INFORMATION TO USERS

This manuscript has been reproduced from the microfilm master. UMI films the text directly from the original or copy submitted. Thus, some thesis and dissertation copies are in typewriter face, while others may be from any type of computer printer.

The quality of this reproduction is dependent upon the quality of the copy submitted. Broken or indistinct print, colored or poor quality illustrations and photographs, print bleedthrough, substandard margins, and improper alignment can adversely affect reproduction.

In the unlikely event that the author did not send UMI a complete manuscript and there are missing pages, these will be noted. Also, if unauthorized copyright material had to be removed, a note will indicate the deletion.

Oversize materials (e.g., maps, drawings, charts) are reproduced by sectioning the original, beginning at the upper left-hand corner and continuing from left to right in equal sections with small overlaps. Each original is also photographed in one exposure and is included in reduced form at the back of the book.

Photographs included in the original manuscript have been reproduced xerographically in this copy. Higher quality 6" x 9" black and white photographic prints are available for any photographs or illustrations appearing in this copy for an additional charge. Contact UMI directly to order.
ADOPTION OF INTEGRATED PEST MANAGEMENT TECHNOLOGIES BY OHIO APPLE GROWERS

DISSERTATION

Presented in Partial Fulfillment of the Requirements for the degree of Doctor of Philosophy in the Graduate School of The Ohio State University

By

Muhammad Ashraf

* * * * *

The Ohio State University
1995

Dissertation Committee:

Dr. J. L. Henderson
Dr. C. Welty
Dr. R. W. Hall

Approved by

Dr. J. L. Henderson
Adviser
Department of Agricultural Education
DEDICATION

To My Parents
ACKNOWLEDGMENTS

I am thankful to the Creator of Universe who gave me health, courage, and understanding to complete this work in a heavy time of my life.

I would like to express my sincere and profound appreciation to my advisor, Dr. Janet L. Henderson for her constructive reviews, editing, enthusiasm, and untiring help throughout my course of studies and dissertation process. I especially want to thank the members of the dissertation committee, Dr. Celeste Welty, Dr. Richard Hall, and Dr. Linda Lobao for their excellent suggestions, criticisms, and guidance during the completion of this dissertation. A special thanks to Dr. Jo Jones, Dr. Nikki Conklin, and Dr. Chadwick Alger for their encouragement and guidance in my course work and serving on my general exam committee.

My deepest appreciation is extended to my parents, Akbar Jan and Abdur Rehman whose support and inspiration helped me endure in these stressful times. I would like to thank one special individual, Saika, my wife, who had to make sacrifices during the time I pursued this degree. Her understanding, patience, friendship, and caring gave me the strength needed to succeed. I would like to thank Mawish, Faiza, and Hannah, my daughters.
Dec 22, 1956 .................................. Bom, Shoran Pakistan

1981   B.S. (Honors) Agriculture,  
North West Frontier Province University,  
Peshawar, Pakistan

1984 ........................................................... M.S. (Honors)  
Agricultural Entomology,  
University of Agriculture,  
Peshawar, Pakistan

1981 - 82 ................................................... Agricultural Officer  
Ministry of Agriculture,  
Azad Kashmir, Pakistan.

1982 - 85 ..................................................... Instructor Plant Protection/Farm Manager  
Ministry of Agriculture,  
Azad Kashmir, Pakistan.

1985 - 86 ................................................... Horticultural Officer in Fruit Tree Nurseries,  
Ministry of Agriculture,  
Azad Kashmir, Pakistan.

1986 - 90 ..................................................... Extension Officer  
Ministry of Agriculture,  
Azad Kashmir, Pakistan.

1992 ............................................................ M.S. in Agricultural Education, The Ohio State University, Columbus, Ohio.

FIELDS OF STUDY

Major field: Agricultural Education
Minor field: International Studies
TABLE OF CONTENTS

DEDICATION ...................................................................................... ii

ACKNOWLEDGEMENTS ................................................................. iii

VITA ....................................................................................................... iv

LIST OF TABLES .................................................................................. vii

CHAPTER PAGE

I. INTRODUCTION

Problem Statement ................................................................. 9
Purpose and Objectives of the Study .................................... 10
Significance of the Study ....................................................... 11
Definition of Terms ................................................................. 12

II. REVIEW OF THE LITERATURE

Diffusion of Innovations ............................................................ 14
Adopter Categories - 'Ideal Types' ............................................... 17
Variables Related to Adoptive Behavior ..................................... 20
Factors Related to Adoption ..................................................... 29
Barriers to Adoption ................................................................. 34
Integrated Pest Management ..................................................... 39
Summary of Literature Review .................................................... 49

III. METHODOLOGY

Research Design ........................................................................... 50
Sample Selection ........................................................................... 50
Instrumentation ............................................................................ 51
Data Collection .............................................................................. 53
Data Analysis ................................................................................ 54
## IV. FINDINGS

- Data Sample ................................................................. 57
- Description of Apple Growers ........................................ 60
- Level of Adoption .......................................................... 71
- Attitudes Toward Adoption ............................................... 74
  Relationships Between Grower
  Characteristics and Attitudes toward
  IPM .................................................................................. 75

Relationships Between Grower
Characteristics, Attitudes Toward IPM,
and Level of Adoption ................................................... 77

Summary of Written Comments ........................................ 79

## V. SUMMARY, CONCLUSIONS, IMPLICATIONS AND
RECOMMENDATIONS

- Problem Statement .......................................................... 82
- Purpose and Research Objectives ..................................... 83
- Methodology ........................................................................ 84
- Summary of Findings .......................................................... 86
- Conclusions/Implications .................................................... 89
- Recommendations ............................................................... 90
- Need for Further Study ....................................................... 92

## APPENDICES

- A. Location of Sample ....................................................... 93
- B. Research Instrument ...................................................... 95
- C. Panel of Experts ........................................................... 111
- D. Correspondence ............................................................. 114
- E. Written Comments ......................................................... 117
<table>
<thead>
<tr>
<th>CHAPTER</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>F. Thirty-Four Intermediate Practices</td>
<td>123</td>
</tr>
<tr>
<td>LIST OF REFERENCES</td>
<td>129</td>
</tr>
</tbody>
</table>
# LIST OF TABLES

<table>
<thead>
<tr>
<th>Table</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Davis' conventions of number magnitude.</td>
<td>55</td>
</tr>
<tr>
<td>2. Differences between respondents and nonrespondents on selected demographic characteristics</td>
<td>59</td>
</tr>
<tr>
<td>3. Age breakdown of the apple growers</td>
<td>60</td>
</tr>
<tr>
<td>4. Educational level of apple growers</td>
<td>61</td>
</tr>
<tr>
<td>5. Number of years of apple growing experience.</td>
<td>62</td>
</tr>
<tr>
<td>6. Number of trees</td>
<td>63</td>
</tr>
<tr>
<td>7. Size of orchard in acres</td>
<td>64</td>
</tr>
<tr>
<td>8. Percentage of labor provided by the operator and family members in the orchard operation.</td>
<td>65</td>
</tr>
<tr>
<td>9. Hours spent per week in the orchard by the owner.</td>
<td>66</td>
</tr>
<tr>
<td>10. Gross sales of apple growers</td>
<td>67</td>
</tr>
<tr>
<td>11. Percent of income from orchard</td>
<td>68</td>
</tr>
<tr>
<td>12. Percent income from off-farm sources.</td>
<td>69</td>
</tr>
<tr>
<td>13. Percent income from other sources</td>
<td>70</td>
</tr>
</tbody>
</table>
14. IPM techniques most frequently practiced by Ohio apple growers. 

