An Assessment of Integrated Pest Management (IPM) in Orange and Ulster Counties, New York

Project Report Submitted to the Faculty of the
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by

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Chapter I: Introduction

Management strategies for pests, such as Integrated Pest Management (IPM), are not novel concepts; humans have been implementing various aspects of biological, genetic, cultural, and chemical tactics to manage pest levels since settlements began. Since the 1960s, IPM research and programs in the U.S. have provided tools that can produce high agriculture yields while sustaining public and environmental protection. However, not only is there a lack of standardized assessment tools and definitions for IPM, but information indicating IPM grower profiles and decision or perception variables have also not been fully assessed for all agriculture communities. Compounding the problem is the fact that U.S. agriculture industries are highly diverse and regionally specific. As such, the transfer of IPM lessons from one area to another is difficult.

In 2003, Cornell Cooperative Extension of Orange County, New York (CCE) offered IPM services to 40 growers in Orange, Dutchess, and Ulster counties. According to a 2002 census by the National Agricultural Statistics Service (NASS), 1,805 farms operate in these three counties.[1] Qualitative baseline information regarding IPM adoption and information regarding the types of growers likely to use IPM in these counties does not exist. Therefore both the determination of IPM adoption and the identification of target groups to encourage IPM adoption are difficult to measure.

[1] National Agriculture Statistic Service, (http://www.nass.usda.gov/ny/).

This report focuses on the assessment of IPM adoption and factors that contribute to the acceptance or rejection of an IPM program in Orange and Ulster counties. Based on findings in the literature and the experience of experts at CCE, a quantifiable definition of IPM was developed. This definition and data collected from farmers in the target counties to estimate the current IPM adoption level as well as to statistically analyze factors that encourage IPM use.

The next chapter outlines a history of IPM. Chapter 3 reviews the literature and its main findings. Chapter 4 details the methodology of this research, including a description of the survey instrument and the regression model. The results are described in chapter 5. Chapter 6 concludes this report with recommendations based on our results.

Chapter II: History of Integrated Pest Management

The use of integrated tactics to manage nuisance pest populations in agriculture systems is not new. As human settlements began altering the landscape for agriculture production, the development of strategies to suppress or eradicate pest species became essential for survival. Early civilizations such as the Sumerians used sulfur agents to subdue insect and mite populations. Chinese cultures implemented forms of mercury and arsenic compounds to treat seeds and body lice. Further, various other cultures from 1500 to 3 B.C. described managing pest levels by adjusting planting dates, prescribing burns, manipulating pest-predator relationships, and selecting seeds from healthy plants sowed (Dent 2000). As human populations grew and villages expanded into cities, the evolution of pest management brought forth a renaissance of innovative tactics highlighting biological systems, genetic selection and also chemical and cultural strategies.

For centuries, subsistence farming was the main form of practiced agriculture, and pest management tools that were discovered centuries before remained effective for human survival. However, by the late 19th century and the beginning of the 20th century, subsistence farming gave-way to more commercially focused agriculture. Technological advances allowed huge tracks of landscapes to be converted for agricultural purposes, which simultaneously increased the diversity and volume of nuisance pests to be managed and controlled (Dent 2000). In the 1920s and 30s early IPM practices were beginning to emerge. Though IPM was not clearly defined at the time, IPM practices revolved around scouting, monitoring, trapping and implementing an economic threshold which resulted in the use of a relevant action i.e., avoidance, suppression, or reduction (Rajotte et al. 1987).

By the 1940s, with the development of a broad array of organosynthetic insecticides including DDT, the management of pests by chemical application became the conventional standard in the U.S. (Carlson 1989).[2] The dawn of the pesticide era proved that chemical applications could be cheaper, easier to store, more readily available and potent pest management device for growers, which ultimately eliminated the demand for non-chemical strategies such as IPM in most areas of the U.S. (Kogan 1998). Indeed, several agricultural professionals considered chemical application as the ultimate cure to the perpetual battle between agriculture production and pest damage (Kogan 1998). However, despite remarkable advances, research institutions involved with pesticides did not take into account the full range of effects on biological systems– particularly the resistance abilities of pests and the resurgence capabilities of pest populations. Nor were researchers fully aware of the extent to which pest interactions within the larger ecosystem or food web could be altered by chemical applications.

Several negative externalities resulting from years of intense chemical application began surfacing at the public level during the 1950s and 1960s. Compounding the situation, during this era, various researchers began advocating for non-chemical use to control pest levels (Stern 1959). Independent research and publications such as Rachel Carson's *Silent Spring* (1962) galvanized a national movement for more extensive regulation and protection from pesticides

[2] Organosynthetic Insecticides are hydrocarbon-based components used to control insect populations but are toxic to warm blood organisms if absorbed at high concentrates.

and other industries contributing to negative environmental and human health damages (Carlson 1989).

During the 1960s, entomologists and researchers at the University of California Berkeley and Riverside began conducting field studies on the relationships between pests and their predator counterparts. From initial trials, researchers determined that in practice, pest management tactics (i.e. culture, biological, genetic, and chemical) could safeguard and even exploit natural predator/prey relationships, resulting in high yields (Carlson 1989). By the late 1960s, researchers had promising evidence concluding that the implementation of integrated strategies which encourage natural systems, coupled with chemical applications, could control pest populations and also maintain high yields with fewer negative side-effects than by use of chemical based pest management strategies.

By the late 60s and early 70s, the scientific literature formally recognized Integrated Pest Management (IPM) as an amalgamation of biological, genetic, cultural, and chemical tactics for the management of pests which also considered negative environmental and human health externalities before application decisions were made (Pilcher et al. 2001).

Public Policy on IPM

In September 1993, IPM policy was placed on the political "fast-track" during the Clinton Administration, which called for U.S. croplands to reduce pesticide applications and promote sustainable agriculture through IPM practices. The U.S. Department of Agriculture (USDA), the Food and Drug Administration (FDA), and the Environmental Protection Agency (EPA) pledged to work jointly to develop IPM programs to be implemented on 75 percent of U.S. crop acreage by the year 2000 (Vandeman et al. 1994).

Despite the attention given to IPM, it soon became clear that IPM definitions and interpretation varied greatly by region, commodities, and organizations. In fact, in a 2002 IPM compendium, over 60 different definitions developed by as many organizations were identified (Bajwa and Kogan 2002). Some of the confusion was attributed to the fact that IPM definitions are dynamic and shift to address public interest or other local factors (Fernandez-Cornejo 1999). The question of how to develop a flexible IPM definition and assessment tool that is applicable to most, if not all, commodities, regions, and social concerns acquired importance.

