (Michigan Agricultural Statistics 2000-2001). The average utilization of Michigan apples is 39 percent for fresh market and 61 percent for processing.

A Challenging Pest Complex

The complexity of the pest problems in Michigan has led to a pest management system highly dependent on chemicals (e.g., organophosphates) that are increasingly problematic for the sustainability of apple production. This Midwest production area appears to be a melting pot for all of the major pests of apple found in the western and eastern US. Over 25 kinds of insects and mites may need to be controlled in Michigan orchards to produce a viable crop (Appendix 1).

At least a dozen insect pests that directly feed on the crop must be effectively controlled to maintain adequate yields of quality fruit that is acceptable to consumers. Key pests include the codling moth, oriental fruit moth, obliquebanded leafroller, plum curculio and apple maggot. Collectively, if left unchecked, this pest complex could be expected to reduce marketable yield by up to 100 percent. Without effective control of these pests, farmers have had entire loads of fruit rejected or in extreme cases have lost an entire season's crop. For these reasons, the MAIPMIP project chose this pest complex as the focus of its efforts.

Many aspects of the conventional approach to apple pest management have accelerated the need to develop alternative pest control tactics. Of particular concern, pest resistance to insecticides is on the increase in some Michigan fruit growing areas (Gut, unpublished data). Broad-spectrum insecticides are highly toxic to natural enemies of most pests, and their use is a major factor limiting the potential of biological control in fruit orchards. Another factor is uncertainty as to the future availability of many pesticides based on conventional chemistries. New regulations governing pesticides, particularly the Food Quality Protection Act (FQPA), and the public's interest in reducing the use of insecticides have created this uncertainty.

In addition, the need for processors, particularly Gerber, to produce a product that meets the highest standards has created a mandate for the industry to move to a different pest management system. In short, pest resistance, federal regulations and the increased public concern simultaneously created a crisis. This crisis produced a strong incentive and an opportunity for apple growers to move to a more stable, biologically and environmentally sound pest management system that enhances the quality of baby food and other apple products.

How to Foster Change

The adoption and implementation of novel IPM strategies, technologies, and materials by agriculturalists is an on-going and evolving process. Not all growers adopt innovation at the same rate. The complexity of the new systems profered by such implementation projects can often inhibit the early adoption and implementation of new IPM practices. Implementation projects can help speed up the innovation-decision process for the majority of growers. The dissemination of information is quickened to this target audience, and the presence of project staff on-farm serves to lend growers the needed confidence necessary to attempt the implementation of innovation in a shorter time frame than occurs without project input. Additionally, implementation project efforts to collect the field data necessary for evaluation, and further efforts to analyze data and disseminate results can help to speed up the process of confirmation necessary for innovation adoption. Further, implementation projects can provide a network of growers, decision-makers, and information providers that can continue to benefit the targeted industries beyond the completion of a successful project.

MAIPMIP—An Opportunity to Improve Apple Pest Management in Michigan

To address this challenging pest problem, to comply with federal regulations and to respond to industry standards, the Michigan Apple Integrated Pest Management (IPM) Implementation Project (MAIPMIP) was established in 1999. Partners involved in this effort include Gerber Products (the market leader in baby food and an outspoken leader in producing safe products), the Michigan Apple Committee (a grower organization), the Michigan IPM Alliance (a consortium of Michigan fruit and vegetable commodity organizations, processors, Michigan State University and the Michigan Department of Agriculture), the Center for Agricultural Partnerships, and Michigan State University (MSU).

The Goal of MAIPMIP

This three-year project has focused on implementing new pest management systems to help boost the state's apple economy while protecting and preserving the quality of the environment and the safety of our food supply.

The goal of the MAIPMIP was:

> *The widescale (state-wide) implementation of an economically viable and environmentally sound pest management and production system that would significantly reduce reliance on broad spectrum pesticides and reduce the potential for residues on both raw and processed products.*

MAIPMIP Objectives

To achive the goal of MAIPMIP, three key objectives were established:

Objective I. To implement a new IPM system that will reduce the overall use of organophosphate (OP) insecticides by 50 - 75% in each year of the project and overall fungicide use by 15% on the acreage in the system, depending pest pressure and weather conditions.

Objective II. – To incrementally increase adoption of the system over three years from 500 acres in year one, to 3000 acres in year two and finally, to 8000 acres in year three.

Objective III. - To train train field staff (consultants, field men, full-time orchard staff) in the implementation of the system so that the information providers for 75% of the growers are trained by the end of the project.

Five Key Areas of Implementation

Within these three objectives, MAIPMIP concentrated on five key areas: 1) implementation and documentation, 2) systematic monitoring, 3) hands-on field training, 4) grower and industry education, and 5) development of user friendly materials and communication. In each of these key areas, activities were designed and carried out to help growers implement new, more complex and environmentally sound pest management practices statewide.

Implementation and Documentation

The core of the MAIPMIP was the implementation and documentation of selective IPM programs on farms in each of five MI growing regions. The MAIPMIP also established grower standard practice blocks as comparison programs, where available. Based on catalytic funding from MAIPMIP industry partners, the Michigan Project Team established 8 demonstration orchards one year in advance of the official start of the project. The MAIPMIP grew from 47 growers participating on 877 acres in 1999 to 106 growers participating on more than 8,300 acres in 2001. Viewed within the current reality of a Michigan apple industry that has lost 18% of its apple acreage and 15% of its farms since 1997, the continued growth of the MAIPMIP 1999 – 2001 was a significant accomplishment.

Systematic Monitoring

The MAIPMIP promoted block-specific orchard scouting, a greater reliance on new, reduced risk insecticide chemistries, use of models to pinpoint pesticide applications, and pheromone mating disruption as tactics to reduce OP insecticide use. Project acreage *was* managed in conjunction with a consultant or scout, engaging most of the private firms that provide these services to Michigan apple growers. Growers selected options that they (and their consultants) felt were appropriate for their specific farm and pest situation. Regional variability provided a powerful impetus for growers in all regions to become involved in the MAIPMIP, so that they could learn first-hand how to effectively implement the new, selective programs on their farms. Weekly scouting and pesticide use data were collected during the field season and fruit injury evaluations conducted prior to harvest.

Hands-On Field Training

This project utilized industry support to conduct hands-on field training for growers and consultants who can now implement the new, more complicated and environmentally sound system on a wide scale.

Grower and Industry Education

The Project Coordinators spent a great deal of time in the field, providing education for growers, discussing strategies, and collecting data. These one-on-one meetings were critical to the training efforts provided by the MAIPMIP. In addition, field workshops and meetings focused on specific implementation issues. An average of 25-40 growers, consultants and extension personnel attended over 50 meetings and workshops during 2000 and 2001. In addition, MAIPMIP results were presented during the Michigan State Horticultural Society meetings (attendance over 2000) and at grower meetings across Michigan during the winter months.

Development of User Friendly Materials and Communication

New fact sheets and a pocket field guide were produced and distributed, training workshops conducted, and a MAIPMIP website established. Through the MAIPMIP, growers learned the power of information and the necessity of on-site monitoring to make sound management decisions.

The following report highlights key accomplishments of the program objectives, reviews program activities in the five key areas, and summarizes program findings.

Section I. Accomplishments of the Michigan Apple Project: Objective I

Objective I. To implement a new IPM system that will reduce the overall use of organophosphate insecticides by 50 to 75 percent in each year of the project and overall fungicide use by 15 percent on the acreage in the system, depending on pest pressure and weather conditions.

Implementing a new system that significantly reduced reliance on broad-spectrum insecticides in an economically viable and environmentally sound manner, while reducing the potential for residues on both raw and processed products required a significant revision to the current pest management system. To successfully achieve this objective, several indicators were tracked in addition to the reduction of organophosphate insecticides (OPs) and fungicides. These indicators included the use of mating disruption, predictive models, quality and yield of product, and the economic viability of pest management strategies. Without all of these components, the new IPM system would not have successfully decreased OP use; nor have provided the proper incentive for an annual increase in participating growers and acreage (Project Objective II).

The primary insect pests of apple in Michigan are plum curculio, codling moth, leafrollers and apple maggot. In general, Michigan growers currently rely on the organophosphate insecticides to manage these pests. These broad-spectrum insecticides provide management of several other non-target insect species that are secondary pests or potential pests in apple. Pyrethroid insecticides can be as effective as the organophosphate insecticides on the key and secondary pest complexes, but the use of pyrethroids can lead to mite outbreaks in orchards by adversely impacting mite predators. Regional variability within Michigan (i.e. in pests, climate, soils, varieties, etc.) and farm to farm variability within the region meant that the selective programs varied by farm and even block to block. This variability provided a powerful impetus for growers in all regions to become involved in the MAIPMIP, so that they could learn first-hand how to effectively implement the new tools/strategies in their region, but specifically on their farms.

The MAIPMIP fostered a range of selective pest management options aimed at reducing orgranophosphate use. Growers selected options that they (and their consultants) felt were appropriate for their specific farm and pest situation. Cooperating growers established selective IPM demonstration blocks (i.e., pheromone mating disruption and selective insecticide chemistries), and compared them with blocks under standard pest management practices.

Objective I: Achievements At a Glance

Table 4 provides a quick overview of the MAIPMIP achievements during all three years of the project. Each sub-objective will be discussed following the table.

Table 4. Objective I: major achievements.

Sub-objectives	Major Achievements
Use of mating disruption (MD)	• Significant increase in the number of growers who use MD for control of codling moth, leafrollers, oriental fruit moth • Moderate increase in the number of growers who use MD for control of borers • Significant impacts of the project on trap placement, number of traps per acre, trap maintenance and lure replacement.
Use of reduced-risk materials	Increased use between entrance and exit surveys: • 36% more growers use SpinTor • 23% more growers use Confirm • 20% more growers use Bts Increased use of new materials registered after start of project: • 83% of growers report using Intrepid • 20% of growers report using Avaunt • 13% of growers report using Esteem • 5% of growers report using Actara (registered summer 2001)
Use of predictive models	• 55% of growers report using predictive models as a direct result of the project • 84% of growers report establishing biofix at 1st sustained capture (industry standard is 5 moths per trap)
Organophosphate use	• 49% reduction in Year 1 • 25% reduction in Year 2 • 30% reduction in Year 3
Fungicide use	• 3 fungicide use workshops were conducted to help growers improve spray timing, resistance management, and use of predictive models • Increased use of strobilurin fungicides
Pesticide residues	• No orchard average exceeded EPA tolerances for the year sampled. • The residue testing was specific to each site. When a compound was used; samples were tested. • Only one block had residue reported without a recorded use. All other residues detected were associated with recorded uses. • Repeatable residues detected over the four years were from the following compounds: Imidan, Captan, EBDC's and late season use of Guthion, Lorsban and Carbaryl. • Organophosphate use and residues were reduced over three years for this group of growers.

Table 4. Continued.	
Sub-objectives	**Major Accomplishments**
Fruit injury	• Maintained or reduced fruit injury on IPM acreage compared to grower's on-farm conventional programs
Economics	• Maintained or increased economic viability of IPM acreage compared to conventional program, depending on control methods and percent of fruit being sold to fresh market

The following subsections discuss the major achievements outlined in the table above.

Pheromone Mating Disruption

Female insects secrete chemicals called sex pheromones to attract male mates of the same species. Mating disruption (MD), as practiced in apple integrated pest management, involves flooding an orchard with large amounts of a female insect's sex pheromone to decrease the likelihood that males will find a female for mating. Disruption products are considered nontoxic and environmentally benign. This technology does not kill the targeted insect, but instead reduces the population levels of the pest by preventing or delaying mating and decreasing female fecundity.

Pest management programs combining the use of MD with selective insecticides offer a real opportunity to reduce broad-spectrum insecticide inputs, thereby providing an opportunity for the natural enemies of pests to establish and survive in orchards. Determining how to use these tools in an efficacious and economic manner has been a focus of growers working within the MAIPMIP.

Growers were surveyed at the beginning of Year 1 and at the end of Year 3 of the project to document changes in the use of mating disruption for key pests. Table 5 illustrates the increased use among growers for control of codling moth, leafrollers, oriental fruit moth, and borers. For a complete description of the survey instruments and methods, please refer to Appendix 2 and 3.

Table 5. Increased use of mating disruption among project growers.

Targeted Pest	Year 1	Year 3	Percent Change
Codling moth	20%	74%	+60%
Leafrollers	7%	56%	+49%
Oriental fruit moth	7%	24%	+17%
Borers	0%	4%	+4%

In addition to the survey, mating disruption was tracked through one-on-one consultations with participating growers. While more growers were indeed using mating disruption, use patterns changed in the 2001 season. Acreage under mating disruption increased from nearly 800 acres in the first year of the project to approximately 2,700 acres in 2000, and we expected a similar 2-3 fold increase in 2001. Whereas, the overall number of farms implementing mating disruption technologies did increase in 2001 from 60 to 67, mating disruption acreage decreased to approximately 1,900 acres of commercial apple orchards (Figure 1). Several factors may have influenced the decrease in acreage under disruption in 2001.

A reoccurring theme in apple production has been the increased economic burdens placed on commercial apple growers. Because the input costs of mating disruption products are often relatively expensive, even at less than full rates, ($50-100/acre for hand applied dispensers vs. $15/spray of guthion) many growers are apprehensive about using these products. Additionally, the application of hand applied dispensers is a labor intensive process (approximately 2 hours per acre), adding labor costs as well as competition for that labor at times of the growing season when many Michigan growers are busy working in other crops. For example, many fruit growers in western MI also grow asparagus. Asparagus harvest season coincides with the timing for the application of codling moth pheromone dispensers, creating competing demands on a limited work force. When you bring the high cost of new pesticide chemistries into the mix, growers are continually making choices on where to allocate limited resources.

A second factor to consider is that many growers are not paid for their fruit upon delivery as with other commodities (e.g., corn and soybeans). Growers may often have to wait longer than a year after their initial expenditure on control products to receive payment for their apples. Growers have less money in hand at the beginning of each season because of delayed payments. This causes them to focus primarily on reducing input costs as much as possible. These factors explain why higher input costs for mating disruption programs may be acting as an adoption deterrent for some growers even when added revenue may eventually result from decreased fruit damage.