15. IPM techniques least practiced by Ohio apple growers.

16. Relationship between demographic characteristics and grower attitudes toward IPM.

17. Relationships between demographic characteristics, growers' attitudes toward IPM, and level of adoption.
Chapter I

INTRODUCTION

All organizations are subject to change to keep up with the techniques and innovations of the business world (Goffos, 1984). Change is a result of the innovation-decision process in which a person passes through the knowledge of an innovation until the confirmation of its decision (Rogers, 1983). Some of these changes are minor and require little adoptive effort. However, some changes are major, requiring much support, understanding, and adaptation skills. Change is the result of the adoption of an innovation. "Innovation is an idea, practice, or object perceived as new by an individual" (Rogers & Shoemaker, 1971 p. 19). The impact of innovations on economic growth has been well known since Adam Smith's Wealth of Nations (1776). Adoption of new innovations has a tremendous impact on economic development. If the impacts of an innovation are prominent from an economic point of view, the technology or innovation will spread rapidly among the clientele (Nowak, 1982). Change, as evidenced by the adoption of new innovations, is a continuous and recursive process necessary for an economic system (Knudson & Bruce, 1989).
Technology is generally defined as the application of accumulated knowledge in a society and technical change is the application of new knowledge (Rogers, 1983). Three components are involved in the process of technical change: a) research and development, b) adoption and diffusion, and c) regulations and institutions. These components are simple, yet complete enough to detect the main factors that drive technical change. Research and development (R & D) involves the creation and application of knowledge and provides the set of technologies from which producers and consumers choose. R & D consists of basic research, product development, and commercial development. The adoption and diffusion component (A & D) deals with those producers and consumers who decide to adopt a new innovation. Several factors affect the decision to adopt an innovation, including: performance and relative cost of the innovation, perceived level of risk, existence of complementary inputs, and the skills needed to use the innovation (Knudson & Bruce, 1984). The third component, regulations and institutions (R & I) define the economic, social, legal, and political environments for the R & D and A & D components. By focusing on the process of technical change, researchers, specialists, and educators can understand and direct the path of change toward socially acceptable outcomes (Knudson & Bruce, 1984).

The adoption and use of improved technology is a central issue in the technology transfer process. The degree to which a
recommended new technology has been adopted is critical for successful technology utilization (Rogers, 1983). Utilization of a new technology can be divided into two main areas: the adoption and use of improved technology and the accessibility and availability of physical inputs (Green, 1985). The life cycle of an innovation depends on several factors. Particularly important is the congruency of the innovation with already present technology, communication systems, and the demographics of a population. An innovation passes through introduction, growth, maturity, and decline (Brown, 1981). At the introduction stage, diffusion is limited to a particular place. The innovation grows as impacts are known. When an innovation reaches its maturity and the majority of the people have adopted the innovation, the rate of adoption starts declining (Brown, 1981).

Farmers adopt new technologies when the techniques are perceived as being in their best interest. In the case of non-adoption of new technologies, producers are either unable or unwilling to adopt (Nowak, 1982). These two reasons are not necessarily mutually exclusive. Producers may be able to adopt new technologies, yet are unwilling. Conversely, producers may be willing to adopt new technologies, but unable for a variety of reasons. Accelerating the adoption of a practice must be based on an understanding of why producers are rejecting a new technology.
Inability to adopt a new production technique implies the presence of an obstacle(s) or that the decision not to adopt is rational and correct. Non-adoption could be due to several factors, including: a) lack of information, b) the high cost of obtaining information, c) the complexity of the new technology, d) the high cost of implementation, e) excessive labor requirements, f) insufficient planning, g) limited availability and accessibility of supporting resources, h) inadequate managerial skills, and i) little or no control over the adoption decision (Nowak, 1982).

Producers may be unwilling to adopt a new practice if they have not been persuaded that the technology will work and is appropriate for their specific operation. A number of reasons for being unwilling to adopt have been identified, including: a) information conflicts or inconsistencies, b) poor applicability and relevance of information, c) conflicts between current production goals and the new technology, d) ignorance on the part of the producer of the technology, e) practice is inappropriate for the physical setting, f) practice increases risk of negative outcomes, and g) belief in traditional practices (Nowak, 1982).

The movement of technology from the laboratory to the field has been an important challenge for transfer professionals. New technologies can be made available to producers via extension agents. One task of an extension agent is to disseminate knowledge and new technologies from universities and research centers to producers. If extension personnel are
aware of the adoption levels of new agricultural technologies by producers, then they can plan more effective extension programs specific to the needs of producers. In addition, if extension agents are aware of the barriers to adoption, they can assist researchers and producers in finding solutions. New agricultural knowledge and practices can be assimilated, objectively evaluated, and systematically transferred through educational training programs to the producers (Barao, 1992).

Farmers have struggled to control their environment since the beginning of time. Crops planted in villages and farms were severely attacked by pests. Farmers unwillingly tolerated insects and diseases and at the same time learned how to improve their conditions through continuous "trial and error." Through this informal learning process, producers became familiar with insects and plant diseases prior to emergence of modern crop protection sciences. Farmers adopted several practices, such as sanitation, cultural practices, rotation, and use of pathogen and pest-free seed to improve production levels (Apple & Smith, 1979).

These practices reduced pest populations and provided economic benefits. However, some serious pests of high economic importance could not be controlled completely. As scientific knowledge expanded in the 18th and 19th centuries and pest problems became more severe, a systematic search was started for effective methods of pest control. Although farmers were
adopting a number of unsophisticated techniques before WW II, after World War II, a new era in plant protection was initiated with the introduction of DDT and 2,4-D. Hundreds of new agricultural chemicals became available for crop production and to fulfill the demands of a growing population. Agricultural production became dependent upon improved varieties, proper fertilizer use, specialized cultural practices, and continuous plant protection. Until a few years ago, chemicals were the main source for plant protection. Extensive use of chemicals brought several negative effects, such as disturbance of natural enemies of pests, human health problems, and pesticide resistance. Due to the hazardous effects of chemicals and the development of resistance among pests for specific pesticides, a new interest was stimulated in alternative methods of pest management (Hagen & Frenz, 1973). Researchers developed a new strategy known as IPM (Integrated Pest Management).

IPM uses a systems approach to reduce pest damage to tolerable levels through a variety of techniques, including predators and parasites, genetically resistant hosts, environmental modifications and, when necessary and appropriate, chemical pesticides. IPM strategies generally rely first upon biological defenses against pests before chemically altering the environment. IPM is the selection, integration, and implementation of pest control based on predicted economic, ecological, and sociological consequences (Bottrell, 1979). IPM
seeks optimal use of naturally occurring pest controls, including weather, disease agents, predators, and parasites. In addition, IPM utilizes various biological, cultural, physical, mechanical, and chemical controls and habitat modification techniques (Bottrell, 1979).

IPM is an example of a technology or practice that is being introduced by extension personnel and adopted by producers. IPM is a strategy for pest control which is the result of a significant change in attitude promoted by reliance on chemical pesticides. The success of chemical control with insecticides was so phenomenal that other non-chemical control techniques received little support. Insecticides were cheap and were widely used for pest control.

IPM represents a complete change in the philosophy of pest control, away from pest eradication toward pest management. IPM is a holistic approach to pest control that considers all factors ultimately affecting the pest complex, including plant nutrition and horticultural practices, as well as elements of insect, disease, and weed control (Hollingsworth, Coli, Cooley, & Prokopy, 1992). "IPM is a pest management system, that in the context of the associated environment and the population dynamics of the pest species, utilizes all suitable techniques and methods in as compatible a manner as possible and maintains the pest population level below that causing economic injury" (Smith & Reynolds, 1991 p. 2). IPM is concerned with the
management of entire pest populations, not only localized ones. Instead of one control technique, several techniques are combined for inexpensive and reliable long-term pest control with minimum chances of harmful side effects. IPM shows the concern and support for a more ecologically oriented approach that incorporates the use of techniques based on the knowledge of the life history and biology of the pest. IPM is based on the philosophy of combining control technologies in a particular cropping system for all pests (i.e., weeds, birds, mammals, pathogens, and insects) for a durable pest management system.