In a 1999 report by Fernandez-Cornejo and Jan of the USDA Economic Research Service (ERS), it was stated that over the past decade, great improvements for assessing IPM adoption in the U.S. have been achieved, but "a complete, practical, and accepted method to measure overall IPM adoption in the U.S. has not yet been developed" (p.9).

In 2001, the U.S. Congress questioned the validity of the USDA, EPA, and FDA's claims of successfully implementing IPM adoption for 70 percent of the United States' cropland, thereby almost achieving the 75 percent goal set in 1993. The U.S. General Accounting Office (GAO) was appointed to investigate the program and reported that, among other factors (leadership failures for instance), inaccurate measuring tools of IPM adoption which could clearly gauge IPM across diverse commodities and regions were lacking. As such, the GAO concluded that the involved government agencies' claim of 70 percent IPM adoption was misleading and not a true indicator of IPM adoption in the U.S. (GAO 2001).

As will be discussed in the next chapter, several studies have developed effective tools to establish basic information regarding IPM definitions and assessment. Research has demonstrated baseline IPM data for grower profiles and decision variables in the U.S. but without a standardized definition or adequate assessment tools, the evaluation and transfer of IPM information from other regions outside of New York is difficult.

Chapter III: Literature Review of IPM Definitions/Quantification of Adoption

This chapter outlines various literature sources which have served as a formation spring board for development of our methodologies, survey instrument, and analysis of results. Specifically, from the literature, information was gathered on assessment tools, grower profiles, decision variables and the categorization of common terms within IPM definitions.

Defining IPM

In an attempt to standardize an IPM definition, Bajwa and Kogan (2002) developed methodologies which determine the frequency of terms and words within various definitions of IPM worldwide.[3] From their research they determined that certain words and phrases were common to many of the definitions (Table 1). Many organizations (54%) used expressions such as: “economic considerations” which referred to a grower’s return revenue from implementing an IPM program; “negative externalities in the environment” (48%); and “pest population” or “the management of target pests” (40%) when defining an IPM program. Indeed, sifting through the extensive literature regarding definitions, we determined that J.R. Cate and M.K. Hinkel’s (1994) definition exemplifies Bajwa and Kogan’s research:

> “Integrated Pest Management is the judicious use and integration of various pest control tactics in the context associating the environment and pests, in ways that complement the facilitation of biological and other natural controls of pests to meet economic, public health, and environmental goals.” (p. 12)

[3] Worldwide, Bajwa and Kogan (2002) identified 67 different IPM definitions for as many organizations.

Table 1: Usage of IPM Terminology

	Frequency of Occurrence (%)
Economic (Revenues to a producer)	54
Environment (Negative externalities)	48
Pest population (Managing targeted pest)	40
Pest control (Goal of IPM)	38
Methods or tactics (Components of the control actions)	27
Ecology or ecological (IPM tactics based on ecological principals/systems)	25
Combination or multiple (Use of integrated tactics)	20
Economic thresholds (Bases for decision of type of action)	18
Social/sociological (Consideration of social costs)	10

Table 1: Common terms expressed in 67 of the most prominent IPM definitions

Source: Bajwa and Kogan (2002), (p.2)

Farm Characteristics

In 1994, Vandeman and colleagues attempted to address the complexity of assessing IPM adoption by surveying 70 percent of the total U.S. acreage used for fruit and nut, vegetable and field crop production. As a stipulation to their research, they defined IPM-oriented growers as farmers who implemented scouting and economic thresholds before considering a pesticide application. For corn producers, IPM users were individuals who implemented crop rotation rather then insecticide application between plantations.

Their results indicated the adoption of IPM varied widely among commodities but overall about 50 percent of growers surveyed adopted some, if not all, of the basic IPM tactics (i.e. scouting, monitoring, and economic thresholds). However, more sophisticated IPM techniques (i.e. use of biological organisms) had a much lower adoption rate. They concluded that the major impediments for IPM adoption were lack of knowledge regarding IPM strategies, too few crop consultants to deliver IPM services, and the high labor intensity of adopting an IPM program.

Pilcher et al. (2001) attempted to develop a standardized measurement tool to determine factors that contributed to IPM adoption for corn, soybean, and cotton production in Iowa and Texas but could be accessible to other commodities and regions. They developed a survey instrument from an IPM definition that represented the widest scope of strategies and determined 21 pest management tactics regarded by growers to be IPM oriented. From preliminary results, over 60 percent of participants identified three variables: scouting, economic threshold, and field records of pest population to be significant when implementing an IPM program. These three tactics were also found to be consistent with other literature regarding measuring IPM (Benbrook et al. 1996).

In an effort to establish a weighted and categorical system to measure the level of IPM used in Texas and Iowa, numerical weights of 2 were assigned to the three tactics determined to be essential (scouting, economic threshold, or record keeping) and 1 for all other IPM tactics tested. The categories and rank scores were "low IPM user" for growers who selected various tactics which total a score of 9 points; "Moderate IPM user" for respondents who scored 10-12; "High IPM user" for a score of 13-15; and "Very High IPM user" for individuals who scored in the 16-17 range. Based on this, Pilcher and colleagues determined that growers in Iowa and Texas tended to fall in the "Moderate IPM User" category, indicating that growers in this group used the three essential IPM tactics plus one or two of the other tactics tested. However, due to low sample size, these results were only preliminary.

Although the methodologies of these two studies differ, their results establish a baseline for identifying common threads within IPM programs. In each study, growers who used IPM implemented scouting, monitoring, economic thresholds and field records. From this one can predict the inclusion of these tactics would be essential to any basic IPM program.

Characteristics of IPM Adopters

For the successful implementation of an IPM program, it is important to acquire a good understanding of potential target audiences. In a 1987 publication, Rajotte et al. surveyed over 3,500 growers in 16 states covering nine commodities and one urban program. Their results determined that a grower more likely to use IPM had completed some higher level of education (college, for example), farmed for fewer years, considered farming as their primary job, and referred to Cooperative Extension resources more frequently than growers identified as non-IPM users, in their study. Sections of Pilcher et al. (2001) research also focused on grower profiles. Their results, similar to those of Rajotte et al., indicated that IPM farmers were younger, had farmed fewer acres, completed a higher level of formal education, practiced farming for fewer years, and also considered farming as their primary occupation than farmers who were considered non-IPM growers.