A third consideration is the concern that MI growers have with high input costs associated with MD technologies that target one pest in a complex of more than two dozen pests. As the technology advances, and new methods of dispensing the pheromone are developed that make applications easier and less expensive, the potential for greater inclusion of disruption into IPM programs increases.

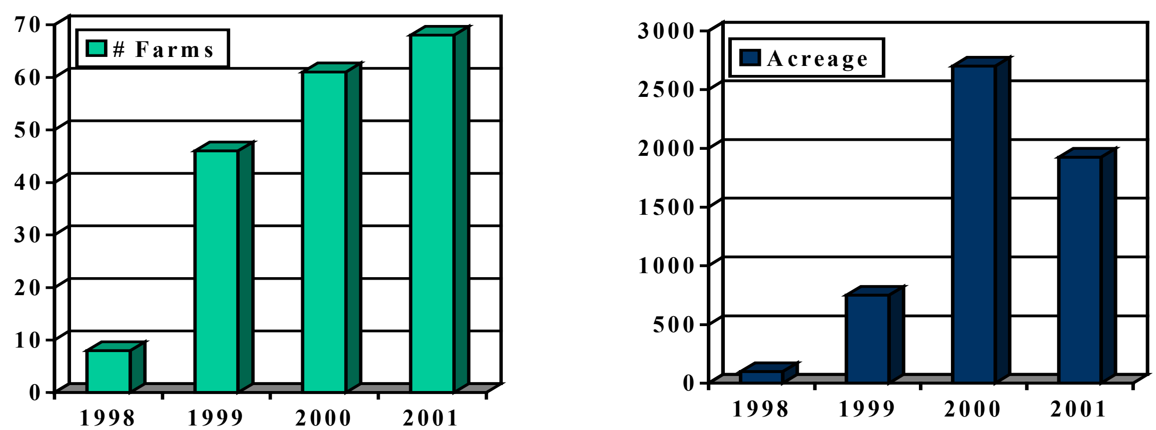


Figure 1. Use of Mating Disruption in Michigan Apple Orchards

Reduced Risk Materials

As their name implies, selective, or narrow-spectrum insecticides target one or a few closely related pest insects. A number of these narrow-spectrum insecticides became available for the first time in 2001, the final year of the MAIPMIP, including Intrepid®, Esteem®, Avaunt®, and

Actara®. These new insecticides provided a strong complement to previously registered selective insecticides which included SpinTor®, Confirm®, Provado®, and *Bacillus thuringiensis* (Bt) products. These selective insecticides have increased the tools in our IPM arsenal and will enhance our ability to implement pest management programs that are less dependent on organophosphate use.

Most of these new insecticides are considered by the U.S. EPA to have "reduced-risk" status. To qualify as reduced-risk by the EPA, a pesticide must have one or more of the following characteristics in comparison to existing conventional products (Felsot 2001):

- Low impact on human health
- Low toxicity to non-target organisms (birds, fish, and plants)
- Low potential for groundwater contamination
- Lower use rates
- Low potential for development of pest resistance
- Compatibility with IPM (i.e., low toxicity to parasitoids and predators)

Figures 2 and 3 below show the increased use of these reduced risk materials due to the MAIPMIP efforts.

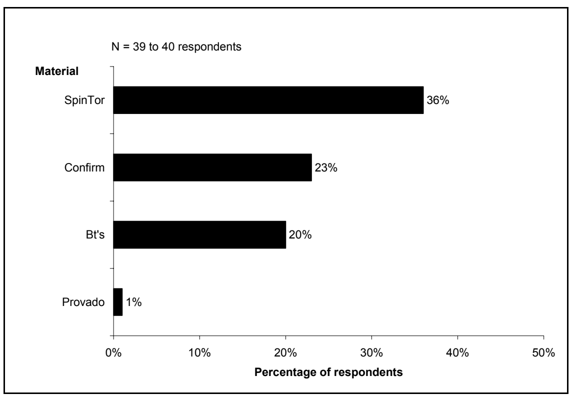


Figure 2. Difference in reduced risk material use between Year 1 and Year 3.

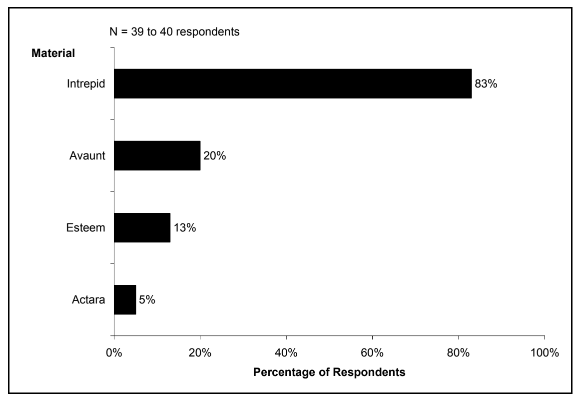


Figure 3. Reduced risk material use (new chemistries).

Predictive models

Another important component of the new IPM system that allowed growers to reduce chemical use (particularly OPs and carbamates) was the use of predictive models. In the exit survey, growers were asked specifically if they timed pest management decisions based on degree day models as a direct result of participating in the program (Figure 4).

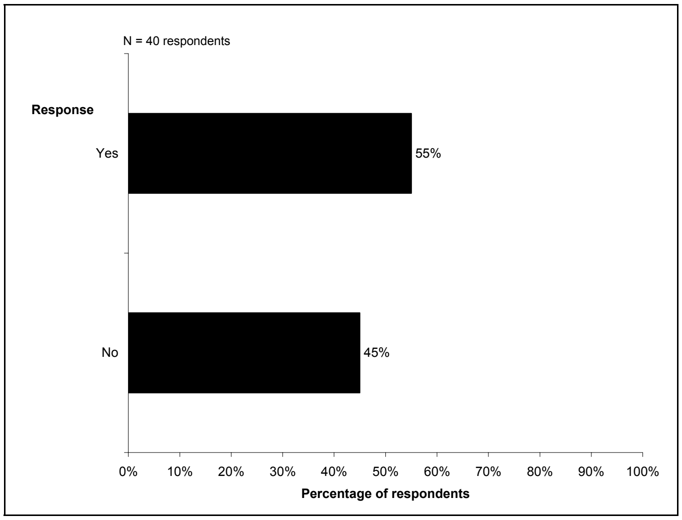


Figure 4. Percentage of respondents who time pest management decisions based on degree-day models as a direct result of the MAIPMIP.

As a direct result of the MAIPMIP, 55 percent of interviewees now time pest management decisions based on degree-day models.

Growers who used degree-day models were also asked how biofix was established on their farms (Figure 5). Biofix is a term that describes a point in time when calculations in a degree-day model are begun. Degree-days are biological heat units that are used to predict biological development of targeted pests, in order to better time control measures for the most susceptible life stage of that pest.

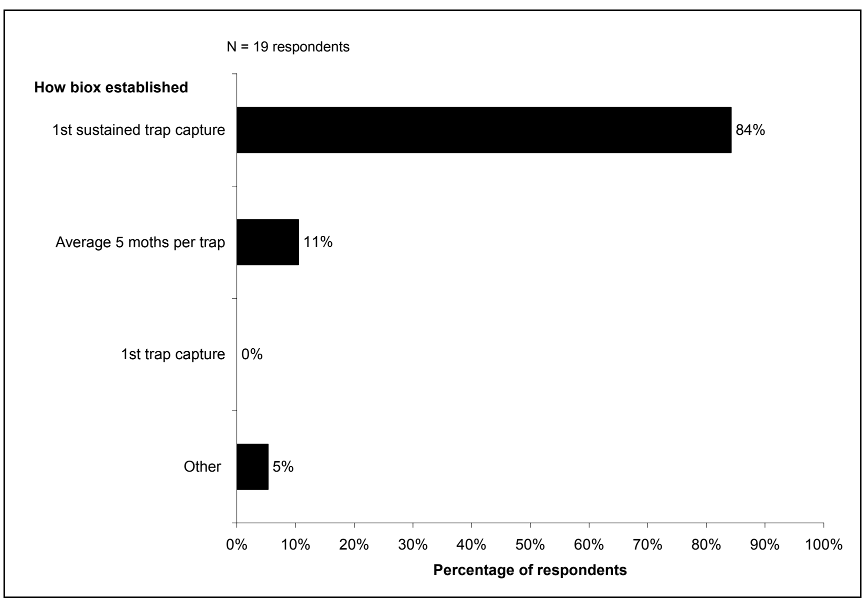


Figure 5. How biofix is established for pest moth species for growers using degree day models.

Eighty-four percent of respondents who used degree day models for timing pest management treatment decisions established biofix at the first sustained trap capture, 11 percent established biofix on an average of five moths per trap, none established biofix at the first trap capture, and five percent established biofix using other methods (Figure 5). Those selecting “other” did not know the method. Sustained trap capture is the standard promoted by the MAIPMIP. The fact that 84% of growers surveyed used sustained catch is significant, especially since, in year 1 of the MAIPMIP, the industry standard was an average catch of 5 male moths in a pheromone baited trap.

Organophosphate Use

Total organophosphate (OP) reduction in selective blocks in 1999, 2000, and 2001 was 49, 25, and 30 percent, respectively (Table 6). First year participants were very successful at reducing broad-spectrum insecticide use, cutting OP use by 49 percent and carbamate use (these insecticides share a common mode of action with the OPs) by 31 percent in the selective blocks compared to the grower standard practice (comparison) blocks (Table 6). As expected, the growers who participated in the first year of the project were mostly innovators and early adopters. Innovators and early adopters tend to accept higher levels of risk compared to late adopters (Rogers, 1995), so the first year participants were fairly aggressive at implementing new practices in their selective blocks, with the resultant reduction in OP use. Although these growers did use selective chemistries in their standard (comparison) blocks during 1999, they still relied primarily on OP insecticides in these blocks, tending not to implement many of the new practices.

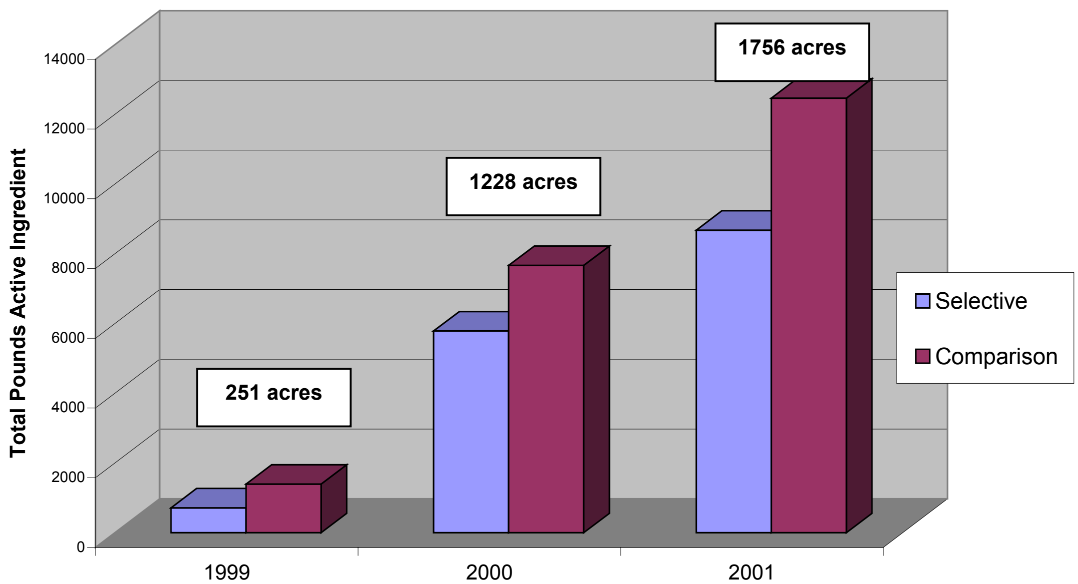


Figure 6. OP use in grower selective and comparison blocks, MAIPMIP 1999-2001.

Growers continued to reduce OP use in 2000 and 2001 in the selective blocks (Table 6, Figure 6), applying 1.53 and 2.16 pounds less OP active ingredient (AI) per acre in the selective blocks, respectively (Table 6). On average, a reduction of over 18,000 pounds of OP AI was achieved on 8,360 MAIPMIP acres in 2001. We speculate that if growers averaged this level of OP AI reduction across the entire Michigan apple acreage (47,000 acres), they would reduce OP use in Michigan apple orchards by over 100,000 pounds of OP AI, annually.

Table 6a. Total number of pounds OP active ingredient for all growers on all acres, MAIPMIP 1999-2001.

Year	# Acres*	Selective	Comparison
1999	251	714	1,397
2000	1,228	5,786	7,668
2001	1,756	8,681	12,467
Total	3,235	16,674	23,471

*based on number of acres with viable comparison blocks, complete spray records, and fruit injury counts

Table 6b. Mean number of pounds OP active ingredient per acre, MAIPMIP 1999-2001.

Year	# Acres*	Selective	Comparison
1999	251	2.84	5.56
2000	1,228	4.71	6.24
2001	1,756	4.94	7.10
Total/Average	3,235	4.16	6.30

*based on number of acres with viable comparison blocks, complete spray records, and fruit injury counts

However, on a percentage basis (Table 6), OP reduction in 2000 and 2001 was less than that observed in 1999, for two reasons. First, as the innovative growers who participated in 1999 gained confidence with the new practices, they began to implement some of these practices on the rest of their farms (e.g. selective insecticide use actually tended to be higher in the comparison blocks than in the selective blocks). Therefore, the adoption of pest management strategies advocated by the MAIPMIP on non-project acres (i.e., comparison blocks) meant that growers were likely using fewer OP's on comparison, as well as selective blocks. This is exactly the way that implementation projects like the MAIPMIP should work: growers begin implementing a new practice or system, gain confidence in a successful trial; expand adoption to much broader acreage; finally, the 'new practice' becomes the standard. Second, as the MAIPMIP expanded in 2000 and, particularly, in 2001, the project attracted many growers who would not be considered innovators or early adopters. Growers who joined the MAIPMIP in 2000 and 2001 were less likely to dramatically reduce OP use because of perceived risk and were also more likely to need additional time to gain confidence in the new practices. We anticipate, that as these groups of growers gain more experience with the new practices, that they, too, will expand adoption to greater acreage.