**Problem Statement**

IPM practices have been introduced on many agricultural crops, including apples. Apples are an important component of U.S. fruit consumption. Estimated per capita consumption in 1988 (fresh and processed) was approximately 28 pounds, ranking apples below oranges and above any other fruit (OARDC, 1991). Per capita fresh consumption, at 19.1 pounds, also ranked second nationally, below bananas at 24.2 pounds, but above oranges at 14.5 pounds (Putnam, 1990). Although fresh imports and exports are rising, the apple industry (unlike bananas or oranges) is dominated by domestic production. Increased per capita consumption, together with increased population, has increased domestic apple production by more than 50% during 1973-90 (OARDC, 1991). The U.S. is a net exporter of fresh apples and an importer of juice concentrate. The apple industry plays an
important role in the economy of Ohio, contributing $22.8 million per year (Ohio Agriculture statistics 1992 p 39). In 1992 Ohio's total apple production was 115 million pounds, while in 1991 it was 120 million pounds. This 4% reduction in yield resulted due to severe rains and cool weather which reduced the bee pollination (Ohio Agriculture Statistics 1992).

Apples are victim to many insects and diseases; 14 major arthropod pests damage apples in Ohio, with the European red mite, plum curculio, and San Jose scale topping the list of most troublesome pests (Hale, 1993). Codling moth, which was the number one pest in 1978, is now ranked 10th (Hale, 1993). A pilot project evaluated several IPM techniques for suitability in Ohio apple orchards (Welty, 1994). There are several important diseases of apple which include apple scab, fire blight, powdery mildew, and black rot.

IPM is developing into a separate field of specialization as a complex process involving the integration of several pest control measures. Knowledge of pests and diseases and their biology is helpful in implementing successful management strategies. Access to this type of information would be helpful to Ohio apple growers for better pest control.

IPM is not simply a practice that a grower uses or does not use, but rather is a collection of practices. Adoption of IPM is a time consuming process. If extension educators could understand the grower's aims and preferences, the adoption of
IPM technologies by apple growers could be accelerated. Adoption of IPM practices could increase per acre production with minimum risks of environmental hazards and resistance development among pests. Determining the current level of adoption of IPM practices by Ohio apple growers is a step that must be taken before identifying the barriers to the adoption of IPM. Studies of adoption and barriers to IPM practices are important steps in the innovation-diffusion process.

**Purpose and Objectives of the Study**

The purpose of this study is to describe the adoptive behavior of Ohio apple growers on selected IPM practices. The specific objectives of the study are to:

1. describe Ohio apple growers on the following demographic characteristics:
   a. age
   b. educational level
   c. years as grower
   d. number of trees
   e. number of acres
   f. level of gross sales
   g. percentage of labor performed by grower and family members.
   h. number of hours worked per week in orchard.
   i. sources of income.
2. determine the level of adoption of IPM practices by Ohio apple growers.

3. determine attitudes toward IPM practices by Ohio apple growers.

4. determine relationships between demographic characteristics and grower attitudes toward IPM.

5. determine the relationships between selected demographic characteristics, attitudes toward IPM, and level of adoption of IPM practices by Ohio apple growers.

**Significance of the Study**

Determining the degree to which IPM practices have been adopted by Ohio apple growers will assist extension and research personnel in the innovation-diffusion process and in the determination of their effectiveness in developing and transferring technical knowledge and skills. This knowledge will assist extension agents and researchers in planning additional programs involving IPM practices. Specific research projects involving scientists, extension agents, and growers could demonstrate the latest IPM technologies. Producers could observe the advantages and disadvantages to the adoption of IPM practices and how pests could be managed through IPM procedures. If extension and research personnel could understand more clearly the situation of apple growers, they could provide specific recommendations for pest managing problems and issues.
**Definition of Terms**

The following terms were defined based on their use in this study:

1. **Apple growers**: are those persons who produce apples for personal or commercial consumption. For the purpose of this study, apple growers were operationally defined as the commercial producers listed as members of the Ohio Fruit and Vegetable Growers' Association (n=190).

2. **IPM practices**: can be defined as all the chemical and non-chemical practices conducted for pest control in a particular crop. For the purpose of this study, IPM practices were operationally defined as the 54 statements outlined on the "Integrated Pest Management Practices for Apples" instrument (Autio & Bramlage, 1992). Each statement had a weighted score ranging from two to 25 points. Scores on the 54 statements could range from 0 to 1,956. Higher scores indicate a higher level of adoption of IPM technologies.

3. **Attitudes toward IPM**: An attitude is a position of the body or manner of carrying oneself, indicative of a mood or condition. An attitude is a state of mind or feeling with regard to some matter. (Morris, 1976). Attitudes toward IPM were operationally defined as the growers' score on 17 statements describing barriers toward IPM. A higher score indicates a more positive attitude toward IPM.
4. **Level of Adoption**: Level of adoption refers to the relative position or rank on a scale. Adoption is defined as "taking and following a course of action by choice or assent; adopting a new technique" (Morris, 1976 p. 18). According to Brown (1981 p. 6) "the adoption of an innovation is primarily the outcome of a learning or communication process." Rogers, (1983 p. 21) stated that adoption is "a decision to make full use of an innovation as the best course of action."

For the purpose of this study, level of adoption was determined by the mean score on the "Integrated Pest Management Practices for Apples" instrument. Scores (achieveable) ranged from 0-1,956, with higher scores indicating higher levels of adoption.
A review of literature was conducted for the study of the adoptive behavior of Ohio apple growers toward IPM technologies. The review focused on two main concepts:

1. The general process of adoption, especially as related to agricultural technologies.
2. IPM regarding apple pest management.

**Diffusion of Innovations**

Innovation-diffusion is the process through which an individual passes from first knowledge of an innovation to an attitude toward the innovation, to a decision to adopt or reject, to implementation of the new idea, and to confirmation of this decision (Rogers, 1983). Diffusion of innovations is a special type of communication, that deals with new ideas, products, and services. This newness of the message gives diffusion of innovations a special character.

Rogers' definition for diffusion is "the process by which an innovation is communicated through certain channels over time among the members of a social system" (Rogers, 1983, p.5). In spite of the volume of results of empirical research on the
diffusion of innovations (Rogers, 1970), there remains a need for more rigorous theoretical studies due to the ever-changing environment of the societies. The innovation-diffusion process consists of five major stages: a) knowledge, b) persuasion, c) decision, d) implementation, and e) confirmation (Rogers 1983).

- Knowledge is the exposure of an individual to an innovation.
- Persuasion is the favorable or unfavorable attitude toward the innovation.
- Decision is the action which leads to adoption or rejection of the innovation.
- Implementation is putting an innovation into use.
- Confirmation is the action of looking for additional information about the innovation. According to Lionberger (1965), five stages in the adoption process include: a) knowledge, b) interest, c) evaluation, d) trial, and e) adoption.

- Awareness or knowledge is when an individual learns about a new practice or idea.
- Interest is the action of trying to obtain more information regarding the innovation to determine whether or not the innovation is useful and applicable.
Evaluation is the examination of the innovation to determine the existing conditions into which the innovation may be performed.

Under the trial, an individual puts the innovation into practice, but only at the experimental level.

Adoption is the acceptance and full-scale continuous use of the innovation.

Hall, (1974) described seven categories of the innovation-adoption process: a) knowledge, b) acquiring information, c) sharing, d) assessing, e) planning, f) status reporting, and g) performing.

Knowledge is when an individual knows about an innovation regarding two meanings: a) the use of the innovation and b) the consequences of its use.

Acquiring information is the action of seeking more information about the innovation.

Sharing is the innovation's network among the members of a system.

Assessing is the weighing and shifting to acquire evidence of the potential or current use of the innovation or some other aspects of it.

Planning is a deliberate, rational, and continuing sequence of activities to be done during the process of innovation-adoption.
- Status reporting is the description of personal status at the present time related to implementation of the innovation.