Pilcher and colleagues determined that IPM oriented growers tended to consult and use extension sources more regularly then non-IPMers. They hypothesized that farmers who attended college may have had more opportunities to interact with extension personnel, perhaps feeling more comfortable with extension information or speaking with extension agencies.

Research by Rajotte et al. also determined perception variables regarding growers' acceptance or rejection of an IPM program. Their data indicated that farmers were more likely to accept an IPM program if they used tactics for one or more of the following purposes: to control pest levels, increase crop yields, increase grower's revenues and/or to protect human health and reduce environmental damage. In a study conducted in Maryland and Virginia by the Virginia Cooperative Extension Agriculture and Natural Resources (ANR) Service in 2002, it was found that time available to scout fields, grower's confidence to identify pests correctly, and access to the most recent IPM resources were essential to corn, soybean, and small grain growers likelihood of adopting IPM. Drost et al. (1996) surveyed over 900 growers in Utah and determined that for potato farmers, the adoption or rejection of an IPM program was determined based on time availability, market demand for commodities based on specific pest management approaches, and real-time IPM information.

Several studies have developed significant baseline IPM tactic information and determined IPM-grower profiles and perception variables. However the data available are specific for certain commodities, organizations, or regions. In New York, agriculture practices and diverse commodities grown in Orange and Ulster counties are unique to the area. It is therefore difficult to directly transfer results from other regions to Orange and Ulster counties, which highlights the importance of a site-specific study such as this one.

Chapter IV: Research Methodology

CCE has offered programs and services for IPM since 1984. In 2003, the CCE-IPM program consulted 11 commodities in three counties (Orange, Ulster, and Duchess), in which approximately 40 growers formally participated. Given that over 1800 farms are listed for these three counties in the 2002 Agriculture Census. Participation in the CCE-IPM program represented only 2 percent of farms. It is hypothesized that the low participation in the program is a function of the difficulty in identifying and targeting potential users of IPM. What is needed to address this constraint is improved qualitative baseline information on IPM adoption, profiles of IPM adopters and an understanding of why a grower may or may not adopt IPM in Orange and Ulster counties.

The goal of this research is to improve outreach and education on IPM for New York's Orange and Ulster counties. To meet this goal, two distinct objectives were established for this survey:

1) To assess the level of IPM adoption in New York's Orange and Ulster counties.
2) To identify factors which influence the adoption of an IPM program for growers in Orange and Ulster counties.

Empirical Analysis

A focus group consisting of local farmers and an advisory committee of CCE educators and faculty from Bard College were appointed to develop a survey instrument and methodology tailored for growers in Orange and Ulster counties. Based on their expertise, the advisory committee determined an IPM definition which exemplifies the purpose of this research as:

> "[A] combination of long and short term production strategies to maximize net profits while minimizing risks of undesirable environmental impacts of agriculture practices".[4]

Building on previous empirical findings and their field experience, members of the committee listed the following explanatory variables that affect IPM use.

IPM Index

In order to identify IPM practices, it is critical to define and develop an index of IPM adoption. Based on focus group information and empirical studies, the advisory committee developed a series of thirteen IPM tactics to include in such an index.[5] The IPM index defined in this study is calculated as a weighted score of each tactic. Thus, the extent of IPM adoption by farmer *j* can be expressed as

In the equation above, w_i represents the weight assigned to the i^{th} tactic and F_{ij} indicates the frequency of use of the i^{th} tactic by the j^{th} respondent. Among the 13 tactics, three were assigned a weight of 2 (scouting, economic threshold, and field-level record-keeping), while each of the other tactics listed was assigned a weight of 1.[6] The

[4] See *Cornell Cooperative Extension: Pest Management Guidelines for Commercial Tree-Fruit Production*, 2003, (p. 4).

[5] Pilcher et al. (2001) used a measurement tool that consisted of only weighted scores for each tactics tested. However, we determined the use of two variables is a more accurate assessment tool for IPM adoption (i.e., weighted and frequency scores for tactics tested).

[6] Other studies determined that scouting, economic threshold, and record keeping were essential to an IPM program. Therefore higher weights were assigned to these tactics while units of 1 were assigned to all other tactics tested (Vandeman et al. 1994 and Pilcher et al. 2001).

frequency of use for each tactic by each farmer, F_{ij}, was captured using a four-point Likert scale: “Often”, “Sometimes”, “Seldom”, and “Never”.[7]

The IPM index developed in this study therefore incorporates both the importance of the IPM tactic as well as the frequency of use of each tactic. This contrasts with the methodology of other studies such as the one by Pilcher et al. (2001), which base their indices on only the relative importance of the tactic adopted. Due to this difference, the range of the IPM index of this study is 0-48, where 48 represents’ the highest possible level of IPM use. We follow the lead of Pilcher and colleagues to translate these numbers into qualitative categories as follows:

Table 2: Categories and IPM Index ranges for IPM Adoption

Low IPM user	27 – 29
Moderate IPM user	30 – 38
High IPM user	39 – 47
Very High IPM user	48 – 51

Explanatory Variables

In order to statistically determine which factors contribute to growers’ acceptance or rejection of an IPM program in Ulster and Orange counties, the advisory committee and focus group members outlined some of the variables thought to be critical to IPM adoption. Other variables chosen for analysis were based on the findings in previous studies.

[7] The Likert technique presents a set of attitude statements. Subjects are asked to express agreement or disagreement scaled on a four-point scale. Each degree of agreement is given a numerical value from zero to three. Thus a total numerical value can be calculated from all the responses.

Demographic Variables

Results from other studies indicated that age, higher level of formal education, and primary occupation influenced growers' adoption of IPM. As Rajotte et al. (1987) and Pilcher et al. (2001) demonstrated, younger growers contributed more to the adoption of IPM. Both studies determined that IPM-oriented growers had completed a higher level of formal education than non-IPM growers. Occupation was shown by Pilcher and colleagues to be a factor regarding IPM adoption (see preliminary regression model explanation, Appendix II).