Fungicide Use

Fungicide use data was analyzed from orchards where residue samples were collected (see Pesticide Residue section, below). While there were several new strategies available for managing insect pests, there were few new strategies available to help growers reduce fungicide use when the MAIPMIP began. MAIPMIP staff worked with Project growers to reduce fungicide use by improving spray timings through educational efforts. This was highlighted at three disease management workshops focusing on resistance management, improved fungicide application timing through the use of predictive models, and the use of new reduced-risk chemistries. The introduction of the strobilurin fungicides had the largest impact on reducing the use of older fungicides (e.g., Captan, EDBC'S) during the three years of the Project.

Pesticide Residues

The following section is from the residue analysis report submitted by Gerber Products Company. The balance of the report includes a detailed description of methods and findings and is included in Appendix 4.

Summary

Concurrent with the extensive use and application variables employed and contributed by the members of the MAIPMIP, the Gerber Products Company provided pesticide residue testing. The residue testing contribution was designed to monitor changes in use practices and the related reduction and or elimination of residues from the fresh fruit and potentially the orchard environments. Starting in 1998 through 2001, three hundred samples were collected. Each sample was a twenty apple composite. Samples were collected at harvest for each variety. The 1998 samples were used to establish a baseline and testing programs for the subsequent years, 1999, 2000 and 2001.

Each grower participating in the residue program set up two distinct blocks of the same variety of apple. One block was designated as a control and standard farm practices for spraying were used. The second block was designated the IPM block where the use of new compounds, mating disruption and scouting to reduce spray applications was employed. Random trees were selected from each block each year for testing. Sample collection was based on the IR-4 recommendation. Twenty-apples, five from the top, bottom and sides both inside and out for each tree comprised a single residue sample. All samples were frozen the same day as sampled. All samples were acquired in the same way every year.

General Results

- No orchard average exceeded EPA tolerances for the year sampled.
- The residue testing was specific to each site. When a compound was used; samples were tested.
- Only one block had residue reported without a recorded use. All other residues detected were associated with recorded uses.
- Repeatable residues detected over the four years were from the following compounds: Imidan, Captan, EBDC's and late season use of Guthion, Lorsban and Carbaryl.
- Organophosphate use and residues were reduced over three years for this group of growers. (See figure 7)

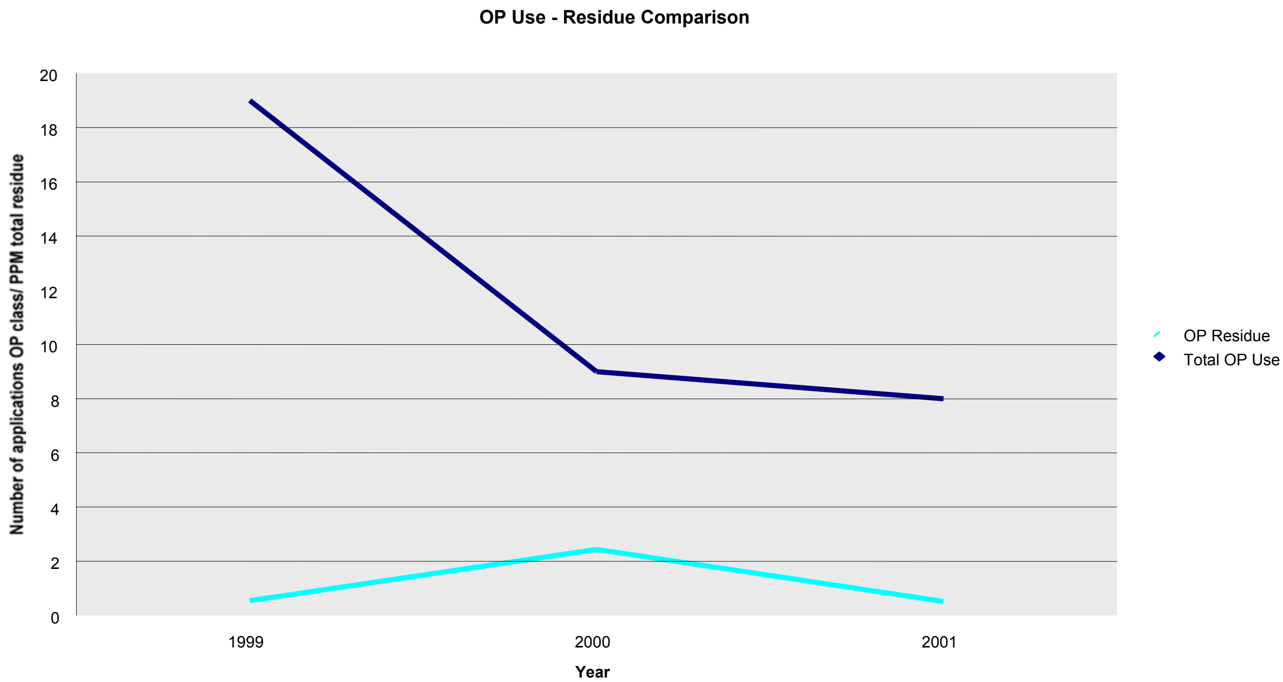


Figure 7. OP use – residue comparison.

Sample and Testing Protocols

Analytical sampling and testing followed EPA recommended methods for selection, storage and testing. The four-year residue-testing project incorporated a representative subset of the total project's grower base. This subset included 16 growers and 8 varieties of apples; Red Delicious, Golden Delicious, Empire, Paula Reds, Fugi, Jonathans, Romes and Ida Reds. Within this subset of growers 42 different pesticides were used, 20 fungicides and 22 insecticides (see Table 7 for compound identifications).

Standard multi-residue methods, which include the N-methyl carbamates, organophosphates, organonitrogen and organochlorine, were used. The multi-residue analytical methods detect more compounds than were associated with use during this project; all positive results were recorded. All results, negative and positive, available from the methods are part of the database; however, only positive detections are summarized in this report. Many of the new compounds used, as alternatives to the organophosphate insecticides are not detected using the standard multi-residue methodologies provided by the EPA and FDA. Detection of the new compounds required a method specific for each compound or class. The manufacturers of the new compounds provided the single residue methods and standards. Gerber Products Company required detection limits of 0.010 PPM and below for all methods used. All testing was accomplished at the National Food Laboratory in Dublin, California. Methods, performance data and analytical results have been retained. Analytical variability is reproducible and limited to the criteria listed in Appendix 4.

Table 7. Pesticide Usage and Detected Residues.

Pesticide	% Use *	% Positive**	Range***	Tolerance
Ambush 2E	27	0		0.05
Agri-Mek	30	0		0.02
Apogee	4	NT		
Asana	43	0		0.05
Avaunt	4	Test Cancelled /Interference		
Azinphos-methyl	87	100	0.005-2.600	1.5
Bayleton 50	30	0		1.0
Benlate	13	0		7.0
Captan	87	100	0.009-22.00	25.0
Carbaryl	40	20	0.020-0.520	10.0
Chlorpyrifos	48	10	0.02-0.100	1.5
Clofentezine	22	0		0.5
Confirm	43	60	0.010-0.300	1.5
Danitol	9	50	0.030-0.072	5.0
Dimethoate	4	0		2.0
EBDC's	78	100	0.010-3.220	2.0 – 7.0
Endosulfan	4	0		2.0
Esfenvalerate	43	0		
Fenarimol	48	0		0.1
Flint	35	40	0.014-0.120	0.5
Hexathizox	4	0		0.5
Imidacloprid	57	15	0.01-0.02	0.5
Imidan	96	100	0.007-3.100	10.0
Intrepid	13	100	Pending	
Kresoxim-methyl	22	0		1.0
Lannate SP	13	0		1.0
Methyl Parathion	4	100	0.02-0.09	1.0
Myclobutanil	43	0		0.5
Neem	4	Test Cancelled/Detection Limit too High		
Oil	9	NT		
Oxamyl	4	0		2.0
Pyramite	43	40	0.007-0.120	0.5
Sulfur	30	NT		
Spinosad	35	13	0.9	0.2
Surround	9			
Thiram	17	See EBDC's	See EBDC's	
Topsin-M	4	See Benlate	See Benlate	
Vanguard	30	43	0.001-0.004	0.1
Vydate	9	0		
Ziram	61	See EBDC's	See EBDC's	
NU= No Use NT= No Test	*% Of Total Grower Use over three years total: 23 growers	**% Growers with positive detection	***Range of positives in mg/kg, PPM	

Discussion

The variability in the pesticide residue results from this project cannot be attributed exclusively to the analytical techniques and methods used. The difference recorded within orchards, between growers and across similar use-patterns raises the question of additional variables that were not included. Total residues amounts measured for both insecticides and fungicides consistently were not dependent on the number of applications or the total amount of active ingredient used over the full season. Application increases and decreases could not be equated with increases or decreases in measured residue (see figure 8 and table 8). The lack of a predictive pattern was disappointing. A similar random response was associated with the active ingredient comparisons. Figure 9 is an example of the tree to tree differences repeated for all compounds and sampling blocks. When organophosphate use in the control block had more applications than the test blocks, the lower of the two was not obvious from the amount of residue reported per sample tree. Both blocks would have sample trees that covered a large range. The residues could range from zero (non-detect) to tolerance levels. No clear distinction was produced when a compound was used in both the control and the test block but with different rates or application numbers. The use/no-use distinction was clearly evident for each comparison. The within grower variability only exaggerated the between grower variability. An example of the block to block comparisons where the same compound, the same number of applications and the same pre-harvest interval (PHI) were used shows the difference. With the major variables held the same and the results from each block averaged a similar residue pattern was expected. It was not demonstrated see figure 10.

As shown in figure 10, comparisons in a growing season/year were varied. The changes in standard farm practices from year to year made comparisons between years difficult. These changes introduced variables that were not recorded for all participants. Some of the changes were captured as incidental information over the course of the project. Changes that may have had an effect on the amount of residue retained are adjuvant use, such as stickers and spreaders, tank mixtures, sprayer used, location of trees samples, spray patterns, age of the orchard, and density of foliage/canopy. Where this information is available with corresponding spray records and the residues detected the recommended adjuvant use with the new chemistries may relate to the broader pesticide residue retention detected. Insufficient documentation is available to conclusively support this relationship.

Conclusion

At the end of the four years Organophosphate use and residues decreased for the 16 growers monitored. What combinations of variables contributed to the third year, 2000, residue increase have not been identified. The data generated from 1999 through 2001, insecticide and fungicide, recorded the changes in standard farm practices as well as the residues. This grower subset consistently implemented the use of new chemistries and practices as part of their standard farm practices limiting year to year comparisons even in the control blocks. The original design and objectives of the control blocks were no use comparisons for new insecticides and technologies. The no use comparisons were valid. The variability within orchards and between growers confounded some of the direct relationship expectations previously used to understand residue reduction. This relationship may still be true if the appropriate variables are also monitored. Reduction in the amount of residue anticipated for a specific apple sample may be based on more than the number of applications, the amount of active ingredient applied and the pre-harvest interval for each season.

Table 8. Detected Residue by Apple Variety.

Variety	Compound	1998	1999	2000	2001
Empire	Captan	0.6	0.1	8.0	0.2
Golden Delicious	Captan	0.1	0.4	8.0	0.2
Red Delicious	Captan	0.1	0.4	3.0	0.4
Empire	EBDC's	NT	0.04	0.3	0.1
Golden Delicious	EBDC's	NT	7.0	1.0	NU
Red Delicious	EBDC's	NT	0.1	0.7	0.01
Empire	Guthion	<0.001	<0.001	0.04	0.02
Golden Delicious	Guthion	<0.001	<0.001	0.1	NU
Red Delicious	Guthion	<0.001	<0.001	<0.001	<0.001
Empire	Imidan	0.3	0.04	0.3	0.1
Golden Delicious	Imidan	<0.001	<0.001	1.2	0.01
Red Delicious	Imidan	<0.001	0.5	0.7	0.4
NU= No Use					
NT= No Test					

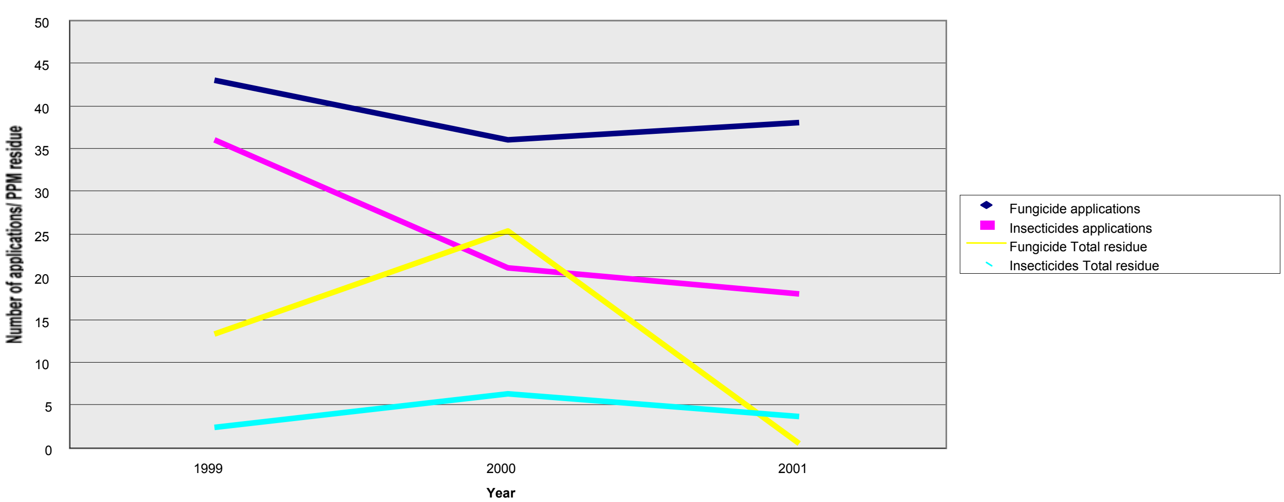


Figure 8. Summary comparison number of applications / total residue PPM.