- Performing is the action of executing the innovation.

**Adopter Categories - Ideal Types**

Three social scientists worked on categorizing adopters of innovations among a social system. All of them used the time factor required to adopt an innovation. A precise and clear statement is given by Rogers (1983, p. 241) in which he stated that "not all individuals in a social system adopt an innovation at the same time." Similarly, Lionberger (1964, p. 21) stated that "people ordinarily do not accept new ideas or practices immediately upon learning about them." Rogers and Beal (1958) provided the basis for classifying adopters by placing them in five ideal categories: a) innovators, b) early adopters, c) early majority, d) late majority, and e) laggards.

a. Innovators

Innovators are also known as venturesome, and are eager to try new ideas and technologies which lead them out of a local circle of peers to a cosmopolite relationship. Mostly, they are wealthy and have the abilities to understand and apply technical innovations; they are daring and desire hazardous, rash and risky decisions. Innovators are willing to launch new ideas in the social system which has an important role in the diffusion process.
Innovators are few in number ranging from 2% to 3% of the population, with an average of 2.5%.

b. Early Adopters

Early adopters are the next 13.5% of the population who adopt the innovation. As compared with innovators they are localite instead of cosmopolitan, having a greater degree of opinion leadership. As compared with other people of the area, early adopters have larger farms and their higher farm income increases their interest in farming which leads them to focus more on farm management. They have risk capital and are willing to take risks. They tend to be 50 years of age or less. They actively seek new ideas and techniques and have very active social lives. Early adopters use university research sources, agricultural agencies, mass media sources, and commercial and other farmer resources.

Rogers (1983, p. 248) differentiated innovators from early adopters by suggesting that "early adopters are a more integrated part of the local social system than are innovators. Whereas innovators are cosmopolites, early adopters are localities." He further stated that, "this adopter category, more than any other, has the greatest degree of opinion leadership in most social systems." "This adopter category has a very important role in the diffusion-innovation process. According to Rogers, "the role of the early adopters is to decrease uncertainty about a new idea by adopting it, and then conveying a subjective
evaluation of the innovation to near peers by means of interpersonal networks."

c. Early Majority

The next 34% of the population which adopts an innovation is known as early majority or "deliberate." They adopt new ideas a little before adoption by the average member of a social system. They interact with their peers, but rarely are involved in leadership positions. The early majority approach innovations with caution and do not adopt until most others have and almost all of the uncertainty about the innovation has been removed.

d. Late Majority

The next 34% of the population of adopters is called the late majority or "skeptical". They adopt a new technology after an average member of a social system adopts it. Probably they adopt new technologies unwillingly, due to economic necessities or social pressure.

e. Laggards

Laggards or traditional is the last category of people who adopt an innovation. This category consists of 16% of the population. They are the most localite in their outlook of all of the adopter categories. They are isolated from the rest of the social system. Laggards follow the traditional, elderly people of the past. Their adoption "lags" far behind the awareness-knowledge of a new idea. They adopt an innovation with a delay
when it may already have been superseded by another more recent innovation which is being used by the innovator. While most individuals in a social system are looking to the road of change in front, the traditional people fix their attention on the "rear-view mirror."

**Variables Related to Adoptive Behavior**

The major elements in the diffusion process and their relationships with elements in the communication model are: a) the source or origin of the innovation, b) the message that conveys the innovation, c) the channels that are the means by which the innovation spreads, d) the receivers who are members of a social system and potential adopters of the new idea, e) the effects of the diffusion of the innovation that are changes in knowledge, attitude, and overt behavior regarding the innovation, and f) feedback (Vora, cited in Brown, 1981).

The major function of most extension practitioners is to facilitate the adoption of new ideas and practices by their clients. To increase efficiency, proper understanding of the processes and factors involved in the diffusion and adoption of innovations is necessary. One of the features of diffusion is that it occurs over time. Generally there is a considerable time, usually several years, between the introduction of a new idea and its widespread adoption. This time lag can vary a great deal from one innovation to another and for the same innovation in different social systems.
The success of an extension program is often measured by the degree to which this time lag is reduced to increase the rate of adoption. This rate is measured by the number or proportion of potential adopters who have adopted an innovation in a specific period of time. The rate of adoption is influenced by at least five factors (Rogers & Shoemaker, 1971):

1. the type of decision involved in the adoption of the innovation,
2. the perceived attributes of the innovation,
3. the nature of the client system,
4. the nature of the communication channels used, and
5. the extent of the extension practitioners' efforts.

Three groups of variables hinder the adoption of agricultural technologies: external, individual, and structural barriers. External barriers are constraints in the adoption of technologies beyond the control of growers (e.g., governmental programs and weather). Farming is ever-changing like the weather. If the market for a particular crop is good it keeps developing, but falls with the downfall of the market. Competition is an important factor which motivates farmers to adopt new technologies. During the 60s and 70s, market pressure, growth in agricultural technologies and low interest rates, resulted in an increase in agricultural productivity which was suddenly changed in the 80s when interest rates were high.
Farmer's decisions for adoption and non-adoptions are greatly influenced to maximize the short run profits (Rasmussen & Margolis, 1986). Tax policies are important factors influencing the adoption-diffusion process of agricultural technologies. When policies subsidize the conversion of marginal land to agricultural production, the additional acreage accelerates the problem of oversupply. This additional land also accelerates environmental degradation problems, soil fertility, and production (Swanson, Camboni, & Napier, 1986).

Structural barriers are related to enterprise size, gross sales, land tenure system, and hired labor. For example, larger farms have a greater capacity to adopt and can afford the latest techniques while smaller farms are unable to do so (Swanson, Camboni, & Napier, 1986).

Researchers have shown that individual characteristics of farmers have an impact on the adoption of agricultural technologies (Swanson, Camboni, & Napier, 1986). These variables are categorized as sources of information and personal characteristics of landowners. Farm organizations like the Farm Bureau also affect farmer's decisions. Personal characteristics of farmers such as age, education, and experience are significantly related to adoption behavior (Swanson, Camboni, & Napier, 1986). Younger people are more likely to adopt agricultural technologies compared to older people. Younger farmers with greater exposure to information sources and higher levels of education are also
more likely to adopt the latest agricultural technologies. New studies have suggested that farmers having access to information, by developing the psycho-social attitudes to support adoption may not necessarily adopt the latest agricultural technologies.

Napier, Napier, & Tucker, (1991) classified adoption barriers into macro and micro social factors. In macro social factors, population pressure on land resources is important. Poverty among the society and the land tenure system also hinders the adoption of latest technologies. Ever changing national policies have an impact on the adoption innovation-decision making process. In micro social factors, awareness of the problem and its solution through new techniques is the primary focus. Communication or access to information systems also have an impact on the spread of innovations. Environmental values and profitability due to adoption also have their own importance.

Adoption of agricultural technologies is affected by social, economic, and institutional factors in third world countries. In the traditional model of diffusion of innovation, awareness of agricultural practices, potential impacts of the innovation, attributes of the innovation, relevance of the agricultural practices, and institutional barriers are considered important in the adoption process. Traditional adoption models
focus on the following nine points in the diffusion of innovations (Napier, 1991):

1. The potential adopter must perceive that a problem exists which cannot be efficiently resolved using existing behavioral practices.

2. The potential adopter must become aware that an innovation exists which is capable of resolving the perceived problem.

3. The potential adopter must perceive that the innovation is relevant to his/her needs.

4. The potential adopter must believe that the innovation being considered for adoption will produce net benefits for him/her.

5. The potential adopter must have access to the necessary economic resources to adopt the innovation.

6. The potential adopter must have knowledge of how to use the innovation effectively.

7. The characteristics of the innovation must lend themselves to easy adoption and continued use.

8. The potential adopter must perceive that the innovation is consistent with other aspects of the individual's social milieu.