Farm-Specific Variables

The advisory committee and focus group members hypothesized that the market value of crops and cost of pesticides contribute to the adoption of IPM. To test for market value of crops and pesticide costs, a range of monetary values were listed (see survey instrument, Appendix III).[8] The other farm-specific variable considered was whether farmers were growing crops in greenhouses and nurseries or not. Typically, pest pressures in greenhouses and nurseries are higher than on conventional farms, therefore the production of crops requires more frequent pesticide applications in order to ensure a better product. Respondents were also asked to identify their primary or secondary crops from a list of 11 commodities.[9]

Perception Variables

Drost et al. (1996) showed that market or consumer demand affected the adoption of IPM. To capture this relationship, a multiple chose list of six of the most common markets used by growers in Orange and Ulster counties was offered for respondents to select from. Participants were asked to identify which market they primarily use from this list. These answers were later combined into two categories, local and non-local.[10] Six perception decision variables were determined to be significant regarding the adoption of IPM. We asked respondents to indicate the importance of each perception variables. These variables were: "financial costs of IPM tactic(s) used;" "confidence an IPM tactic(s) used will decrease pest levels;" "consumer or market forces for IPM tactics;" "confidence tactic(s) used will reduce effects on the environment or human health;" "confidence an IPM tactic used would result in more time for respondent;" "sufficient knowledge of IPM tactics;" and "confidence an IPM tactic(s) used will produce an increase in yield or a better quality crop." A four-point Likert scale to quantify each variable was also used, the scale was as follows: "High" (3 units), "Medium" (2 units), "Low" (1 unit), "Never" (0 units).

Survey Instrument

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[8] Monetary ranges for market values tested and pesticide costs were based on focus group and advisory committee members' calculations and recommendations.

[9] The 11 crops tested were based on CCE official list of commodities enrolled in their 2003 IPM program. The crops we selected were onions, lettuce, potatoes, field corn and alfalfa, poinsettias and bedding plants, pumpkins, fruit crops, sweet corn, tomatoes, and peppers.

[10] Based on recommendation from committee and focus group members, local markets were determined as: Direct to Consumers, Total Direct Market, and Community Support Agriculture and non-local markets were; Wholesale to others, Direct Mailing, and Wholesale Direct Market.

A survey instrument was developed for gathering data from farmers in the two counties, names and addresses of whom were provided by CCE. The questionnaire consisted of 17 questions. These growers were sent an information packet and instructions to return the questionnaire within two weeks of receiving the packet. A reminder postcard was sent to each participant eight days after the initial mailing. For all questionnaires not received by the set deadline, a trained interviewer attempted to contact participants by phone.[11]

Chapter V: Results

Of the 110 questionnaires sent, 59 were returned, for a response rate of 52 percent, of which two questionnaires were deleted due to lack of complete information.

Three perception variables and two farm specific variables were found to be collinear and were deleted from our regression.[12],[13] Preliminary testing also showed significant collinearity among primary and secondary crops, onions, lettuce, sweet corn, tomatoes, and a low response for primary and secondary crops, peppers, potatoes, and poinsettias and bedding plants. Only field corn, alfalfa and fruit crops were used as variables for primary crops. Also, for similar reasons, only field corn, alfalfa and pumpkins were used for secondary crops in our regression model. All other crops were combined into an "other" category and used as a reference variable.

The final regression equation that was used is as follows (where the index *j* refers to the j^{th} farmer):

[11] See appendix III, for questionnaire and additional informational packet material.
[12] We determined three perception variables to be collinear and were deleted from our regression model: "confidence tactic(s) used to decrease pest levels;" confidence IPM tactic(s) used will reduce effects on the environment and human health;" and "confidence tactics used will increase yield or quality of crop;" to have collinear and were deleted from our regression model.
[13] Pesticide costs and market value of crops indicated collinearity and also were deleted from our regression model.

$$\begin{aligned} \mathbf{IPM\_INDEXj} = \beta_0 + \beta_1\ \mathbf{AGE}_j + \beta_2\ \mathbf{PRIM\_CROP}_j + \beta_3\ \mathbf{SEC\_CROP}_j \\ + \beta_4\ \mathbf{GREEN}_j + \beta_5\ \mathbf{MARKET\_\ LOCAL}_j \\ + \beta_6\ \mathbf{FINANCIAL\_COSTS}_j + \beta_7\ \mathbf{MARKET\_DEMAND}_j \\ + \beta_8\ \mathbf{TIME\_AVAILABILITY}_j + \beta 9\ \mathbf{KNOWLEDGE} + \epsilon_j \end{aligned}$$

Respondent Profile

Average age and number of years farming were 48 and 25 years respectively.

More than half of respondents had college education and most identified farming as their primary occupation (Table 3).

Table 3: Summary Statistics of Respondents (n = 57)

AVERAGE AGE (Years)	48
AVERAGE EXPERIENCE (Years)	25
PRIMARY OCCUPATION FARMING (%)	91
COLLEGE GRADUATES (%)	63

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Analysi nt of growers fell into the

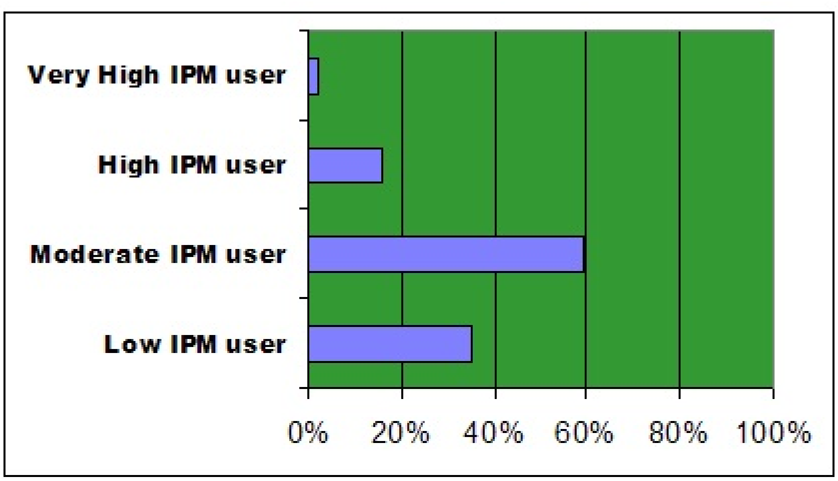

Figure 1: Distribution of User-Type by Extent of IPM Adoption

Of the 13 IPM tactics tested, over 50 percent of participants indicated using 11 tactics "often" (Figure 2). Regarding the three tactics, Vandeman et al. (1994) and Pilcher et al. (2001) determined essential to an IPM program, scouting was used by 82 percent of respondents; 77 percent of respondents' implemented economic thresholds; and recording of pest levels was used by 55 percent of participants.