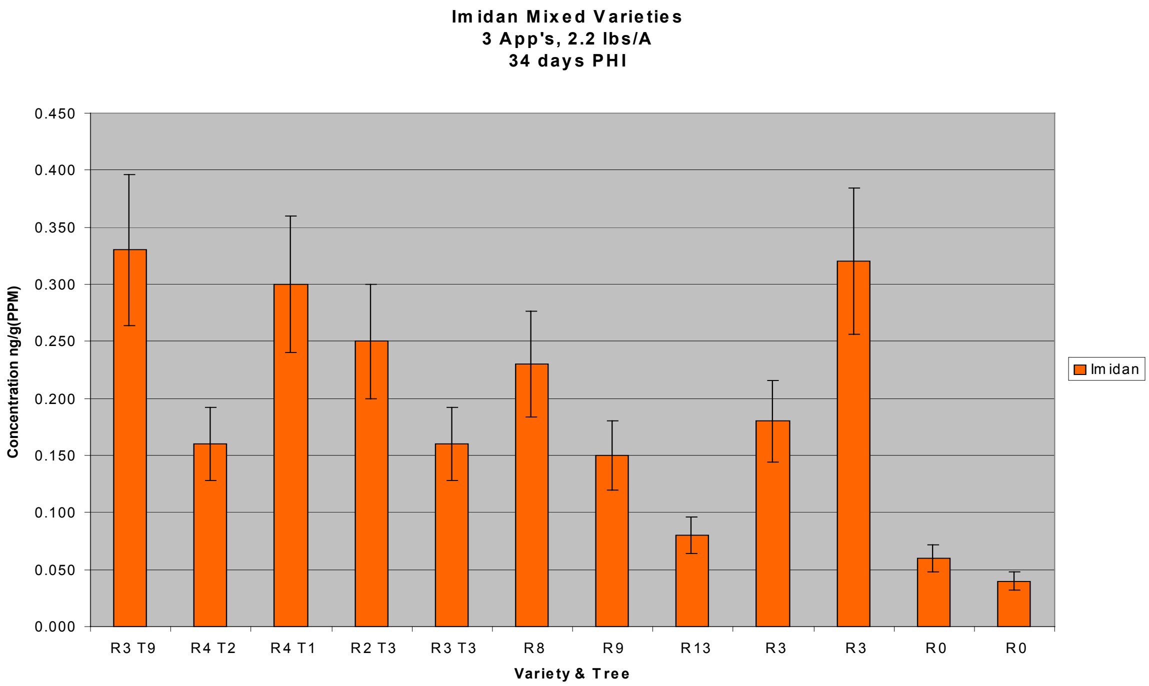


Figure 9. Imidan Residues on mixed varieties.

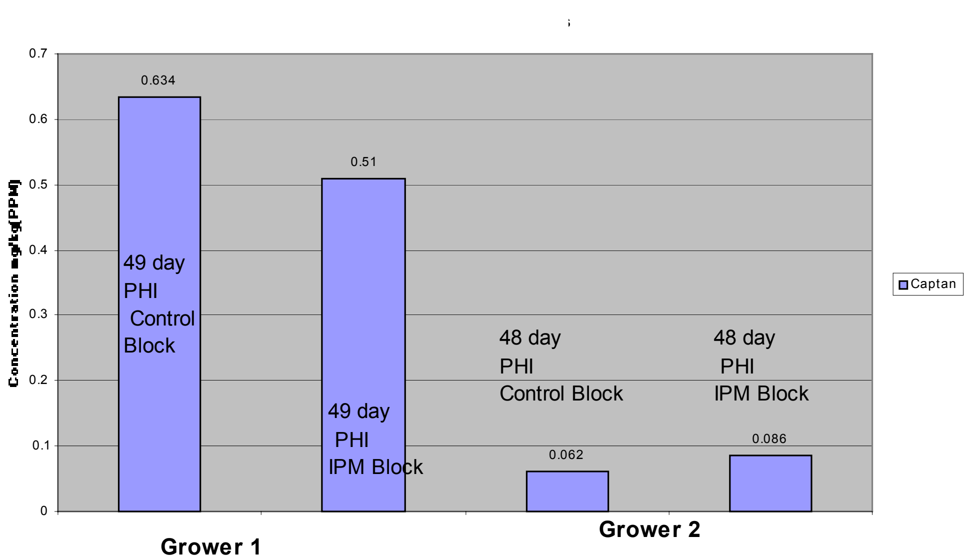


Figure 10. Captan: 7 applications

Section I. Accomplishments of the MAIPMIP: Objective I (*Continued*)

Fruit Injury

One of the greatest concerns among growers adopting a new IPM system is the ability of the program to maintain product quality and yield. Fruit injury evaluations were conducted on selective and comparison blocks prior to harvest. Fruit injury data from 1999-2001 demonstrates that control in project selective blocks was equal to or improved when compared to growers' conventional (comparison) blocks for both codling moth and obliquebanded leafroller (OBLR), two of the most important insect pests of apples in Michigan (see Table 9-10).

Interestingly, comparison blocks were unavailable on some farms, because growers had placed all their acreage in the MAIPMIP program. This demonstrates increased confidence gained by using the new strategies, facilitated by MAIPMIP. At other farms, viable comparison blocks were not available because of significant differences between selective blocks (e.g., type of planting, physical distance of planting from other farm blocks, tree size, tree health, etc.).

Table 9. Mean Percent Apple Injury by Codling Moth and Obliquebanded Leafroller for 4 Management Programs in MAIPMIP Selective and Comparison Blocks, 1999-2001.

	# Farms*	Codling Moth		Leafroller	
		Selective	Comparison	**Selective**	Comparison
Selective Insecticides**	18	**1.2**	1.3	**1.1**	0.8
C+	56	**1.3**	2.1	**0.8**	1.4
C Special	50	**0.5**	1.0	**2.4**	2.5
LR MEC	41	**0.2**	0.2	**3.0**	4.2

C+ = Isomate C+ hand applied pheromone dispensers for codling moth mating disruption
C special = Isomate CM/LR hand applied pheromone dispensers for codling moth and leafroller mating disruption
LR MEC = Leafroller sprayable microencapsulated pheromone
*The same farms were counted more than once if included in more than one year.
** Selective Insecticides were also used in mating disruption (MD) programs

Although codling moth damage was relatively consistent across the three years of the Project, obliquebanded leafroller damage decreased dramatically from the first to the final year of the Project. Obliquebanded leafroller damage during the 1999 season was greatest on the farms that had the highest pest (OBLR) pressure, where comparison and selective blocks had 9.3 percent and 6.4 percent damaged fruit, respectively (Table 10).

Table 10. Mean Percent Apple Injury by Codling Moth and Obliquebanded Leafroller for 3 Pheromone Mating Disruption Programs in MAIPMIP Selective and Comparison Blocks for each year of the project.

Primary Pheromone	# Farms*	Codling Moth		Leafroller	
		Selective	Comparison	**Selective**	Comparison
1999					
C+	8	**1.5**	1.2	**1.2**	2.6
C Special	10	**0.5**	0.6	**1.3**	4.1
LR MEC	11	**0.4**	0.3	**6.4**	9.3
2000					
C+	25	**1.1**	2.9	**1.1**	2.0
C Special	24	**0.6**	1.6	**1.7**	2.6
LR MEC	21	**0.1**	0.2	**2.4**	3.2
2001					
Selective Insecticides (No MD)	18	**1.2**	1.3	**1.1**	0.8
C+	23	**1.4**	1.6	**0.4**	0.3
C Special	16	**0.5**	0.3	**0.6**	1.4
LR MEC	9	**1.2**	1.3	**1.1**	0.8

C+ = Isomate C+ hand applied pheromone dispensers for codling moth mating disruption
C special = Isomate CM/LR hand applied pheromone dispensers for codling moth and leafroller mating disruption
LR MEC = Leafroller sprayable microencapsulated pheromone
** Selective Insecticides were also used in mating disruption (MD) programs

In 2001, selective blocks under the same program as in 1999 (LR MEC, sprayable pheromone) had 0.1% damage, whereas, comparison blocks had only 0.3% fruit damage from obliquebanded leafroller, a dramatic reduction from 1999. One of the major factors responsible for this decrease was the introduction of new insecticides that have high efficacy against obliquebanded leafroller (e.g., SpinTor® and Intrepid®). Growers were quick to adopt these new, alternative chemistries on comparison acreage as well as on selective blocks where OBLR control was a problem. In addition, many growers used scouting information on the pest presence and abundance obtained from scouts and consultants in selective blocks, to make decisions in nearby comparison blocks. This information allowed growers to target treatments more effectively and decrease fruit damage from insects. These factors in combination increased the efficacy of obliquebanded leafroller management programs in both selective and comparison blocks.

Economics

Agricultural economist Jeffery Connor (currently with the Australian CSIRO) was contracted by the MAIPMIP after the 2000 growing season to address several limitations of the economic model begun by the MAIPMIP in 1999. Limitations included the assumption that 100% of all fruit was destined for the fresh market, and the assumption of average yield for all growers. Dr. Connor developed a ranging analysis that included a more complete range of yields and prices. This section is an excerpt from an economic analysis report submitted by Dr. Connor. The complete report of the economic analysis includes a description of methods and background, and is included Appendix 5.

The viability of currently prevailing pest control programs in apple is a significant and growing concern. Faced with growing regulation and declining effectiveness of prevalent materials, growers in Michigan often express the need for alternative insect pest control strategies. However, apple production is a competitive business and downward pressure on apple prices in recent years is making the economics of production tougher than ever. Consequently, the uptake of IPM pest management programs is significantly influenced by program economics. While some apple growers will consider IPM programs involving small additional costs, programs that are much more costly are unlikely to be widely adopted. Switching to an IPM program, like the mating disruption based programs trialed in the MAIPMIP, influences apple production costs in two ways:

- It changes the cost of inputs for arthropod pest control.
- It changes fruit damage and consequently fruit sales revenue.

There are at least two reasons that growers tend to focus primarily on input costs in their thinking about switching programs:

- Inputs must be purchased at the outset of a season. Revenues are only received after harvest. The time lag can be significant. Growers are typically not paid for stored apples until they are sold – sometimes up to a year or more after harvest.
- Revenue losses from pest damage are much harder to quantify than input costs. While growers receive damage count reports from apple processors, they do not generally get information in a form that lets them infer the relationship between alternative treatment and resulting damage.

At the outset of the MAIPMIP, growers had several reasons to be skeptical about the economics of mating disruption programs:

- The cost of mating disruption inputs is high – $50 to $100 per acre for materials alone.
- It seemed unlikely to many that the reductions in use of organophosphates that could be expected to result would result in sufficient savings to justify the cost of MD. Especially because MD products available target only two of over two dozen arthropod pests of concern to Michigan growers.
- In addition, two of the mating disruption products (hand applied twist tie dispensers) trialed required significant labor to apply (about two hours per acre).
- Many Michigan apple growers also grow other crops. The added MD application labor requirement often occurs at a time of peak labor demand time in other crops.

Results of the full economic analysis are shown in Table 11. Positive values equate to a savings (in dollars/acre) of mating disruption programs over grower comparison programs. Negative values in red represent an increased cost per acre for mating disruption programs relative to comparison pest management programs. Cases where the mating disruption program costs exceed comparison programs cost by less than $25/acre are lightly shaded in the figure. While a the $25/acre cost difference is somewhat randomly chosen the light shading gives a good visual sense of the range of circumstances where mating disruption is more expensive than the comparison approach, but not by a large amount.

The mating disruption programs listed in table 11 include LRMEC (sprayable leafroller pheromone), Dual, also referred to as CM/LR (hand-applied dispensers with codling moth and leafroller pheromone), and C+ (hand-applied dispensers with codling moth pheromone).

Results of this analysis indicate that in both 1999 and 2000 the LRMEC mating disruption program was the most economical of the three programs.

- With average yields, the LRMEC programs were more economical than comparison programs until the percentage of fruit going to the more profitable fresh market was between 50% and 75%.
- Even with 75% of fruit going to a processing market, the LRMEC was not prohibitively more expensive than grower standard programs. The difference in cost was less than $25 in both 1999 and 2000.
- For growers at one extreme end of the spectrum, with yields at *1.5-fold greater than the average and all fruit going to a fresh market*, the economic analysis predicts significant savings resulting from the LRMEC program - $38 in 1999 and $57/acre in 2000.

The dual dispenser CM/LR program was the least economical of the three mating disruption programs.

- In 1999, even under the most favorable conditions - 150% of average yields and all fruit going to fresh market, the CM/LR programs were still $16 dollars per acre more expensive than comparison programs.
- In 2000, however, the CM/LR programs fared better. At an average yield with all fruit going to a fresh market, the CM/LR was $6/acre less expensive than non-mating disruption comparison programs.
- The dual dispenser approach was still economical with comparison programs at average yields with 75% of fruit going to the processing market.

A decline in cost between the two years was seen in the C+ program similar to the decline in cost observed for the dual dispenser programs.

- In 1999, with an average yield and 75% of the fruit going to a processing market, the C+ mating disruption programs were $20/acre more expensive than standard comparison programs.
- In 2000, under the same yields and marketing conditions, the C+ programs were more economical, with a savings of $2/acre,
- By 2000 the C+ program was not much less competitive than the comparison programs (less than $25/acre more expensive) even with 75% of the fruit going to the processing market and yields as low as 50% of average.