9. The potential adopter must perceive that the risks associated with adopting the innovation are within acceptable limits.
The basic element in the adoption of innovations is the transfer of information. Potential adopters must be aware of the problems and their solutions. There are several ways through which educators can make the awareness more effective. In this era of technology, printed (newspapers, books, magazines) and electronic media (television, radio, microcomputer links) are very efficient for information dissemination among the community. Mass media and personal communication has important impacts in the diffusion of agricultural technologies (Napier, 1991).

Impacts of adoption on the social well-being of the adopter's community is an important factor in the adoption of innovations. When the impacts are perceived as good the search for the technologies increases and in this way communication becomes more effective within a society. If people perceive that the adoption of an innovation threatens their socio-economic well-being, then they will be reluctant to adopt it (Camboni, et al., in Napier, 1991).

Attributes of innovations

Attributes are the relevance of the innovation with the existing problem solution. Potential adopters give consideration to only those innovations which have direct relation to their problems. In this respect, the economic cost of adoption is an important factor. Expensive costs of adoption are considered as less relevant to people with limited economic resources. People
may desire to adopt such innovations, but their resources do not allow them (Napier, 1991).

If the innovation is relevant with existing technologies and does not need high skills to receive the benefits, its adoption rate is high. If more skills are needed for adoption and the adopters do not have the resources to achieve those technical skills, the innovation is considered as less relevant to the people. Rate of change of the innovation also has an impact on adoption. If the rate of disruption is accelerated by the adoption of certain technologies and people cannot accommodate the innovation in their life style, adoption rates are decreased. If there is a chance that the innovation can be incorporated into an existing system with little modifications, adoption rates would be high. Innovations which are perceived as extensively disrupting existing social situations tend to be resisted (Napier, 1991).

In the adoption decision-making process, observation of the innovation used is an important factor. Innovation outcomes can only be measured if the potential adopters have the ability to observe its impacts (Roger, 1983). Complex innovation impacts are difficult to understand through media and personal contacts, but direct observations give real insights into the innovations. The ability for trial increases the probability of an innovation's adoption. If the trial does not cost much, adoption rates are high (Napier, 1991).
Rollins (1993) stated that following five factors affect the adoption of new technologies:

1. The type of decision involved in adoption
2. Perceived attributes of the innovation
3. Communication channels used
4. Nature of the client system
5. Extent of the practitioner's effort

Extension practitioners make the technology easy to understand for their clientele and hence accelerate the rate of adoption.

Adoption Models

One model of adoption is characterized by the farmers' selection of modern technologies by using high yielding varieties along with inputs (i.e., fertilizer, irrigation, and pesticides) and traditional technology. In static individual adoption models, farmers adopt only one modern agricultural technology and decide whether and to what extent to adopt it (Feder, Just, & Zilberman, 1985).

Aggregate adoption models are based on the behavior of the diffusion process among a society over a period of time. Research shows that this adoption model makes an S-shaped pattern of diffusion based on the type of communication. This process can be described accurately by mathematical formulas. Parameters involved are based on the distribution of certain properties, such as risk aversion and wealth distribution, among
the population of decision makers, economic factors concerning the technology, and the environment where the technology is introduced (Feder, Just, & Zilberman, 1985).

The first study of aggregate adoption over time was conducted by Griliches (1957). All the studies conducted on the diffusion of innovations established a notion regarding adoptive behavior over time. Beal and Buhlen (1957) and Rogers (1957), in their separate studies, found the gap between the awareness and experimentation periods is shorter for the early adopters than for followers. Rogers also studied the diffusion of weed spray technologies and in all cases the diffusion process made an S-shaped curve. This curve is affected by several variables, such as communication methods, persons involved in communication, type of technologies, and their relation with the existing technologies.

The technology treadmill model offers another approach to analyzing the innovation-diffusion process in agriculture. The treadmill model relies upon rural sociology studies of adoption of innovation behavior and divides farmers into three categories: early adopters, followers, and laggards. This model was initially developed by Rogers who stated that "farmers face a number of innovations, but adopt only one at a time" (Feder et al., 1985 p. 267).

Studies show that landownership and rental arrangements of farms play an important role in the adoption-diffusion process of agricultural technologies. A land-tenure
model was developed by Bardhan and Rudra in 1979. Analysis showed a number of results, including: "a) the percentage of area under tenancy will increase if a land-augmenting technological change is introduced, b) a larger degree of imperfection in the market for inputs complementary with high yield variety (HYV) cultivation technology leads to a lower percentage of area under tenancy, and c) a higher labor intensity of the crop induces a higher incidence of tenancy" (Feder et al., 1985 p. 268).

Factors Related to Adoption

Researchers have shown that if local varieties of crops are inferior to improved varieties, the rate of adoption is much higher and vice versa. Farm size and land tenure are not considered as serious constraints in the adoption of HYVs. Still, smaller farmers follow the larger farmers in adoption of HYVs. Both farm size and the tenure system have several effects on farm production. Through introducing HYVs, farm production increases significantly, but in the adoption of HYVs, landowners are ahead when compared with tenants. Brown (1976) stated that the diffusion of an innovation is dependent upon the socioeconomic status and the demographic characteristics of the people in a social system. Several factors are involved in the spread of an innovation: soil structures, climatic conditions, availability of improved varieties, pesticides, fertilizers, transportation, credit, labor and machines, extension services, and personalogical variables such as age, economic status, and
educational level of the farmers involved in the extension and/or training process.

Farm Size

One factor considered in adoption-diffusion research is farm size which affects adoption in several ways. Other factors interlinked with farm size are adoption costs, risk preferences, human capital, credit constraints, labor requirements, and tenure arrangement. Weil (1970) indicated that adoption of technologies and farm size are negatively correlated.

Risk and Uncertainty

Yield depends on different techniques and lack of knowledge of appropriate production techniques can negatively affect yields. Differences in weather, pest susceptibility, and uncertainty of timely availability of important inputs can greatly affect the adoption process. Choices of adoption are based on the subjective probabilities of farmers, hence their familiarity with new technology is important (Feder et al., 1985).

Human Capital

Studies on human capital effects on adoption are linked with theory rather than practice. Schultz (1964) demonstrated that "changes in the technological environment increase the value of farmers' entrepreneurial ability." Ability is defined as "the ability to perceive, interpret, and respond to new events in the context of risk."
Educational Level

Ram (1976) found that farm operators' contributions to production are positively related to their education, whereas worker contributions are not. Chaudri (1968) found that "differences in education explain variations in cropping among regions in India but not variations in yields." Sidhu (1976) stated that although farmers' education has some effect on yield, it had relatively greater effect on gross sales by farmers in the early stages of the Green Revolution in the Indian Punjab (Feder et al., 1985). Effects of education on agriculture and adoption can be measured in a number of ways. Huffman (1977 p. 59-80) stated that "use of nitrogen by corn producers in the U.S. shows that farmers with better education adjusted their nitrogen use more than less educated farmers." Extension efforts are shown to substitute for education in the adjustment process. Petzel (1976) showed that education and scale of farm operations in the U.S. accelerate the adjustment of land use in soybean production to changes in output and input prices. Gerhart (1976) found that the likelihood of adoption of hybrid maize in Kenya was positively related to education. Rosenzweig (1978) found that the probability of adoption of high-yield grain in the Punjab was positively related to education and farm size.
Labor Availability

Availability of labor is also an important factor in the adoption process. If HYVs are more laborious, but labor is not available, their adoption is negatively effected. Labor-saving technologies are more easily adopted compared to laborious technologies. Hicks and Johnson (1974) found that higher rural labor supply leads to greater adoption of labor-intensive rice varieties in Taiwan, and Harriss (1972) has found that shortages of family labor explain the non-adoption of HYVs in India. Most researchers agree that operative constraints in African farming systems are the scarcity of labor in peak-season (Feder et al., 1985).