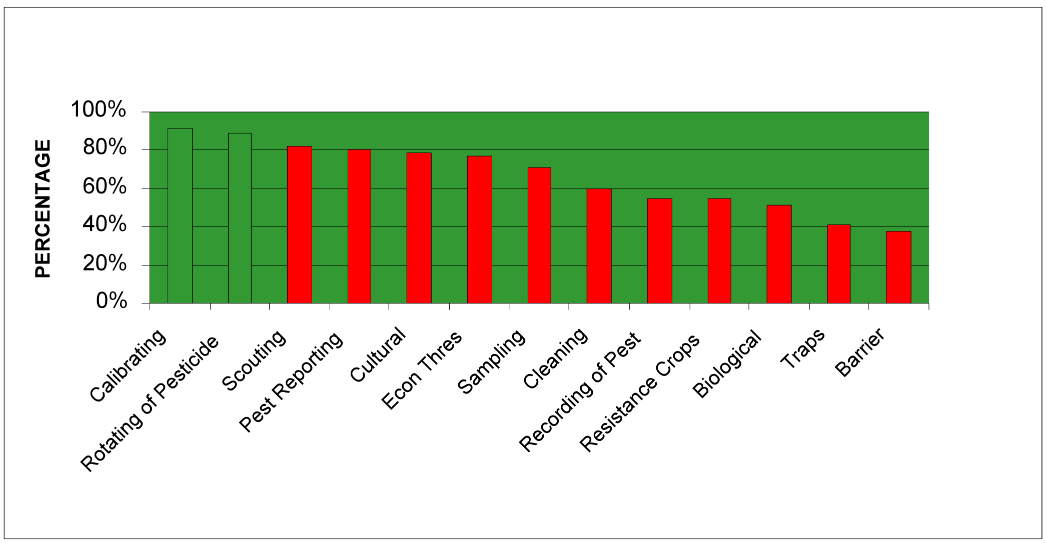

Figure 2: Percent of respondents using IPM tactics "often" in Orange and Ulster Counties in 2003 (solid bars indicate IPM tactics: scouting, economic threshold, and recording of pest levels)

Other tactics with high frequency of use included: calibration of machinery 92 percent; rotation of pesticides to reduce pest resistance 89 percent; and use of local pest reports 81 percent.

Factors Affecting Adoption

Based on farmers' responses, 56 percent indicated that "confidence in an IPM tactic(s)'ability to increase yield or improve the quality of crops," was of "high" importance. Fifty four percent and forty nine percent of respondents indicated that "confidence of a tactics' ability to decrease pest levels" and "sufficient knowledge about an IPM tactic," were of high importance when using an IPM tactic respectively. Thirty three percent of participants identified "Financial Cost" as highly important when deciding to use an IPM tactic (figure 3).

From a list of information sources tested, respondents indicated the most commonly used materials when considering pest management approaches were CCE-based information 88 percent and personal contact from CCE county agencies 81 percent. Growers stated that the most common media sources used were CCE meetings and workshops 65 and 54 percent respectively. Chemical company product meetings were used by 51 percent of respondents.

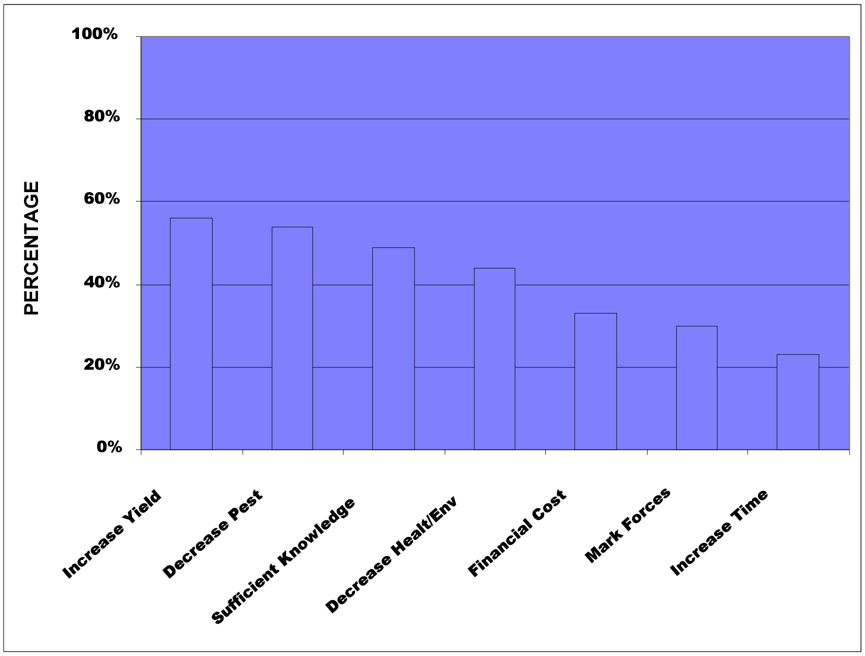

Figure 3: Proportion of Farmers Who Perceive Factors Too Be Highly Important

Regression Results

The final regression model included 11 variables which influence IPM adoption. The overall F-statistic of the regression model was 0.001, which shows that all the explanatory variables are jointly significant.

Table 3: Regression Results

Variable	Coefficient	p-value
AGE	0.07	0.310
PRIM_CROP_FCA*	-5.20	0.080
PRIM_CROP_FC	-1.06	0.600
SEC_CROP_FCA	-1.51	0.630
SEC_CROP_PUM	1.71	0.440
GREEN	1.27	0.510
MKT_LOCAL	-0.10	0.960
FIN_COST	-0.75	0.440
MKT_DMD*	1.64	0.060
TIME_AV	1.52	0.120
KNOWLEDGE***	3.56	0.008

* Significant at 10% level
*** Significant at 1% level

Results from the regression analysis indicated that growers' perception of their own level of understanding regarding IPM tactic information is most significant and positively related to the adoption of IPM. The perception of consumer demand for less chemicals-based agriculture is also significant and positively related with the extent of IPM implementation.

Respondents who produce a primary crop of field corn and alfalfa demonstrated a significant negative relationship with IPM adoption. Forage crops, such as, field corn and alfalfa, are mostly used for non-human consumption purposes and have a low market value. Producers of these types of commodities do not focus on pest damage as much as with other commodities. Also, primary crop fruit producers demonstrated no significant relationship with IPM adoption implying that these growers are no more or no less likely to use IPM. Fruit crop is a high valued crop and one would infer that growers would use less IPM and more chemical application to ensure a better yield. Our results showed otherwise.

Counter to other studies, respondents' age had no significant relationship with IPM adoption. Growers' use of a greenhouse or nursery to produce a crop also had no significant relationship with IPM adoption. This would imply that growers of any age and who use a greenhouse or nursery are just as likely to adopt IPM then other grower (table 3).