Key conclusions from the first two years of project experience were

- The relative cost of mating disruption appeared to be declining between the two years. This may be explained by the increased confidence of growers in year 2 that enabled them to further decrease insecticide applications and input costs.
- Mating disruption IPM programs appeared to be a viable means of saving money while reducing use of organophosphate and other chemical pesticides for a significant number of Michigan apple growers.
- The economics appeared to be particularly attractive for growers who market significant amounts of fresh fruit and growers with high yields.

Table 11. Mating Disruption Returns Relative to Standard Comparison

	1999	Percent of Fruit to Fresh Market				
	Yield	0%	25%	50%	75%	100%
1999 C+	50% of average	-$40.70	-$36.00	-$33.59	-$31.17	-$28.76
	75% of average	-$39.87	-$32.81	-$29.19	-$25.57	-$21.95
	average*	-$39.04	-$29.63	-$24.80	-$19.97	-$15.15
	125% of average	-$38.20	-$26.44	-$20.41	-$14.37	-$8.34
	150% of average	-$37.37	-$23.26	-$16.02	-$8.78	-$1.53
1999 Dual	50% of average	-$73.53	-$67.53	-$63.44	-$59.35	-$55.25
	75% of average	-$72.83	-$63.83	-$57.69	-$51.56	-$45.42
	average*	-$72.14	-$60.13	-$51.95	-$43.77	-$35.59
	125% of average	-$71.44	-$56.44	-$46.21	-$35.98	-$25.75
	150% of average	-$70.75	-$52.74	-$40.47	-$28.20	-$15.92
1999 LR MEC	50% of average	-$26.55	-$21.20	-$15.86	-$10.51	-$5.16
	75% of average	-$26.55	-$18.53	-$10.51	-$2.48	$5.54
	average*	-$26.55	-$15.86	-$5.16	$5.54	$16.24
	125% of average	-$26.55	-$13.18	$0.19	$13.56	$26.93
	150% of average	-$26.55	-$10.51	$5.54	$21.58	$37.63
	2000					
2000 C+	50% of average	-$33.93	-$23.25	-$21.29	-$19.33	-$17.37
	75% of average	-$30.75	-$14.72	-$11.79	-$8.85	-$5.91
	average*	-$27.57	-$6.20	-$2.29	$1.63	$5.55
	125% of average	-$24.40	$2.32	$7.21	$12.11	$17.00
	150% of average	-$21.22	$10.84	$16.71	$22.59	$28.46
2000 Dual	50% of average	-$27.24	-$22.18	-$19.37	-$16.55	-$13.73
	75% of average	-$26.42	-$18.84	-$14.62	-$10.39	-$6.16
	average*	-$25.61	-$15.50	-$9.87	-$4.23	$1.41
	125% of average	-$24.80	-$12.16	-$5.12	$1.93	$8.98
	150% of average	-$23.98	-$8.82	-$0.37	$8.09	$16.55
2000 LR MEC	50% of average	-$35.94	-$29.03	-$21.85	-$14.67	-$7.49
	75% of average	-$36.04	-$25.66	-$14.89	-$4.12	$6.65
	average*	-$36.14	-$22.30	-$7.94	$6.42	$20.78
	125% of average	-$36.23	-$18.94	-$0.99	$16.96	$34.91
	150% of average	-$36.33	-$15.58	$5.96	$27.51	$49.05
	2001					
2001 C+	50% of average	$37.22	$50.72	$51.09	$51.46	$51.83
	75% of average	$42.00	$62.25	$62.80	$63.36	$63.91
	average*	$46.79	$73.78	$74.52	$75.26	$75.99
	125% of average	$51.57	$85.31	$86.23	$87.15	$88.08
	150% of average	$56.35	$96.84	$97.95	$99.05	$100.16
2001 Dual	50% of average	-$50.71	-$49.46	-$47.26	-$45.06	-$42.86
	75% of average	-$51.06	-$49.19	-$45.89	-$42.59	-$39.29
	average*	-$51.40	-$48.92	-$44.52	-$40.12	-$35.72
	125% of average	-$51.75	-$48.65	-$43.15	-$37.65	-$32.15
	150% of average	-$52.10	-$48.38	-$41.78	-$35.18	-$28.58
2001 LR MEC	50% of average	$13.35	$17.21	$20.70	$24.19	$27.68
	75% of average	$13.48	$19.26	$24.50	$29.74	$34.97
	average*	$13.62	$21.32	$28.30	$35.29	$42.27
	125% of average	$13.75	$23.38	$32.11	$40.83	$49.56
	150% of average	$13.88	$25.44	$35.91	$46.38	$56.86

Gray shading highlights cases where the mating disruption programs costs exceed comparison programs cost by less than $25/acre

In 2001 the economics of the LRMEC and C+ mating disruption programs - the most economically attractive program in 1999 and 2000, got even better.

- On average in 2001, both C+ and LRMEC programs resulted in savings relative to standard comparison programs regardless of assumptions about yield and percentage of fruit fresh marketed.
- As portrayed graphically in Figure 11 in the set of bars labeled “input”, C+ and LRMEC programs in 2001 actually resulted in input cost savings. In other words, the growers using these two programs were able to reduce expenditure on organophosphates, miticides and other chemical for arthropod control by more than the additional money spent on mating disruption.
- The economics of the C+ mating disruption program appeared to be particularly favorable in 2001. One significant reason was the average rate of internal fruit damage was 1.7% higher on standard comparison bocks for the C+ treatment. This is a larger difference in internal damage than observed in previous years. Internal damage has a particularly significant impact on economic returns as fruit damaged in this manner cannot be sold. Externally damaged fruit, in contrast, is merely downgraded and receives less revenue.

The dual dispenser CM/LR program was again the least economical of the three mating disruption programs in 2001.

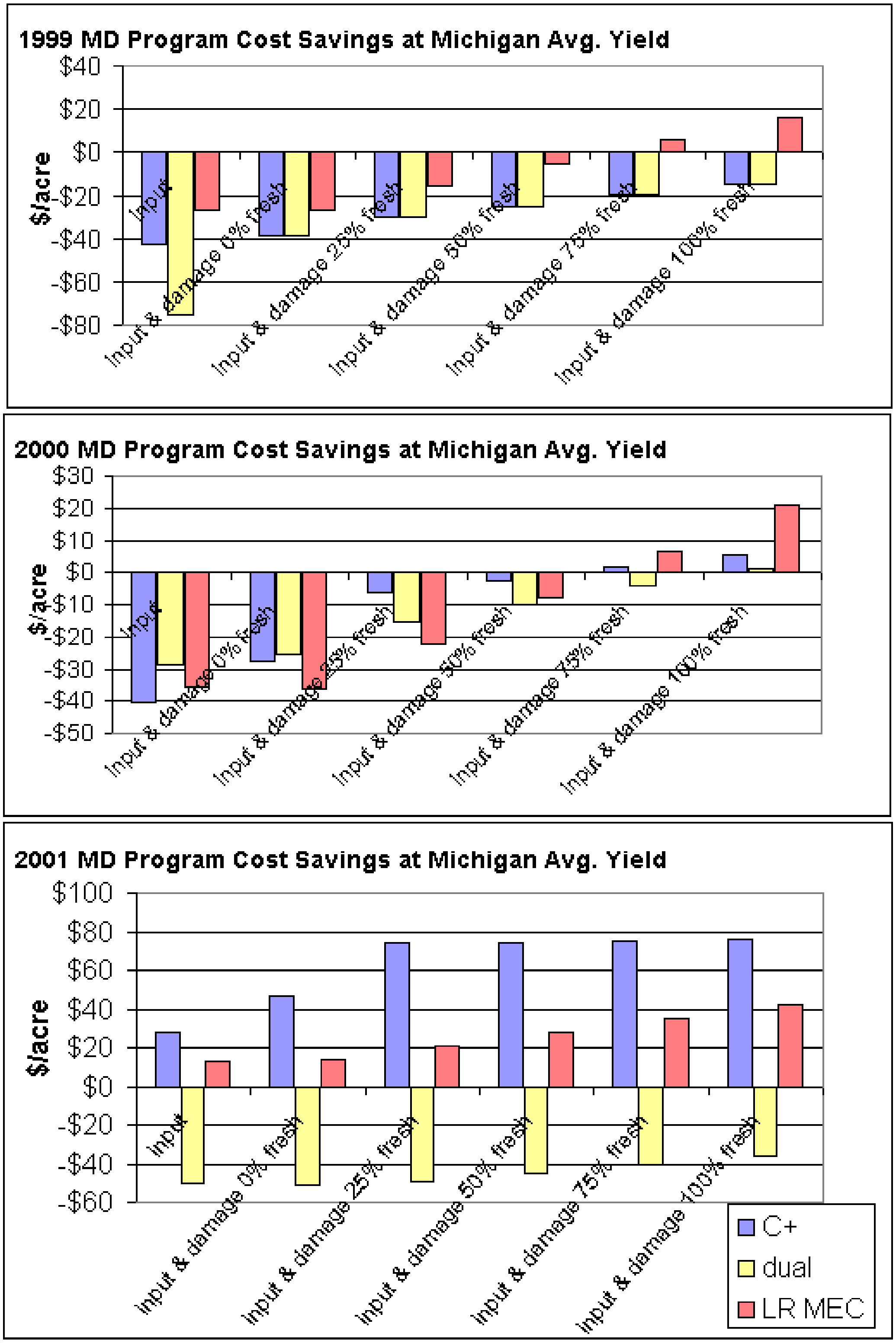
- Even under the most favorable conditions - 150% of average yields and all fruit going to fresh market, the CM/LR programs were still $29 dollars per acre more expensive than comparison programs.

The MAIPMIP results offer evidence that those growers who implemented C+ and LRMEC IPM programs can save money. The evidence that these programs are economically viable is especially strong for Michigan growers with average or better yields who market more than half of their fruit to the fresh market. The economic analysis suggests savings to such growers in all three years of programs experience. Furthermore, the economics of the C+ and LRMEC mating disruption programs appear to be improving over time. In 2001 these program appear to have been more cost effective than standard comparison approaches even for low yield growers marketing all fruit for processing.

Study results provide at best limited evidence that dual dispenser leaf roller / codling moth pheromone based IPM can be cost effective for Michigan growers. The economics appeared favorable for growers with high yield and percentage fresh market fruit in 2000. However, results from both 1999 and 2001 suggest the program was unprofitable across the entire range of yield and marketing assumptions considered. While dual dispensers programs appear to reduce fruit damage, little input cost savings are being realized with these programs.

A final conclusion is that for all of the programs considered in all of the years evaluated, looking at the economics of IPM from the input cost perspective alone and ignoring revenue impacts of reductions in damage would lead to a distorted perception. Especially in cases where yields are high and fresh marketing is important, savings resulting from pest damage reduction influence the perceived economics of IPM significantly.

Figure 11. Relative Cost of Apple Mating Disruption at Michigan Average Yield



Section II. Accomplishments of the Michigan Apple Project: Objective II

Objective II. To incrementally increase adoption of the system over three years from 500 acres in year one, to 3000 acres in year two and finally, to 8000 acres in year three.

Critical to the achievement of Objective II was the documentation of results under Objective I to provide evidence to new participants that the new IPM system maintains quality and yield of the product and is economically viable. Without this evidence, recruiting new participants each year, and thus increasing the acreage by significant amounts, would have been highly unlikely. In addition to the documentation, everyone associated with the MAIPMIP actively promoted the project at industry meetings, in newsletters (e.g., Gerber's IPM Newsletter), and through training efforts (see Objective III).

Objective II: Achievements At a Glance

Increased grower participation and acreage enrolled.

Project Year	Number of Growers	Acreage Enrolled
1999	43	850
2000	63	2,833
2001	103	8,360

Partners in a Statewide Network

One of the most significant accomplishments of the MAIPMIP was increased grower participation over the three years of the project. The MAIPMIP grew from 43 growers participating on 850 acres in 1999 to 103 growers participating on more than 8,300 acres in 2001. Viewed within the current reality of a Michigan apple industry that has lost 18 percent of its apple acreage and 15 percent of its farms since 1997, the continued growth of the MAIPMIP is a significant accomplishment (Figures 12, 13, 14 and 15).

Fig. 12. Michigan apple acreage 1991 - 2000

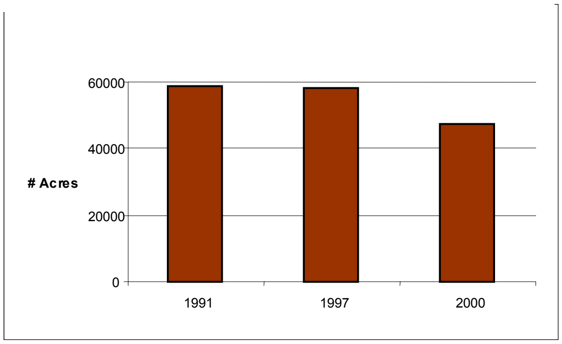


Fig. 13. Grower acreage in the MAIPMIP 1999 –2001

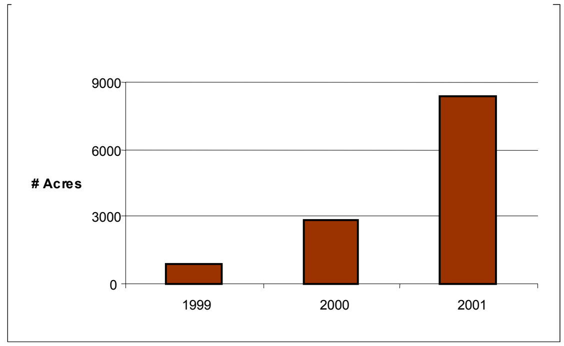


Fig. 14. Apple farms in Michigan 1991–2000

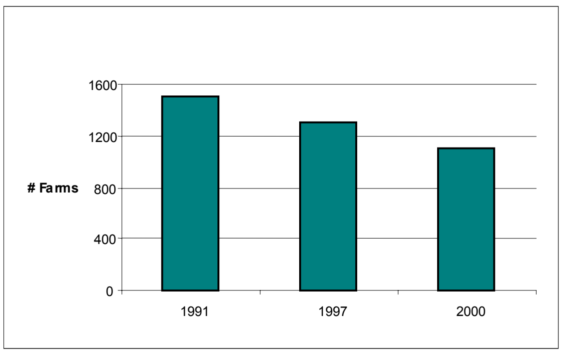
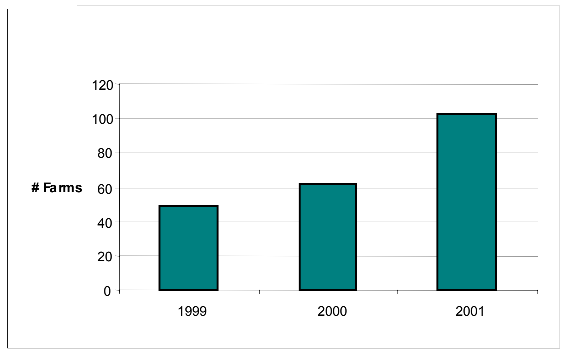


Fig. 15. Number of growers in the MAIPMIP 1999-2001



Recruitment efforts were effective statewide as measured by the increase in the number farms and acreage in the MAIPMIP in 2000 and 2001. The highest acreage in the Project was located in the Ridge, Northwest, and Southwest regions of Michigan.