Credit

Capital or farmer's savings are necessary to finance new agricultural technologies. Many researchers suggest that fixed investments hinder small farmers in the adoption of new technologies (Feder et al., 1985). Other researchers state that credit itself does not hinder adoption of new agricultural technologies (Feder et al., 1985). According to Schutjer and Marlin (1977), a number of researchers suggest that the profitability of HYVs motivate even small-scale producers to adopt Von Pischke, (1978). Other researchers found that credit is important in the adoption of HYV technologies. According to Frankel (1971), Wills (1972), and Khan (1975), the majority of small-scale farmers do not adopt HYVs due to a shortage of funds.
Similarly, Scobie and Franklin (1977) stated that lack of credit discourages the adoption of fertilizers and pesticides.

Tenure

Land tenure has been studied by different researchers as having effects on the adoption of HYV technology. Parthasarathy and Prasad (1978) concluded that compared with farm owners, tenants have a lower tendency to adopt HYVs while the usage of fertilizer was the same among tenants and owners. There are confusing results among the different studies on land tenure, likewise there is no clear relationship between tenure and adoption. Vyas (1975) stated that in the adoption of HYVs of wheat in India, tenants were not only innovators like landowners, but also used more fertilizer than owners. Van der Veen (1977) suggested that the effects of tenancy may be due to the correlation between tenure and access to credit, input markets, product markets, and technical information (Feder et al., 1985).

Supply Constraints

The availability of inputs is an important factor in the adoption of HYVs. Improved seed will be adopted if the supply of complementary inputs like fertilizer are available because in many cases HYVs are successful only with such complementary inputs. Clay (1975) and Vyas (1975) suggested that such adoption decisions should consider both factors of complementarity inputs and availability of HYVs (Feder et al., 1985).
Barriers to Adoption

Adoption of new technologies is a complex process based on economic, agronomic, and environmentally sound strategies. Simple technologies, that are easy to understand and are compatible with existing technologies, spread in short periods of time among farmers. If the technology is complex and incompatible with the existing system, the adoption process is time consuming (Nowak, 1982).

Studies show that the higher the differences in the use of existing and latest technology, the stronger negative effects on the adoption of new technologies. With such technologies, the situation of risk is increased and dominates the impact of the innovation. Researchers suggest that variations in existing technologies cannot be ignored in the adoption-innovation process. A study was conducted to assess the adoption of IPM in farms with irrigated and non-irrigated systems. Producers who used dry farming technologies, partially adopted IPM; this study is congruent with that of adoption under high-risk situations (Szmedra, Wetzstein, & McClendon 1987).

If extension educators are interested in changing the behavior of their clients or the ways they react, then they must be familiar with the clients' environment and perceptions of the new technologies. Growers do not always resist change, rather they resist the ways in which the change was presented to them. Still, if farmers are resistant to change, then extension
educators must determine the reasons for resistance. Several factors are involved in non-adoption. The practice might not be compatible with the existing system or the grower's needs, but are important prerequisites to change or to developing a sound rational for non-adoption. Farmers may be willing to accept a new idea, but the resources necessary for change may not be available. In the case of non-adoption, change agencies and agents may mishandle the transfer process. Change institutions may fail to teach the critical steps concerning a new technique, to gain the support of other key people involved in decision making, or fail to facilitate the growers with access to credit and other needed services. Lack of confidence in a new idea or practice could be the result of a lack of confidence in the change agent or agency. Farmers may perceive the uncertainty as greater than the expected benefits (Chaudhry, 1984).

Hooks, Napoier, & Carter (1983), studied the adoption of selected farm technologies by Ohio farmers. The variables chosen for examination were socio-demographic characteristics, attitudes, and economic constraints. Findings indicate that economic constraint factors were the best predictors of adoption levels. In addition, the researchers also found that diffusion models provide some understanding of farm technologies and their utility which ultimately affect their adoption. Three categories of technologies were developed. Drying equipment, spray equipment use, and metal grain storage were designated as
high technology, and herbicide use, early-time operations, wet harvest with mechanical drying, and high number of plants per acre were identified as intermediate technology. Use of fertilizer, use of custom-blended fertilizer, installation of plastic drain tile, and crop rotation were considered low technology. Farmers who adopted high technologies also tended to adopt intermediate technological practices. Farmers who had adopted low technologies were content to adopt low technological practices. High technology adopters, however, were randomly distributed relative to low technology.

Lasely and Bultena (1986), studied the effects of two sets of variables (i.e., farm characteristics and personal characteristics) on the adoption of three types of technology; alternative energy sources, DNA research, and high technology (e.g. robotics, personal computer for farm families, and confinement livestock facilities). Age was negatively associated with the acceptance of alternative energy sources and high technology; younger farmers were found to be more supportive of these technologies than older farmers. Educational level was positively related to high technology innovations, but not related to DNA research and alternative energy sources. Farm characteristics were not related to the adoption of the three types of technology except total acres under farm and gross farm sales, both of these factors were positively related to the adoption of high technology.
Market fluctuations of price or subsidies in agricultural inputs accelerate the adoption of new technologies. The price of an agricultural product has a tremendous impact on the adoption of new technologies. If the price of a product or output is raised or the price of inputs, such as seed and fertilizer is reduced, the chances of adoption of new technologies are increased (Miller & Tolley, 1989).

Olson, Langley, & Heady (1982) estimated the widespread adoption of organic practices in U.S. agriculture. The researchers used a national and inter-regional linear programming model of U.S. agriculture to estimate the effects of three possible farming alternatives. The first two alternatives used conventional farming. Alternative I incorporated export levels based on historical trends in world trade. Alternative II involved export levels that required the use of all available cropland. Alternative III employed organic farming and export levels that required almost all available cropland. Results showed that compared with conventional farming, the widespread adoption of organic farming would increase net farm income on a national level and allow domestic demand for agricultural crops to be satisfied. Consumer food costs would increase, export levels would decrease, and a regional shift in production would occur. Some regions may suffer economically, and the United States would not have enough land to feed the whole world.
Shaw and daCosta (1985) studied the different levels of technology adoption in a major rice growing region of Guyana where traditional local inputs into rice production were being replaced by imported, science-based inputs. The researchers identified the relative importance of factor inputs on output and returns to farms that adhered to traditional rice varieties and methods of cultivation. Output showed a strong response to inputs for three categories of farms: traditional, non-irrigated, and irrigated. Land continues to be an important factor of production in non-irrigated areas, but has declined in relative importance with the adoption of biological and chemical yield-increasing innovations. The provision of an adequate level of water was critical for successful adoption of new strains of rice. At the same time, availability of fertilizer, chemicals, and machinery would improve the likelihood of obtaining the maximum yield potentials.

Nguyen and Anderson (1990) stated that rapid adoption of HYVs are replacing locally adapted cultivars throughout the developing world. Crop varieties adapted to local conditions will spread among farmers, be adopted in short period of time, and also increase per acre yield. Conversely, when varieties are widely adopted but not suitable to local conditions, a reduction in per acre production results. As the degree of control in an environment increases, yields tend to increase abruptly; in
contrast, those environments which are regulated but sub-optimal, slow increases in yields tend to be encountered.

One hypothesis is that learning and accumulation of knowledge plays a key role in the adoption-innovation process. For example, the dissemination of new technologies in agriculture is directly related with time spent on learning. If the speed of knowledge dissemination is accelerated, the technologies will spread in a short period of time. High risks of uncertainties could be reduced through the accumulation of experience and if innovations are adopted by large number of producers in less time (Feder & O'Mara, 1982).

Cost of technology adoption is a major factor in the innovation-diffusion process. A study conducted on the adoption of new irrigation technologies in California showed that use of drip and sprinkler irrigation are more favorable for tree growers. Those farmers who use ground water are adopting the latest irrigation technologies compared to those using surface water. Another factor affecting the adoption of these irrigation technologies is that of location. Farmers' responses in different locations for these technologies were significantly different; water-price can affect the adoption of the technologies (Caswell & Zilberman, 1985).