Chapter VI: Recommendations and Conclusions

Among the explanatory factors, growers' perception of their understanding of an IPM tactic had a positive and significant coefficient. Interestingly, the majority of respondents indicated using CCE information for pest management. This would indicate that CCE's information is reaching growers. Nonetheless more than half of respondents fell within the moderate level of IPM adoption; therefore we might reasonably infer that CCE IPM information relating to pest management is not clearly presented or misunderstood by growers. This is supported by this randomly chosen publication explaining how to calculate output for the calibration of machinery:

> "The gallons of spray desired per acre and the time required to spray an acre determine the rate of output for which the sprayer must be nozzled. Since volume of spray needed per acre varies with tree size, the most common row-spacing for the tree size to be sprayed should be used in calibrating the sprayer".[14]

Hence, our policy recommendation is to make CCE pest management information simpler to comprehend and implement.

A good place to begin distributing more understandable IPM information would be during the pesticide certification and training seminars sponsored by the CCE and DEC that growers are required by New York State Statute to attend

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[14] See *Pest Management Guidelines for Commercial Tree-Fruit Production, 2004* (p. 20).

annually.[15] Most of the information provided at these events is technical and specific to certain commodities or to agriculture research. To bolster IPM information comprehension, instead of just disseminating the data CCE and DEC should simplify their presentations and work to specifically target their message with language and concepts to the audience in attendance.

To accelerate the dispersal of IPM practices within the agricultural community, CCE and DEC could also sponsor a series of IPM training courses through the off-season months which would specifically, yet simply, address IPM and how it relates to various commodities (i.e., vegetable, fruit, ornamental, etc.). Classes would begin by supplying the basic foundation of IPM tactics; then, as the courses progress, the scope would widen to include more extensive, detailed IPM information. To make this concept more expansive and accessible to rural communities, web-based or video linkage such as technology used by colleges and universities should also be available. As an incentive for growers to participate, pesticide credits could be issued upon completion of course material.

The perception by growers regarding a market or consumer demand for IPM products also indicated a positive significant relationship with IPM adoption. This suggests that if greater consumer or market demand existed for commodities produced with IPM, then more IPM tactics would be adopted. IPM markets and/or consumer's demand for IPM products are clearly under-capitalized in New York State.

[15] New York State, Environmental Conservation Law statute: 33-0303 (3)(d), (e) part 325, requires any individual applying "Restricted-use Pesticide" or "Restricted Pesticide" labeled pesticides to

CCE could stimulate more overall IPM adoption by investing in educating consumers about the importance and benefits of IPM products. Indeed, the New York State-based IPM program and related not for profit organizations, such as Protected Harvest and the IPM Institution of North America, have extensive web-based, public and campaign materials regarding the benefits of IPM approaches, products, and labeling campaigns.[16] However, the will for identifying products produced with IPM tactics is slow to develop, in part due to growers' reluctance to circulate information about their pest management practices and also because of consumers' lack of knowledge of the benefits of IPM.

In New York, CCE holds a unique position as a well-established educator and partner of the public and also as a trusted consultant to growers. Through the use of education information at schools or information displays at grocery stores and markets, CCE could encourage consumers to purchase more IPM products. CCE could use its link with growers to educate them about the importance of grower--consumer relationships. Extension agencies could also partner with other organizations who are interested in pesticides or IPM use to establish and steer information campaigns via media or print advertisement, labeling, or the internet.

In 2003, CCE formal IPM program offered a basic IPM services consisting of scouting, reporting of pest levels, calculating of economic thresholds, recommendations for pest management, and trapping of pests. However, 50 percent of respondents indicated using tactics offered by CCE and in addition several other tactics not offered by CCE (i.e. calibration of machinery, pesticide rotation, cultural, local pest reports, etc.). This suggests that for growers in our targeted counties, an IPM program should include

[16]

all eleven of the tactics identified in our survey. This could be achieved by offering a range of tactics or customized IPM program for individual growers. Costs to utilize this approach and to hiring personal with sufficient IPM background to work as season employees may be expensive and difficult.

Result also indicated that younger growers were not found to be more likely to adopt IPM than older aged growers. This suggests that in Orange and Ulster counties, targeting IPM education material to growers should not be based on age. This also demonstrates that contrary to information found in other studies, if other variables are controlled (i.e. secondary and primary crop, primary occupation, use of greenhouse for production, perception variables, etc), age is not a significant factor. This clearly illustrates that given the variation in results among our results and other studies, a standardized measuring tool to assess IPM is needed.

Growers who produce field corn and alfalfa for a primary crop were challenged significantly regarding the adoption of IPM. This would imply that targeting IPM outreach and education to these groups of growers would not be an effective use of resources.

Most other research we analyzed for this research assessed IPM through the use of one indicator (weighted scores for IPM tactics used). Our results indicated that by using only weighted scores, IPM adoption tended to be distorted, which could indicate a higher level of IPM adoption than actually exists. Through the use of a frequency score and weighted scores for IPM tactics tested. We used two variables and generated a more concise picture of actually IPM adoption. We recommend that other studies should follow on our method when assessing IPM adoption.

In order to successfully provide outreach and education to perspective IPM users, one must first be able to identify current IPM users and then predict potential users. Once such identification has been made, one must find a suitable approach for teaching these growers not only how IPM works, but how it can work for them. That is why compiling user profiles and gathering information about them is so critical; without these steps in place, IPM has little chance of true growth. With the information of this study our intention is to further the efforts of outreach and education of IPM. Our hope is that the results will serve as a catalyst for the adoption of IPM technology and will therefore contribute to the sustainability of agriculture in the Hudson Valley.

Appendix I: Bibliography

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Appendix II: Regression Explanation

Exploratory Variables

Due to significant colinearity or low response, some variables in our preliminary regression model were deleted or used as reference variables in our final regression. Below is a description of all variables used, including variables chosen for our final regression model, and a comprehensive explanation of how numerical scores were assigned to each variable.

$$IPM\_INDEXj = \beta 0 + \beta 1\ AGEj + \beta 2\ SCHOOLj + \beta 3\ OCCUj + \beta 4\ PRIM\_CROPj + \beta 5\ SEC\_CROPj + \beta 6\ DECISIONj + \beta 7\ GREENj + \beta 8\ MARKj + \beta 9\ VAULEj + \beta 10\ PEST\_COSTj + \epsilon_j$$

Equation 1: Preliminary regression equation.