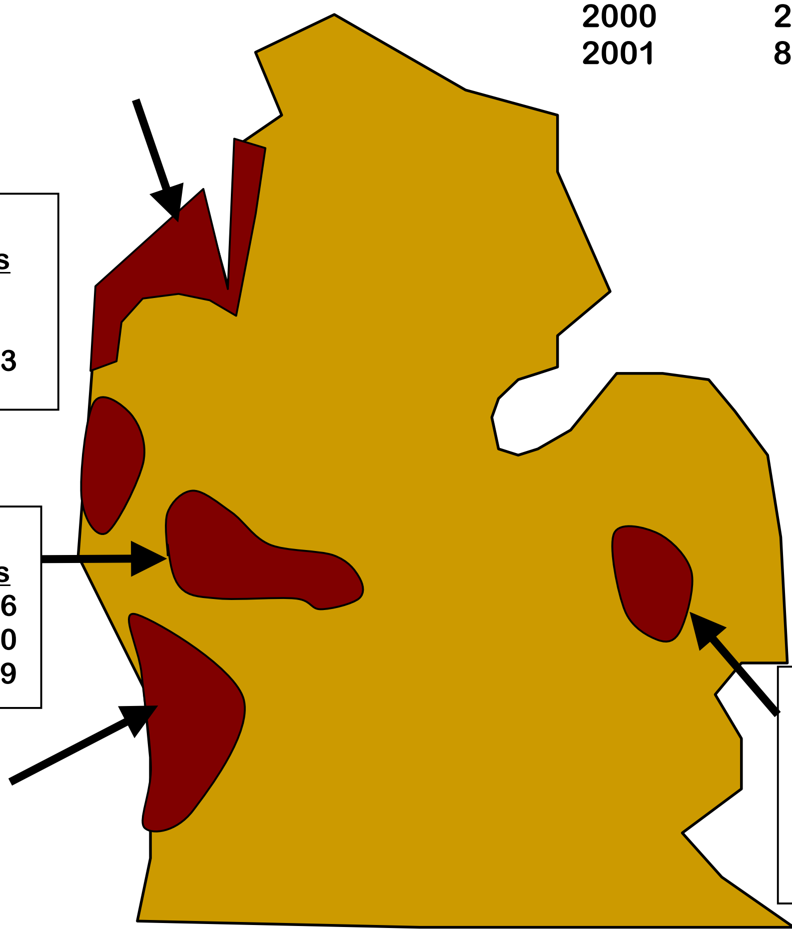
The project co-coordinators, David Epstein and Daniel Waldstein took the lead recruiting roles for 2001, with other Project Team members and industry partners helping in recruitment efforts. The MAIPMIP Project Management Team had broad representation from key groups involved with the Michigan Apple Industry, including growers from four of the five main apple production regions in Michigan, private firms that provide scouting and consulting services, Gerber, the Michigan Apple Research Committee, the Michigan Apple Committee, the Michigan IPM Alliance, MSU Extension fruit agents from key regions, and MSU.

A major part of the recruitment process included a mass mailing sent to more than 1,000 Michigan apple growers in early March. A letter from the project coordinators, a letter from the Michigan Apple Committee, and a promotional brochure were included in the mailing. This resulted in an enthusiastic response from many commercial apple growers interested in participating in the project in 2001. Another recruiting opportunity occurred at a March 8th meeting at the Southwest experiment station with approximately 65 commercial apple growers in attendance. A fruit growers' cooperative from SW Michigan sponsored this event, which included presentations by extension agents and university researchers on the management of codling moth and oriental fruit moth. David Epstein presented information about the Michigan Apple IPM Implementation project and how it can be used as a resource to benefit growers. Presentations at numerous other regional meetings were also given by the project coordinators (Appendix 6). These provided opportunities to increase grower awareness about the project and further enhanced recruitment efforts.

Figure 16. Michigan Apple IPM Project 1999 - 2001 Grower/Acreage

Totals

Year	Acres	Growers
1999	877	47
2000	2833	63
2001	8360	103



Oceana –Mason

Year	Acres	Growers
1999	133	5
2000	335	8
2001	458	13

Ridge – Belding

Year	Acres	Growers
1999	457	26
2000	1543	30
2001	5611	49

Eastern

Year	Acres	Growers
1999	98	8
2000	212	8
2001	284	9

Section III. Accomplishments of the Michigan Apple Project: Objective III

Objective III. To train train field staff (consultants, field men, full-time orchard staff) in the implementation of the system so that the information providers for 75% of the growers are trained by the end of the project.

The success of Objective III is necessarily intertwined with both objectives I and II. Ongoing outreach, training and education was critical to the success of implementing a new system that reduced organophosphate use while achieving project growth in each year of operation.

Objective III: Major Achievements At a Glance

Sub-objective	Major Achievements
Training & Outreach	• Created the MAIPMIP Industry Network, comprised of 106 growers, 24 consultants and field scouts, and 26 extension personnel, and 5 processors and packers • Conducted 8 training workshops attended by 289 growers, consultants, and extension personnel • Participated in 67 meetings, workshops, and conferences attended by over 9400 participants in 2000-2001 • Made thousands of phone calls and on-farm visits with growers and consultants • Significantly impacted on-farm monitoring practices by increasing frequency, monitoring for beneficials, and time spent per monitoring trip • Improved overall pest management skills of participating growers • Seven additional pest management scouts were hired by consultants in 2001 • Conducted baseline survey of 39 participating growers in 1999 and 2000 • Conducted exit survey of 50 growers in 2001-2002
Educational Materials	• Pocket manual for IPM scouting and decision-making developed; 1500 copies distributed • Produced 4 educational fact sheets on mating disruption, monitoring, and Leafroller biology; distributed at grower meetings and in grower seasonal packets • Contributed 6 articles to 3 Gerber IPM newsletters devoted to the MAIPMIP; 500-600 copies distributed to growers and industry • Created MAIPMIP website: www.cips.msu.edu/maipmip/ • Seasonal summaries of field data containing individual grower scouting reports, chemical spray applications, economic analysis, and pre-harvest fruit quality evaluations distributed yearly to participating growers • Annual educational tours for federal and state regulatory personnel (US EPA, USDA, MDA, and DEQ) at participating MAIPMIP farms in 1999, 2000, and 2001

Training & Outreach

The creation of a statewide network to design, implement and evaluate the new IPM systems included 106 growers, 33 private and chemical company crop consultants, and 26 MSU extension faculty and specialists. The creation of this network was critical to the development of new IPM systems that work and increasing the number of growers participating in the program throughout the state. Table 12 provides a list of the private and chemical company crop consultants who participated in the network. The extension agent(s) for each region are included in parentheses.

Table 12. MAIPMIP Network of Extension Agents and Crop Consultants/Scouts

Name	Affiliation
Ridge Belding: (Phil Schwallier, Amy Irish-Brown)	
Babs Burmeister	
Doug Pider	Independent consultant
Heidi Davey, Dave German, Dave Gavin	Cheever's, Inc.
John Ivison, Deb Kober, Russ Sage	UAP Great Lakes
Heidi Davey, Chandra Bunker, Jim Nauta	Reisters
David Schwallier, Rick Schoenborn, Case	Total Agri
DeYoung, Brian Wernstrom, Tim Riley	Wilbur-Ellis
Jeff Wolgemuth, Chris Falik	Gerber Products Company
Southeast: (Bob Tritten)	
Margaret Herr & Jennette Yaklin	Independent consultants
Southwest: (Mark Longstroth)	
Doug Murray & Paul Schaeffer	Murray Pest Mgmt.
Creela Overton	Westcentral MI Crop Mgmt. Association
Mike Thomas	TMT Consulting
Matt Disterheft	UAP Great Lakes
Oceana-Mason: (Mira Danilovich)	
John Bakker	Westcentral MI Crop Mgmt. Association
Don Allen	Mason County Fruit Packers Association
Pete Kelly, Doug Pider	Cheever's, Inc.
Northwest: (Gary Thornton)	
Jim Laubach & Mark Dougherty	Hort Systems
Romain LaLone	Independent consultant
Julie Lutz	Great Lakes UAP

Project acreage was managed in conjunction with a scout or consultant, thus engaging a significant number of those private firms that presently provide these services to Michigan apple growers (Table 12). All of the chemical supply companies that partnered with the MAIPMIP network added new scouts to meet the demands of implementing these new programs. Many of these consultants hired additional field scouts as a direct result of the MAIPMIP.

A program of regular orchard scouting is the cornerstone of pest management decision-making in any sustainable fruit production system (Samson 1987, Ferrentino 1992, Higley and Pedigo 1993, and Zalom 1993). Pest management decision-making based on orchard ecology includes site-specific information on key pests and beneficials, and tree phenology and health. One major emphasis of the MAIPMIP was educating growers on the importance of intensive, site-specific pest and beneficial monitoring in an effective and economical pest management program.

To gauge the project's impact on monitoring, growers were asked a series of questions related to the monitoring of their orchards (Figures 17, 18, and 19).

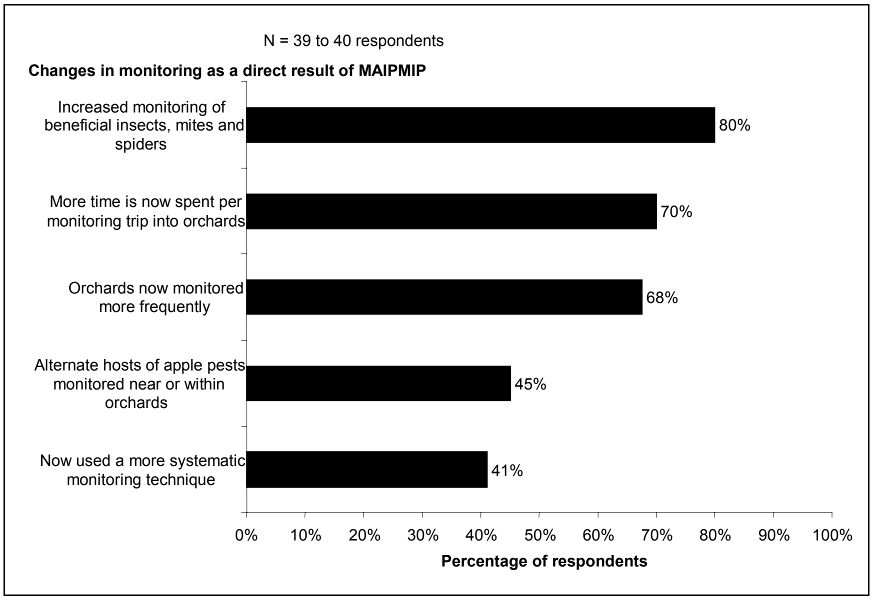


Figure 17. Changes in monitoring as a direct result of participating in MAIPMIP.

Growers were first asked if they made any changes in the way their orchards are monitored **as a direct result of participating in MAIPMIP** (Figure 17). The greatest impact was seen in the increase in monitoring of beneficial insects, mites and spiders. Knowledge of what beneficial insects and mites are present in the orchard, what pests they are helping to control, and what spray materials are harmful to their proliferation is an extremely important part of implementing a successful IPM program. This knowledge allows growers the opportunity to eliminate certain chemical applications (particularly for soft bodied aphids and mites). The second and third greatest impacts of the program on monitoring are that more time is now spent per trip into the orchard (70 percent) and monitoring is done more frequently (68 percent). In addition, the program has seen almost half the growers interviewed begin monitoring alternate hosts of apple pests near or within their orchards (46 percent) and also begin using a more systematic monitoring technique (41 percent). (See discussion on orchard scouting in the introduction to the final report to better understand the significance of these findings).

In the exit survey, growers were asked to rate the level of impact their involvement with MAIPMIP had on the placement, number, and maintenance of traps (Figure 18).

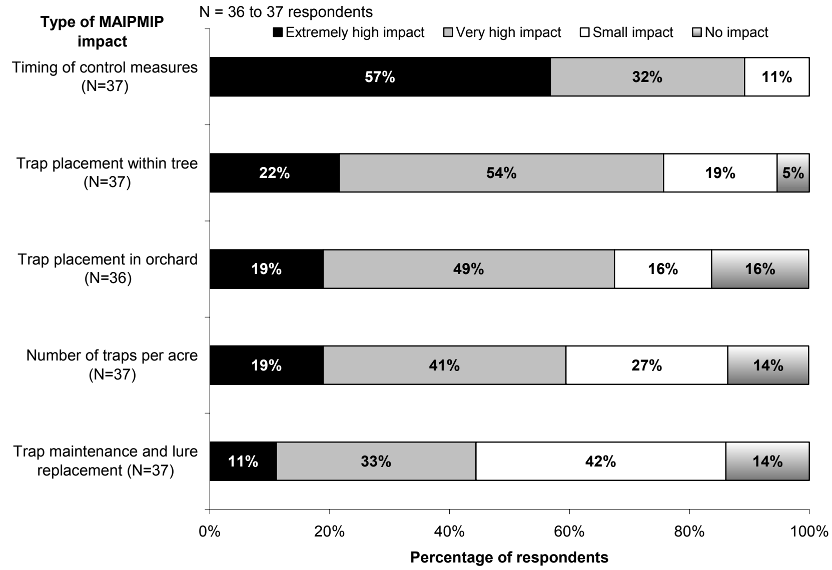


Figure 18. MAIPMIP impact on trap placement, number and maintenance.