**Integrated Pest Management**

The human population has always dealt with a variety of harmful insects, weeds, microorganisms, rodents, and several
other organisms called pests. Man appeared on earth approximately seven to four million years ago, but it is unlikely that he had any influence on plants and insects. The real association and friendship of man with plants dates back to only 10,000 years. Most of the first plants cultivated were "multi-purpose" plants that supplied principal nutrients, such as starch and sugar. With the passage of time, the cultivation of plants changed. This change was so great in the United States that the period between 1750 and 1880 became known as the period of the agricultural revolution (Dethier, 1976).

Metcalf and Luckmann (1982) classified pest management in different historical phases, i.e., subsistence phase, exploitation phase, crisis phase, disaster phase, and integrated control phase. The deterioration of environmental quality, which began when man first collected into villages and utilized fire, has existed as a serious problem since the industrial revolution. In the last half of the twentieth century, under the ever-increasing impacts of increasing human population and of industrializing society, environmental contamination of air, water, soil, and food has become a threat to the continued existence of many plant and animal communities of the ecosystem and may ultimately threaten the very survival of the human race (Metcalf, & Luckmann 1982).

Before WWII, farmers either used labor-intensive cultural practices for managing pests, or they accepted loss to pests as an inevitable part of crop production. After WW II, synthetic insecticides were available in the market. The number of registered pesticides in
U.S. rose from 30 in 1936 to more than 900 in 1972 (Beers, Burnner, Willett, & Warner 1993). However insects soon began to develop resistance to insecticides and a new problem arose due to the elimination of the natural enemies of the pests. This adverse effect of the pesticides on the natural enemies led researchers to develop and encourage biological control. Researchers also realized that the chemicals were also having a dangerous effect on the ecology. To overcome these issues, a new approach of insect control emerged. This philosophy was termed as integrated control (Stern, Smith, Bosch, & Hagan, 1959), while its latest counterpart is called "integrated pest management" (IPM) (Huffaker, 1980). This latter concept emphasizes more on the need to understand crop dynamics and its influence on pest numbers. Integrated control allows producers to utilize all suitable techniques and information either to reduce pest populations and maintain them below the economic injury level or to manipulate the populations so that they are prevented from causing such injury (Bosch, Messenger & Gutierrez, 1982).

Integrated control is based on two primary considerations i.e., the degree of ecosystem disruption, and valid economic thresholds for the pest species. A successful IPM program incorporates a variety of compatible tactics such as biological control, cultural control, judicious use of insecticides, and autocidal techniques such as mating disruption of the pests. IPM does not exclude chemical control, but ranks chemicals as the last line of defense against pests. According to Beers, Burnner,
Willett, & Warner (1993), the components of IPM are pest identification, monitoring, degree day models, decision making, and management tactics.

More than 500 insects feed on apple trees worldwide (Slingerl & and Crosby, 1930). In an unsprayed apple orchard in Wisconsin, more than 760 arthropods were reported by Oatman, McMurtry, & Voth (1964). Many were incidental migrants or natural enemies over 100 were phytophagous on apple trees or fruits. Of these, 43 were of economic importance and less than 10 were serious pests. Early studies on integrated apple pests were started in 1943, and indicated that population of several pests of economic importance were decreased with the use of chemicals and a great need was realised to combine the chemical and biological control measures (Pickett, Putman, & LeRoux 1958).

Agriculture is vital for every country's economy. Pesticides and fertilizer application have resulted in an increase in productivity over the past half century. Similarly, their use is growing throughout the world, including the U.S. The use of agricultural chemicals has also resulted in serious environmental, social, and economic costs. Wide use of chemicals resulted in accumulation of pesticides in the environment. The hazardous effects of pesticides were realized in early 70's on wildlife, fish and human health. This work was already begun in some countries. This situation led the council on Environmental Quality in 1972 to an IPM approach (Bottrell, 1979). In the U.S.
much attention is given to the issue of pesticide levels in food and environmental contamination by agricultural chemicals, particularly ground and surface water supplies. The most recent results of the U.S. Environmental Protection Agency's (EPA) National Pesticide Survey indicate that nitrates are the most common contaminants of ground water and are present in 52% to 57% of community and private wells nationwide (Curtis, Mott, & Kuhnle 1991).

Extensive use of agricultural chemicals during the past 30 years, to increase per acre production, has resulted in several externality effects. One of the effects is a decline in the quality of drinking water in major agricultural areas of the U.S. The source of ground water contamination is nitrogen fertilizer and pesticide use in crops (Hallberg, 1987). Shallow ground water is becoming unfit for human consumption and water supplies are exceeding recommended nitrate drinking water standards. Although pesticides are appearing in water, their concentration is not life threatening, yet this contamination is of wide public concern (Hallberg, 1987).

Wide-spread use of agricultural chemicals to reduce specific crop pests results in externality impacts on crops. Environmental hazards, like destruction of wildlife, worker health risks, residues in food and drinking water and various other externalities are well known by researchers and the public. Through chemicals the natural chain of predator-prey is disturbed
and a species of secondary insect can become a serious pest of the same or other crops. Other inputs such as water, new seed varieties, and length of growing season have a two-fold effect on crops. Inputs increase per acre production, but contribute to pest pressure. In this way farmers lose new inputs, as well as increase pest pressure (Harper & Zilberman, 1989).

Decisions of farmers using pesticides over the past few decades have resulted in significant off-site externalities. Pesticides also affect human health through contamination, kill fish, birds, and beneficial insects, and expose workers to hazardous chemicals which may result in cancer and reproductive problems in humans. Another problem of the continuous use of pesticides is that of resistance development in pests. In spite of these problems, pesticides have improved agricultural productivity, therefore an alternative approach to reduce the externalities has been formulated as IPM. IPM reduces pesticide use and has proven more useful than conventional chemical control (Burrows, 1983).

Growing pressure to reduce the toxicological and environmental risks demand that the public and private sectors find new ways of pest control. Agricultural researchers are working to discover alternatives; IPM is one of several remedies to reduce the environmental problem. In addition to biological control, the development of genetically-engineered pest resistant
varieties of crops and plants and their combinations are replacing chemical strategies (Duke, Menn, & Plimmer 1992).

Pest management has passed through several stages during the past 40 years and still faces numerous challenges for the future. Currently, experts are focusing on two major objectives in pest management: the nature, history, and current status of pest management and alternative strategies in pest management for future agriculture. IPM is considered a better alternative in terms of socioeconomic and environmental effects when compared to other pest management strategies. IPM is defined as "a systems approach to reduce pest damage to tolerable levels through a variety of techniques, including predators and parasites, genetically resistant hosts, natural environmental modifications and when necessary and appropriate chemical pesticides." (Bird, 1987).

IPM was first introduced to 1,200 apple producers in New York in 1975. IPM was used to manage a variety of pest complexes found in the state. IPM adopters were younger in age and better educated and had less farm experience than non-adopters. Growers that adopted comprehensive IPM practices used 30% less insecticides, 47% less miticides and 10% less fungicides than growers that did not use IPM practices. Adopters reduced pesticide use by 235 kg. active ingredients per hectare and saved an average of $95.80 per hectare per year without affecting fruit quality (Kovach & Tette, 1988).
IPM adoption is one of several technologies which has received considerable attention in recent years. Different researchers have worked on several aspects of IPM; economic factors are considered a major component effecting the adoption of IPM technologies among farmers. Insect sweep nets and treatment thresholds technologies were widely adopted by farmers due to extension activities in these specific areas. Results from the areas under extension activities were significantly different from the areas having no extension activities, such as field days in terms of insect sweep nets and knowledge of treatment thresholds (Harper, Rister, Majelde, Drees, & Way 1990).