Demographic Variables

Other studies (Pilcher et al. 2001 and Rajotte et al. 1987) indicated that demographic variables, age, formal level of education, and primary occupation influenced growers' adoption of IPM. Therefore, to test for correlation between age and IPM adoption, we asked respondents to enter their age. Based on respondents' age information, scores for our regression model were assigned from the actual age of respondents. To capture the relationship between level of formal education and IPM adoption, respondents were asked to indicate their level of formal education for a list of multiple choose answers. Numerical scores were assigned based on respondents' selection from this list. The scores and categories were as follows: (1 unit—some high school or less; 2 units—high school graduate; 3 units—technical school; 4 units—some college; and 5 units—college graduate or more). For primary occupation, respondents were asked to indicate their primary profession based on a list of multiple choice answers. Each answer listed was assigned a score which was based on respondents selection, the scores and categories were: farming as a primary occupation (3 units); both farming and off-site job (2 units); and only off-farm job (1 unit).

Farm Specific Variables

The advisory committee and focus group members hypothesized that primary and secondary crops, use of greenhouse or nursery, pesticide costs, and market value of crops all contributed to the adoption of IPM by growers. Therefore to capture these factors, our questionnaire asked respondents to identify types of primary and secondary crops produced, whether they used a greenhouse or nursery, and their total costs of pesticides and market value of their crops in 2003.

For crops produced by growers, a list of 11 commodities was compiled for respondents to indicate their primary and secondary crops.[17] Based on a dummy variable system, responses were given a score of 0 units for No and 1 unit for Yes. However, due

[17] We choose commodities, Onions, Lettuce, Potatoes, Field Corn and Alfalfa, Poinsettias and Bedding plants, Pumpkins, Fruit Crops, Sweet Corn, Tomatoes, and Peppers to be tested in our regression model.

to collinearity among commodities tested, primary and secondary crops, onions, lettuce, sweet corn, tomatoes, and a low response for primary and secondary crops peppers, potatoes, and poinsettias and bedding plants were collapsed into an "other" category and used as reference variables. Field corn, alfalfa and fruit crops were used as variables for primary crops and only field corn, alfalfa and pumpkins were used for secondary crops in our regression model.

To capture greenhouse or nursery use for the production of crops, a similar dummy system, 1 unit for Yes and 0 units for No was also used for variables greenhouse or nursery. However, only numerical scores for yes responses were used and all no answers were used as reference variables in our regression model.

Respondents were asked to identify costs of pesticide application and market value of their crops produced in 2003. A range of monetary values were listed on the questionnaire for respondents to choose from. Numerical values used in our regression model were based off the mid-point of the monetary value range indicated by respondents.[18],[19]

Perception Variables

[18] Multiple choice answers for market value of crops in 2003 were: Less than $9,999, $10,000- $99,999, $100,000- $249,999, $250,000- $499,999, $500,000- $999,999, Greater than $1,000,000.

[19] Multiple choice answers for pesticide application costs in 2003 were: Less than $9,999, $10,000- $99,999, $100,000- $249,999, $250,000- $499,999, Greater than $500,000, Not applicable.

Drost et al. (1996) determined that market or consumer demand affected the adoption of IPM. Also our advisory committee determined six other decision variables to be important for consideration.

In our questionnaire we captured this by asking respondents to select from a list of six market channels determined by our advisory committee and focus group to be used in New York. Three of the six were considered local markets and three were considered non local markets.[20] Answers were assigned a score of 1 for yes or 0 for a no response. For our regression model, we used only yes or no responses for local markets and all responses for non local markets were used as reference variables.

In our questionnaire, we asked respondents to indicate the level of important for six perception variables based on a four point Likert scale. The six decision variables were: "financial costs of IPM tactic(s) used;" "confidence an IPM tactic(s) used will decrease pest levels;" "consumer or market forces for IPM tactics;" "confidence tactic(s) used will reduce effects on the environment or human health;" "confidence an IPM tactic used would result in more time for respondent;" "sufficient knowledge of IPM tactics;" and "confidence an IPM tactic(s) used with produce an increase in yield or a better quality crop." A four-point Likert scale to quantify each variable was as follows: "High" (3 units), "Medium" (2 units), "Low" (1 unit), "Never" (0 units).

However, three of the perception variables were deleted from our final regression model due to colinearity. These were; "confidence tactic(s) used to decrease pest levels;" confidence IPM tactic(s) used will reduce effects on the environmental and human

[20] Markets that were considered local were, Direct to Consumers, Total Direct Marke, and Community Support Agriculture. Markets that were considered non local were, Wholesale to others, Direct Mailing, and Wholesale Direct Markets.

health;" and "confidence tactics used will increase yield or quality of crop;" to have collinear and were deleted from our regression model.

Therefore our finally regression equation was as follows:

$$\textbf{IPM\_INDEXj} = \beta_0 + \beta_1\ \textbf{AGE}_j + \beta_2\ \textbf{PRIM\_CROP}_j + \beta_3\ \textbf{SEC\_CROP} + \beta_4\ \textbf{GREEN}_j + \beta_5\ \textbf{MARKET\_ LOCAL}_j + \beta_6\ \textbf{FINANCIAL\_COSTS}_j + \beta_7\ \textbf{MARKET\_DEMAND}_j + \beta_8\ \textbf{TIME\_AVAILABILITY}_j + \beta 9\ \textbf{KNOWLEDGE} + \epsilon_j$$

Equation 2: Final regression model.

Appendix III: Questionnaire and Support Materials

Pest Management Questionnaire

Instructions

This questionnaire was developed to assess the types of Integrated Pest Management (IPM) practices used by growers in Orange and Ulster Counties and to help improve Cornell Cooperative Extension's (CCE) IPM program. This survey should not take more than 20 minutes to complete. Your answers will remain confidential and anonymous. Thank you for your time and input.

GROWERS INFORMATION

1. Are you the person responsible for managing pests at your operation?

☐ No
☐ Yes

2. What is the title of the person responsible for your pest management decisions and how many years of experience does that person have?