MAIPMIP had an impact in all areas cited in Figure 18. MAIPMIP was able to leverage the most impact on the timing of control measures with 100 percent of respondents saying there was at least a small impact, and 57 percent of those saying the impact was extremely high (top bar in graph). The program had the least impact on trap maintenance and lure replacement (bottom bar in graph). This response is not surprising, in that most of the growers surveyed were not personally involved with trap maintenance and lure replacement, but relied on their scout/consultant for these activities, and were not sure how to answer this question on their own (see appendix 3).

That growers' orchards are monitored more frequently is supported by the data presented in Figure 19.

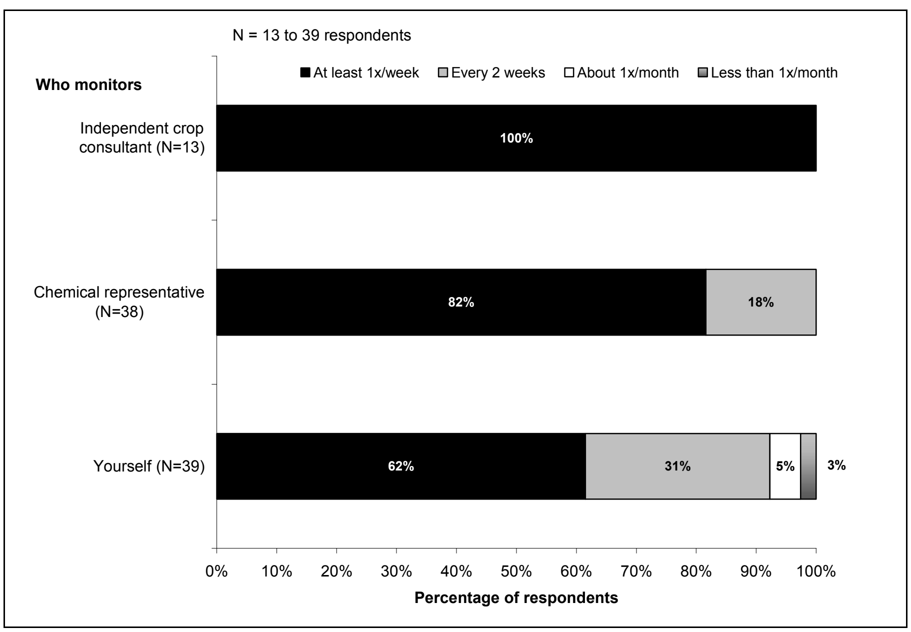


Figure 19. Frequency of orchard monitoring.

Of the growers who use an independent crop consultant, 100 percent report that these consultants monitor at least once a week. Eight-two percent of respondents report that their chemical representative monitors at least once a week, while 18 percent monitor every two weeks. Sixty-two percent of growers report that they spend at least once a week monitoring, while 31 percent of them monitor every two weeks, and eight percent (3 growers) only monitor once a month or less. All three growers who report monitoring about once a month or less also report that an independent consultant or chemical representative monitors their orchards at least once a week.

Entrance interview surveys revealed 73% of growers monitored orchards by themselves, 73% used a chemical company representative, and 48% employed a scout and/or consultant. When asked how often during the growing season each orchard was scouted, 0% scouted monthly, 78% scouted weekly, 11% scouted bi-weekly and 11% scouted an another unspecified schedule.

The vast majority of fruit acreage in MI is currently scouted through 4-5 chemical supply houses, all of which participated in the MAIPMIP (see Table 12). Consider the fruit-growing region north of Grand Rapids (Ridge), which is Michigan's largest apple producing region. Agrichemical suppliers have offered scouting as a part of their services, displacing independent consultants in the region. In 2001, there were no independent consulting firms working in this region. A scarcity of well-trained individuals was one reason. Another is that low profit margins in the fruit producing business have led growers to minimize all off-farm inputs. Many growers feel that they have little choice but to opt for the chemical supply houses' offering of what is perceived as "free" consulting. Unfortunately, the large number of farms serviced by chemical company representatives has traditionally limited their ability to spend the time necessary to intensively scout each site.

The MAIPMIP required participating agrichemical companies to hire additional scouts to provide the intensive level of scouting and data collection necessary for the project (and, of course, to successfully implement the new systems). In 2001, seven additional pest management scouts were hired by the agrichemical companies as a direct result of their cooperation with the MAIPMIP. The MAIPMIP worked with these companies to improve monitoring services on Project acreage, enabling site-specific, intensive monitoring to be a part of the overall pest management decision-making process. According to both growers and consultants who participated in the project, the additional scouting services proved beneficial to their efforts to successfully implementing innovative IPM practices (Appendix 3).

Growers and other participants' comments emphasize the important role played by the MAIPMIP. "Educating and training scouts, consultants, and growers to effectively use more intensive scouting techniques was a key success of the project. Emphasis on how pest monitoring is the crucial decision making tool led to orchard control strategies focused more on scouting, degree-days, life cycles, and thresholds than on calendar spraying." Jeff Wohlgemuth, Gerber Products Co. "Growers now knew that my regional reports did not automatically relate to the pest conditions in their orchards. Good growers were now interested in getting accurate information on their own individual plantings…" Mark Longstroth, District Extension Horticultural & Marketing Agent. (Appendices 3 and 7).

Results from all three years of the project were presented at state and regional meetings. MAIPMIP personnel participated in over 60 meetings, workshops, and conferences (Appendix 6) affording the project an opportunity to distribute information to a wide audience and directly led to the recruitment of new grower-participants in 2000 and 20001 (see discussion under Objective II). Presentations of the results from the final year of the project were made through March of 2002.

Dr. Mira Danilovich, District Horticulture & Marketing Agent for West Central Michigan wrote, "Over the past few years I have been hearing good comments coming from the growers regarding the project (MI Apple IPM Implementation Project) that you (David Epstein) and Dan (Daniel Waldstein) have been working on so diligently… I appreciate your active participation in my many "in-season" meetings…" (Appendix 7).

Training efforts were highlighted by a series of IPM eight training workshops conducted on project participants' farms, and attended by 289 growers, consultants, and extension personnel. The Project Co-coordinators and Westcentral Michigan Crop Management Association Manager, John Bakker provided information on monitoring of pest and beneficial insects, predictive models, use of selective insecticides, and pheromone mating disruption to growers in apple growing regions throughout the state. All of the growers interviewed who participated in these workshops found them at least somewhat useful, with 40 percent rating them very useful.

Each time MAIPMIP staff visited a farm or met with a consultant represented a potential training opportunity. In addition, there was significant farmer to farmer exchange and interaction amongst consultants and growers during the course of this project. A concerted effort was made by MAIPMIP staff to work one-on-one with growers (through on-farm visits and thousands of frequent phone conversations) to train them in scouting their own orchards.

Growers were specifically asked if their involvement in the MAIPMIP helped improve their pest management skills (Figure 20).

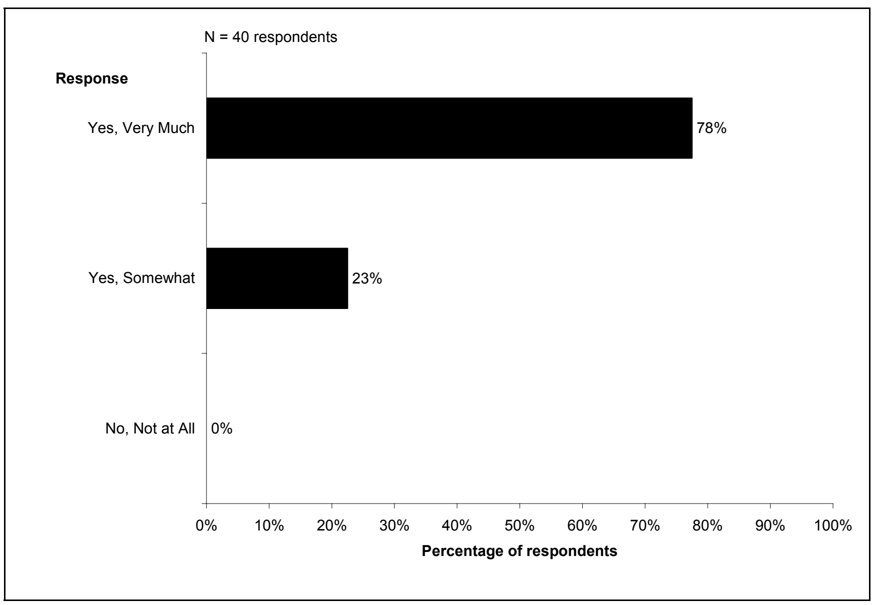


Figure 20. MAIPMIP helped improve growers' pest management skills.

And all interviewed growers felt that their participation was at least somewhat valuable (Figure 21).

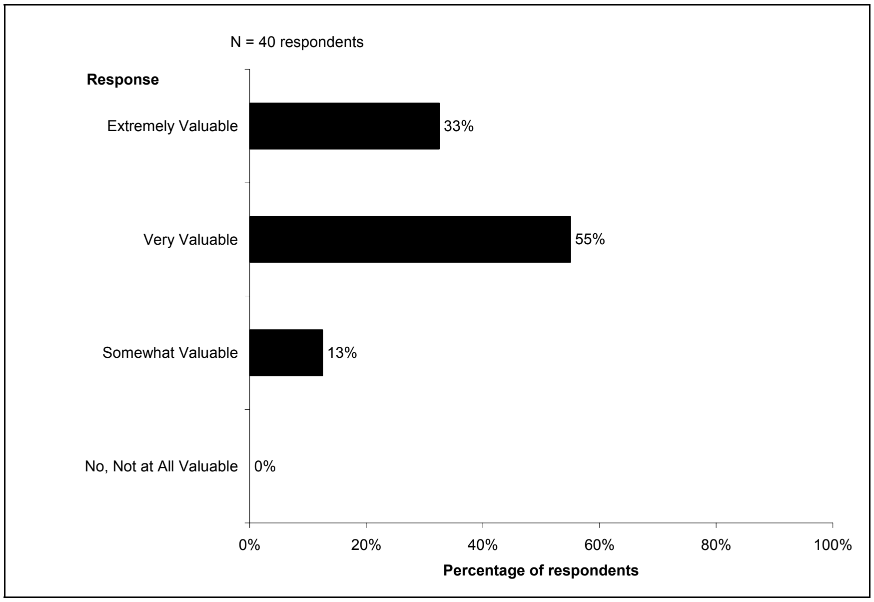


Figure 21. Value of participation in MAIPMIP.

In addition, growers indicate that they intend to continue most of the practices that they began using during their program participation (Figure 22).

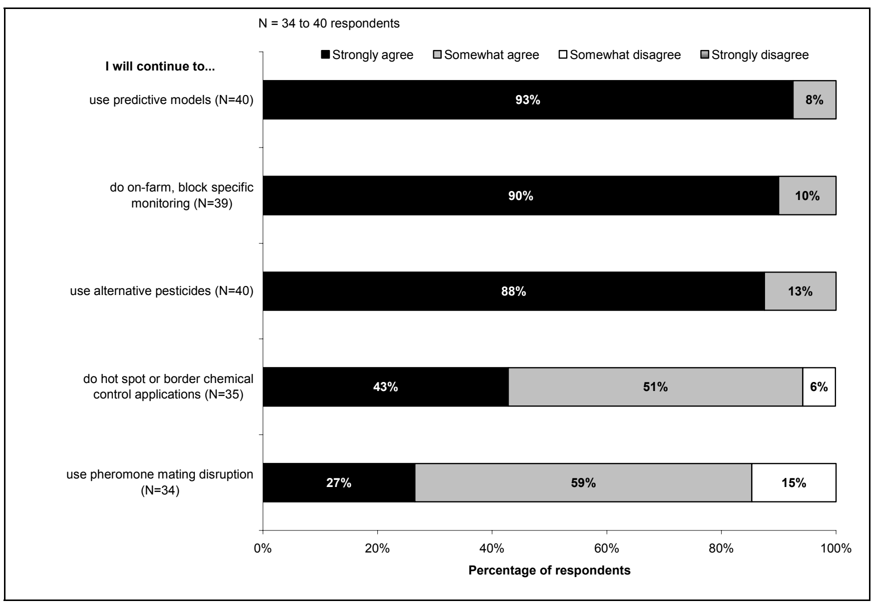
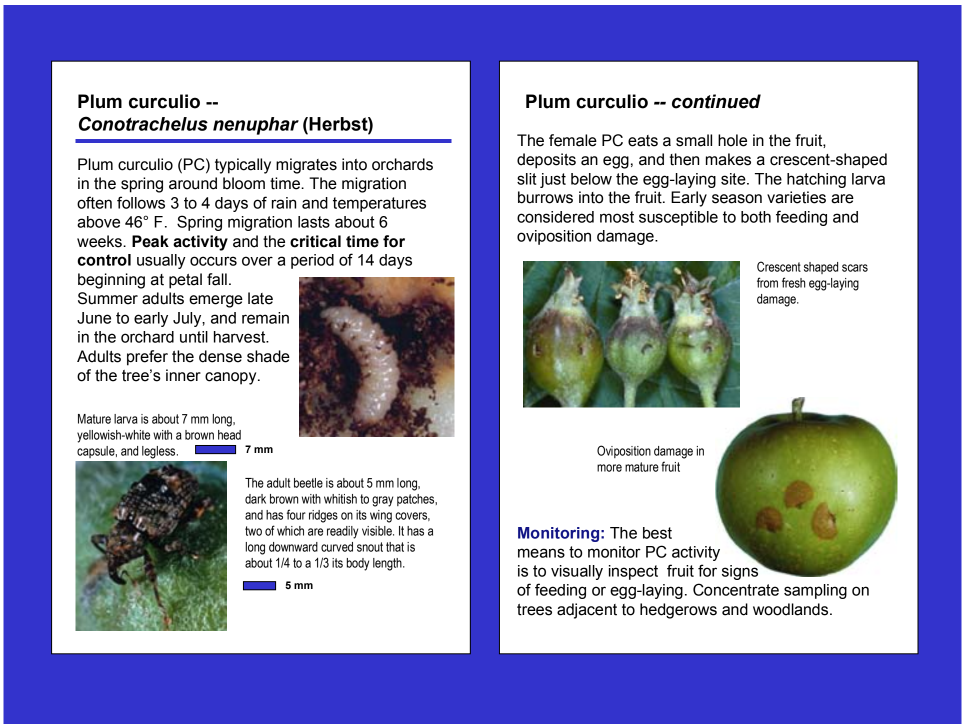


Figure 22. Intended continuation of IPM practices promoted by MAIPMIP.