☐ Farm Manager ☐ Farm hand
☐ Farm Owner

☐ Other_________________________

Years of experience_____________

3. What do you consider your primary occupation?

Off-farm job ☐ Both equally
☐ Farming

4. What is your age? _____ years

5. What level of formal education have you completed?

High school graduate
Some High school or less
Some college
Vocational/ Technical school
☐ Other ________________________
College graduate or more

FARM PRODUCTION

6. Which commodities do you consider your ***primary*** crops and how many square feet (ft^2) do you farm for each crop? (*Check all that apply and provide approximate ft^2*)

Onions_______ ft^2 Pumpkins_______ ft^2 Tomatoes________ ft^2

Lettuce_______ ft^2 Fruit crops______ ft^2
Peppers_________ ft^2

Potatoes______ ft^2 Sweet Corn_____ ft^2

Field Corn & Alfalfa_______ ft^2

Poinsettias & Bedding Plants______ ft^2

Other_______________________ and___________________ ft^2

7. Which commodities do you consider your ***secondary*** crops and how many square feet (ft^2) do you farm for each crop? (*Check all that apply and provide approximate ft^2*)

Onions_______ ft^2 Pumpkins_______ ft^2 Tomatoes________ ft^2

Lettuce_______ ft^2 Fruit crops______ ft^2
Peppers_________ ft^2

Potatoes______ ft^2 Sweet Corn_____ ft^2

Field Corn & Alfalfa_______ ft^2

Poinsettias & Bedding Plants______ ft^2

Other_______________________ and___________________ ft^2

8. Are any of your crops produced in a greenhouse or nursery?

☐ Yes ☐ No

9. What are your primary market(s)? (Check all that apply)

☐ Direct to Consumers ☐ Wholesale to others ☐ Wholesale Direct Market

☐ Total Direct Market ☐ Direct Mailing

☐ Community Support Agriculture ☐ Other_____________________________

PEST MANAGEMENT

10. Please indicate the type(s) of pest management tactics you used in 2003 by checking the corresponding levels.

A. Scheduled scouting of crops and identification of nuisance pests

☐ Often ☐ Sometimes ☐ Seldom ☐ Never

B. Use of economic thresholds to determine appropriate remedies for the reduction of pest levels

☐ Often ☐ Sometimes ☐ Seldom ☐ Never

C. Use of resistant crop varieties

☐ Often ☐ Sometimes ☐ Seldom ☐ Never

D. Rotation of various pesticides to reduce pest resistance

☐ Often ☐ Sometimes ☐ Seldom ☐ Never

E. Use of pheromones or sticky traps for monitoring pest levels

☐ Often ☐ Sometimes ☐ Seldom ☐ Never

F. Use of cultural approaches to minimize pest levels. Cultural approaches could include: removal of brush/debris, crop rotation, tillage, cover crops, plant/row spacing, timing of harvest and water management, trap crops, avoiding planting in areas with historically high levels of pests, and pest-free seeds

☐ **Often** ☐ **Sometimes** ☐ **Seldom** ☐ **Never**

G. Use of local pest reports

☐ Often ☐ Sometimes ☐ Seldom ☐ Never

H. Use of local weather reports to minimize pesticide application when appropriate forecasting models are available

□ Sometimes □ Seldom □ Never
□ Often

I. Use of soil and/or leaf sampling
□ Sometimes □ Seldom □ Never
□ Often

J. Use of biological controls to minimize pest levels. Types of biological controls could include: predatory, parasites, competitors, biological pesticides and genetically modified Bt products

☐ Sometimes ☐ Seldom ☐ Never
☐ Often

K. Maintaining of field maps or records for areas with high pest levels

☐ Sometimes ☐ Seldom ☐ Never
☐ Often

L. Cleaning of machinery or tools to reduce disease or insect transfer

☐ Sometimes ☐ Seldom ☐ Never
☐ Often

M. Calibrating of spray machinery at the beginning of the season and adjusting as needed

☐ Sometimes ☐ Seldom ☐ Never
☐ Often

N. Mechanical barriers, removal, or exclusion (i.e. row cover, Remay, etc.)

☐ Sometimes ☐ Seldom ☐ Never
☐ Often

☐ None of the above

☐ Other (Please be specific)_______________________________________

11. Please rate how significant these factors were for you in selecting your responses to question 10.

A. Financial cost(s) to implement and use tactic(s)

☐ High ☐ Medium ☐ Low ☐ Never

B. Confidence of tactic(s) to decrease pest levels

☐ High ☐ Medium ☐ Low ☐ Never

C. Consumer/market driven forces requiring tactic(s) to be implemented

☐ High ☐ Medium ☐ Low ☐ Never

D. Confidence of tactic(s) reducing effects on the environment or human health

☐ High ☐ Medium ☐ Low ☐ Never

E. Tactic(s) implemented would provide additional time for you to complete other duties

☐ High ☐ Medium ☐ Low ☐ Never

F. Sufficient knowledge about the tactic(s) implemented

☐ High ☐ Medium ☐ Low ☐ Never

G. Confidence of tactic(s) producing an increase in yield or a better quality crop

☐ High ☐ Medium ☐ Low ☐ Never

12. How satisfied are you with your present level of pest management?

☐ High ☐ Medium ☐ Low ☐ Not

13. If you think your level of pest management could be improved, what resources or services would you need? (*Use page 8 if necessary)*

SOURCE OF INFORMATION

14. When determining pest management strategies for your operations in 2003, which **information sources** did you use? (*Check all that apply*)

Extension bulletins, manuals, handbooks

Agri-products publications

Trade Journals

County extension agents

Local agri-education teachers

University specialist

Neighbors or other producers

Independent consultants

Agri-products dealers

Your own scouts

□ Not applicable

Other ____

15. When determining pest management strategies for your operation in 2003,which **media sources** did you use? (*Check all that apply)*

- ☐ Newspaper articles
- ☐ General farm magazines
- ☐ Extension Websites
- ☐ Television
- ☐ Extension phone recordings
- ☐ Extension sponsored workshop
- ☐ Chemical Co. product meeting
- ☐ Field demonstrations
- ☐ Not applicable
- ☐ Trade journals
- ☐ Extension videos
- ☐ Other Internet Websites
- ☐ Radio
- ☐ Extension sponsored meeting
- ☐ Commodity/Ag industry meetings
- ☐ Young Farmers program
- ☐ State Department of Agriculture
- ☐ Other ____

FINANCIAL INFORMATION

16. What was the total market value of your crop(s) in 2003?

Less than $9,999

$10,000- $99,999

$100,000-$249,999

$250,000-$499,999

$500,000-$999,999

☐ Greater than $1,000,000

17. What was the estimated dollar amount you spent on pesticide application in 2003? (i.e. cost for pesticide compound, additional machinery if appropriate, labor, etc.)

Less than $9,999

$10,000- $99,999

$100,000-$249,999

☐ $250,000-$499,999

☐ Greater than $500,000

☐ Not applicable

ADDITIONAL COMMENTS:

Once completed, please mail this questionnaire in the self-addressed envelope. Thank you for your time and input. If you have any questions or concerns please contact Robert Koch at (845) 853-3020 or email: apple_leaf_2@yahoo.com.