Educational Materials

Two editions of the scouting pocket manual for field identification of pest and beneficial insects were completed and distributed. The high demand for this practical resource by members of the apple industry in Michigan and throughout apple growing regions in the U.S. and abroad necessitated a new printing of an additional 1,000 copies. The second edition of the guide contains new information including a degree day model for the oriental fruit moth developed by Pennsylvania State University researchers, and other insect pests occasionally found in commercial apple orchards. According to growers, they appreciated the easy to use format, and the up-to-date information on pest and beneficial identification and pest management decision-making (Appendix 3). Several comments from other cooperators also indicate the usefulness of the pocket-scouting guide. "Development of the pocket-scouting guide enhanced understanding and recognition of many of the pests and beneficials in the orchard system." Jeff Wohlgemuth, Gerber Products Co. "The pocket -scouting guide has been a remarkable success drawing requests from all over the U.S. and Canada." Todd DeKryger, Chairman, Michigan IPM Alliance. "Insect field manual has been an excellent tool for the growers, field scouts, chemical representatives and consultants." Dr. Mira Danilovich, District Horticulture & Marketing Agent, West Central Michigan (Appendix 7).

Figure 23. Example Pages from the Apple Pocket Scouting Guide



Plum curculio --
Conotrachelus nenuphar **(Herbst)**

Plum curculio (PC) typically migrates into orchards in the spring around bloom time. The migration often follows 3 to 4 days of rain and temperatures above 46° F. Spring migration lasts about 6 weeks. **Peak activity** and the **critical time for control** usually occurs over a period of 14 days beginning at petal fall. Summer adults emerge late June to early July, and remain in the orchard until harvest. Adults prefer the dense shade of the tree's inner canopy.

Mature larva is about 7 mm long, yellowish-white with a brown head capsule, and legless. **7 mm**

The adult beetle is about 5 mm long, dark brown with whitish to gray patches, and has four ridges on its wing covers, two of which are readily visible. It has a long downward curved snout that is about 1/4 to a 1/3 its body length.

5 mm

Plum curculio -- *continued*

The female PC eats a small hole in the fruit, deposits an egg, and then makes a crescent-shaped slit just below the egg-laying site. The hatching larva burrows into the fruit. Early season varieties are considered most susceptible to both feeding and oviposition damage.

Crescent shaped scars from fresh egg-laying damage.

Oviposition damage in more mature fruit

Monitoring: The best means to monitor PC activity is to visually inspect fruit for signs of feeding or egg-laying. Concentrate sampling on trees adjacent to hedgerows and woodlands.

MAIPMIP staff also produced a series of 4 fact sheets on implementing mating disruption, monitoring mating disruption orchards, and leafroller biology and monitoring. These were distributed at grower meetings and in grower seasonal packets.

MAIPMIP staff also contributed 6 articles to 3 separate Gerber IPM newsletters, and wrote educational articles for the Farm Bureau News, The Great Lakes Fruit Grower News, and the MSU Fruit Crop Advisory Team Alert.

A thorough follow-up to the 2000 and 2001 seasons informed project participants and other members of the apple industry about the benefits provided by the MAIPMIP. As in 1999 and 2000, each grower participating in 2001 was presented with an individual report folder that included data from both the comparison (standard) and selective blocks. Similar packets were distributed to consultants to provide information about the project acreage on which they consulted. Information about the biology and control of major pests, including seasonal flight graphs, and the efficacy and suggested timing of new selective insecticides was included in the packets. In addition to providing the latest information on IPM for commercial apple orchards, these packets provided a tool to help the growers and consultants effectively review and evaluate their pest management programs from season to season. The information also served to accentuate the value of the weekly scouting reports and spray records received during the season. Through the MAIPMIP, growers learned the power of information and the necessity of on-site monitoring to make sound management decisions.

To augment print articles, a website (http://www.cips.msu.edu/maipmip/) was designed by an outside consultant to publicize the project. The site begins with an overview of the project's goals and components, written for the general public. The goal is to inform a non-technical person about pest-management challenges to apple producers in the state and associated topics such as broad and narrow spectrum insecticides, mating disruption and key insect pests of apples. The site also includes project results (grower participation, economic analysis, etc). The site provides another means for the public to increase their awareness about the project and learn more about pest management issues.

In general, the majority of participating growers themselves did not use the MAIPMIP website as a means to acquire information about the program (Appendix 3). The website was primarily used to communicate with the public in general about the project. Web server logs of visitors indicated that the site was visited several hundred times per month, and that visitors found the website when searching on terms that included insecticide, pheromone, mating disruption, several pesticide names, and several others.

The site will be maintained for at least another year, will include final results and information about IPM and mating disruption for apple growers as well as links to related projects.

Finally, industry-wide education includes informing a broad range of individuals about the project. Project orchards in several of the five Michigan production regions have been a part of educational tours that have included representatives from Federal and State regulatory agencies (e.g., U.S. Environmental Protection Agency, MI Department of Agriculture, MI Department of Environmental Quality), input manufacturers, Michigan State University, and the Center for Agricultural Partnerships. According to tour participants, each of these visits helped underscore the importance of the project, and provided an opportunity to discuss implementation efforts and project management.

Figure 24. MAIPMIP Website Homepage

Changing Attitudes

The changes that are being fostered in agricultural pest management systems require time before the changes are widely implemented. Rogers refers to the innovation-decision process as, "the mental process through which an individual (or other decision-making unit) passes from first knowledge of an innovation, to a decision to adopt or reject, to implementation of the new idea, and to confirmation of this decision". The MAIPMIP has been hard at work in Michigan since 1999 to speed up this process of adoption and implementation of new pest management systems (see Appendix 6). As can be seen from a review of the exit interviews of growers that were conducted after the close of the 2001 growing season, much progress has been made (Appendix 3). Growers and consultants are more actively involved in block-specific scouting for pests and beneficials in 2002 than they were in 1999, novel tactics such as mating disruption have become an integral part of many growers IPM programs, and new chemistries have been integrated into these systems as well.

Implementation projects such as the MAIPMIP are effective agents of change. One consideration for funders and participants of future projects is project duration. Three years is a very short time in agriculture. Due to the nature of the innovation-decision process, and the fact that the majority of growers are not innovators or early adopters (Rogers), the MAIPMIP has come to a close just as we were poised to make our biggest inroads into how pest management is practiced on the majority of apple farms in Michigan. Letters from MSU extension agents and industry leaders (Appendix 7) to Project staff, as well as comments from growers (Appendix 3), consistently express the sentiment that the project is ending just as we have attained the attention of the majority of the apple industry.

The following quotations from these individuals are indicative of the desire to continue with the project beyond 2001:

> *"It is unfortunate that now that you have a large population eager for information and eager to change that the funding for your program is ending. It seems to me that lots of educational opportunities still exist."*
> -Mark Longstroth, District Extension Horticultural & Marketing Agent.

> *"Now, after three years of the project, I feel that growers are finally realizing what the program has to offer them, but it has come to an official end… I do believe, however, that an additional two years of the project would make a tremendous difference in whether or not some of the IPM techniques the growers had a taste of will become a permanent tool in their IPM toolboxes."*
> -Amy Irish-Brown, MSU Extension District Fruit ICM Agent.

> *"The model program has been set in place; the challenge now is to keep the momentum going without the formal funding."*
> -Jeff Wohlgemuth, Gerber Products Co. (Appendix 7).

It is the opinion of Project staff that future implementation projects should last for five years. This would allow the majority of the industry targeted for change enough time to work through the process from innovation to confirmation. This best serves the interests of the promoters of change, as well as the affected industries.

Section IV. Concluding Section. Broadening the Impact of the Michigan Apple Project…Leaving a Legacy

Impacting an Industry

The Michigan Project Team expanded the number of commercial orchards in the MAIPMIP during the final year of the project, with direct project acreage at 8,384 acres and 103 Michigan apple growers in 2001 (Figure 10). Industry response and support in the final year of the project was outstanding. To date, figures reported as 'project acreage' only include those acres participating directly in the project (i.e. under specific management protocols that include use of selective insecticides and/or pheromone mating disruption). However, it is becoming clear, that many participating growers and consultants have already begun to utilize the lessons learned from these 'project acres' on additional acreage. One must certainly consider the breadth of influence that encompasses this additional acreage, to relate the true impact of the project. According to the MAIPMIP exit survey, (Appendix 3) 90% of the growers involved in the Project farmed between 50 and 400 total acres. With over 100 growers involved in the Project, at an approximate average of 200 acres/grower, the potential impact of the MAIPMIP was approximately 20,000 acres, over 40% of the apple acreage in Michigan.

MAIPMIP – A Catalyst for New Funding

Funded grants that will benefit the Michigan apple industry were written by and/or involved MAIPMIP staff. The project helped to identify issues that needed to be addressed in subsequent projects. To some extent, the projects either build on the successes of the MAIPMIP or utilize the network created by the project to further the overall goals of the MAIPMIP.

1.) MI Dept of Environmental Quality; "Helping MI Growers Reduce Pesticide Use Through Improved Pest Monitoring and the Use of New Controls for Key Apple Pests"; **D.L. Epstein,** MSU IPM Program, **D. Waldstein**, MSU IPM Program, L. Gut, MSU Entomology, M. Whalon, MSU Entomology, O. Liburd, MSU Entomology, C. Edson; MSU IPM Program; $135,000.

2.) NC IPM; " Delivering IPM Information into the Hands of Fruit Growers, Grape and Stonefruit Pocket Guides for the Northcentral United States ", **D Epstein**, MSU IPM Program, R Isaacs, MSU Entomology, C Edson, MSU IPM Program, A Jones, MSU Plant Pathology, A Schilder, MSU Plant Pathology, L Gut; MSU Entomology; $20,000.

3.) USDA SARE; "Educational Materials and Training that Foster Implementation of Ecologically Based Pest Management Decision-Making in Great Lakes Apple Production"; **D. Epstein**, MSU IPM Program, J. Haley, American Farmland Trust, J. Bakker, Westcentral Michigan Crop Management Association, C. Edson, MSU IPM Program, L. Gut, MSU Entomology; $92,500.

4.) USDA/RAMP; Development of alternative management strategies in commercial apple and peach production systems. P. Scherer, R. Brumfield, L. Hull, G. Krawczyk, H. Hogmire, J. Walgenbach, A. Agnello, J. Nyrop, H. Reissig, and L. Gut; $80,000/yr. for four years.

5.) MSU Project GREEEN; "Evaluation of Three Models to Privatize Scouting in Michigan Tree Fruit", **D. Epstein**, L. Gut, L. Olsen, and A. Irish-Brown. 3 year funding of $240,000.

Proposal for scouting infrastructure

The proposal “Evaluation of Three Models to Privatize Scouting in Michigan Tree Fruit” mentioned above was developed as a direct result of the MAIPMIP. The proposal addresses the need to further develop scouts/consultants, and to further develop the infrastructure necessary to support them. The proposal was written by David Epstein, and developed with the input of MAIPMIP growers, consultants, and MSU extension agents, drawing upon experiences from 3 years of MAIPMIP activities.

Pocket Scouting Guide

“A Pocket Guide for IPM Scouting in MI Apples” has been widely accepted as a significant contribution to apple IPM (Appendix 3). Almost 2,000 copies have been sold and distributed through the MSU bulletin office to customers throughout MI, the U.S., and internationally. Requests to sell the guide have been received from “The Good Fruit Grower”, one of the most prominent industry publications, and from Great Lakes IPM, an international supplier of IPM tools. Requests have also been received by David Epstein to collaborate with researchers in Greece and Argentina in the production of similar publications.

Additionally, the success of the apple pocket guide has provided the impetus for the development of pocket guides in several other MI cropping systems. The MAIPMIP Guide was cited in grant proposals for stone fruit, grape, and landscape/nursery crops as an example of the type of publication needed to further the aims of IPM. Each of these grants were funded, and are currently being developed.

Personnel Remaining at MSU

The MSU IPM Program hired David Epstein as its tree fruit IPM specialist in July of 2000. Mr. Epstein will continue to work with the MI apple industry on many of the same projects begun as a result of the MAIPMIP.

Beyond the Michigan Border

Larry Gut and David Epstein are collaborating with apple researchers to successfully establish an IPM implementation project in the Tatura region of Australia. David Williams and Alex Il’lechev visited the MAIPMIP in 2000 to learn from our efforts, and Dr. Gut and Mr. Epstein will be traveling to Australia to conduct workshops and seminars with the participants of their implementation project.

Project staff have also been involved in numerous presentations of the MAIPMIP outside of Michigan’s borders (Appendix 6). Interest generated by these presentations has led to several collaborative opportunites with researchers from other U.S. land grant universities.

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