Many entomologists and plant pathologists study the profitability, risk, and demand for inputs of IPM and assess the profitability, yield, and use of pesticides by adopters and non-adopters. Their analysis shows that IPM is a knowledge-based technology with two major components; a) knowledge: consisting of human capital in the form of expertise in entomology, plant pathology, and crop science and b) information: based on sampling to know the pest population and other informative variables. In every case of IPM applied through different agencies, there is a very important role of these two components, because level of application of IPM depends on the method and accuracy of scouting of the pest populations. IPM inputs cannot be measured like other standard inputs, but still an index of IPM use can be
measured. IPM does not always involve less pesticide use and more environmental protection; sometime IPM practices violate these "rules" in specific situations (Hall, & Duncan, 1984).

Favorable beliefs and congruency of the information about an agricultural technology accelerates its adoption. On the other hand, lack of information, uncertainty, and risks involved with the technique hinder its rate of adoption. Three IPM technologies i.e., scouting, using information from pheromone traps to determine insect population trends, and preservation of beneficial insects through using selective pesticides were examined in a study. Adoption was measured as either yes or no on the use of the technology. Variables studied were personal and farm characteristics and their influence on adoption of IPM technologies. Results showed that growers who use pheromone traps had a higher education, were young, acquired information through personal contacts and group meetings, and strongly believed in the benefits of IPM. Growers using selective pesticides for the protection of beneficial insects had high gross farm sales, and were strongly linked with IPM consultants (Thomas, Ladweig, & McIntosh 1990).

The amount of risk associated with pest management technologies plays an important role in adoption. IPM needs to be emphasized as a combination of biological, cultural, and chemical control methods. IPM is considered the best alternative in saving costs of production, environmental protection, and resistance
development in insects. Incomplete information on specific IPM techniques hinders its adoption. For instance, information on IPM practices in soybeans is present throughout USA, but its application varies from place to place due to an uneven presence of IPM programs, technologies, public support, crop value, and environmental variability. Studies show that when risk is considered in pest management, IPM is the best alternative for farmers (Green, Kramer, Norton, & Rajotte 1985).

Like adoption of other technologies in agriculture, IPM techniques are initially adopted very slowly, but adoption increases with time. When the number of farmers who have adopted IPM techniques is greater than those who have not adopted, the rate of adoption will decrease. Farm size is a significant factor in adoption, larger farms are more likely to adopt IPM technologies than small farmers. Yet in some states of the U.S., farm size does not have significant impact on IPM technology adoption (Cornejo, Beach, & Huang, 1992). Unpaid family labor and operator are positive factors showing that quantity and quality of labor affect the adoption decision (Cornejo et al., 1992).

Research was conducted on the relationships between producer characteristics, farm structure, management practices and institutional factors and adoption of IPM practices. Producer characteristics, such as age, education, percent farm income and yield were positively related to the adoption of IPM practices.
IPM education programs may affect the rate of adoption as producers learn about IPM and gain expertise in IPM practices (McNamara, Wetzstein, & Douce, 1991).

**Summary of Literature Review**

The adoption of IPM technologies among apple growers in Ohio is similar to the adoption of other agricultural technologies. Adoption of innovations is a slow process in all fields of science and technology. The adoption process can be accelerated through better communication and by creating a favorable environment with needed inputs. By focusing on existing technologies and making the newest practices more compatible with old ones, adoption levels can be improved. Education of the clients is also an important component in the adoption-diffusion process. If farmers are better educated and have full knowledge and expertise of the technology, adoption levels are high. A deficiency of knowledge and failure in proper handling decreases the adoption rate. Land ownership may increase adoption and availability of labor and credit also accelerate the adoption process.

Reducing the gap between the introduction of an innovation and its adoption is the goal of the transfer agent. In the adoption-diffusion process, there are a number of factors that influence the process, especially economic considerations. If the adoption of a new technology results in a favorable return or is less expensive, its adoption will be rapid.
CHAPTER III
METHODOLOGY

Research Design
The purpose of the study was to describe the adoption of IPM practices by Ohio apple growers. The study was designed to determine the adoption level of apple growers along with certain demographic characteristics, and the relationship between demographic characteristics and level of adoption of IPM practices. The design for the study was descriptive correlational.

Sample Selection
The target population for the study was all Ohio commercial apple growers. The accessible population for the study was 190 apple growers listed in the 1993 Ohio Apple Marketing Directory, available from the executive director of the Ohio Fruit and Vegetable Growers' Association. Selection error was reduced by reviewing the list for duplicate names. After a careful review of the list, 127 apple growers were randomly selected to represent the accessible population. From the remaining 63 apple growers, 20 growers were randomly selected to pilot test the instrument.

To select the sample, the researcher consulted a table of random numbers. Using a random start, the researcher selected the
first three digits from the table until 127 names were chosen to represent the target population of apple growers in Ohio. The location of the sample population is illustrated in Appendix A.

Instrumentation

An instrument developed by the Massachusetts Department of Plant and Soil Sciences (Hollingsworth, Coli, Cooley & Prokopy, 1992) was adapted by the researcher to measure the adoption of IPM technologies for Ohio apple growers. The instrument was divided into three parts. Part I of the instrument focused on specific IPM practices for apples. This part of the instrument had seven sections. Section #1 determined the degree to which improved cultural technologies have been adopted by apple growers in Ohio; this section contained six statements. Section #2 measured knowledge of pesticide application and record keeping with five statements. The monitoring and controlling of insects were measured in section #3 which contained 24 statements. In section #4, the knowledge of apple diseases was measured with 11 statements. Section #5 focused on weed management using three statements. Weather and crop monitoring were included in Section #6 which contained two statements. Section #7 measured the growers' knowledge of different training/educational programs with four statements. The response to each statement was categorized in the following manner: Always (A), if the statement described a technique the grower was always practicing; Very Often (VO), if the statement described a technique the grower
very often practiced in his/her orchard. Sometimes (S), if the statement described a technique that the apple grower sometimes practiced in the orchard. Rarely (R), if the statement described a technique that the grower rarely practiced in his/her orchard; and Never (N), if the statement described a technique that was never practiced by the grower; and Not Applicable, (NA) if the statement did not apply to the grower's operation. Each statement received a weight score from two to 25 points. The weight of the score was recommended by the Massachusetts Department of Plant and Soil Sciences with minor changes by the researcher and panel of experts. The weighted scores were based on the importance of the prescribed technique in IPM. Scores for the 54 statements could range between 0 and 1,956 with higher scores indicating higher levels of adoption of IPM practices.

Part II of the instrument was designed to measure the orchard growers' attitudes toward IPM. This part consisted of 17 statements rated on a six-point Likert scale ranging from Firmly Disagree (FD), to Firmly Agree (FA). The statements were rated from a high of 6 to a low of 1. Scores could range from 17 to 102, with a higher score indicating a more positive attitude toward IPM.

Part III of the instrument gathered demographic information on the apple growers. The apple growers were asked eight questions regarding their age, educational level, years as an apple grower, size of orchard, labor provided by family, and the owner, number of hours worked in orchard per week, gross sales of
the orchard in previous year, and primary source of income. A copy of the research instrument is located in Appendix B.

Validity

The question of validity is concerned with the extent to which an instrument measures what it is supposed to measure.

Content validity of the instrument was established by a panel of experts. The panel consisted of professors specializing in entomology, plant pathology, horticulture, agricultural education, and rural sociology from the Ohio State University. A list of the panel of experts is located in Appendix C. Using input from the panel of experts, the phrasing of some questions in the instrument was modified.

Reliability

The instrument was pilot tested for reliability with those Ohio apple growers not included in the sample. A list of 63 commercial apple growers remained from the accessible population. Twenty apple growers were randomly selected from this group to assist with the pilot testing of the instrument. The instrument was mailed to the 20 apple growers in second week of July, 1994. Eleven growers returned usable instruments for data analysis procedures. The reliability coefficients (Cronbach's alpha) calculated for Part I of the instrument were $r = .89$, and $r = .90$ for Part II.
Data Collection

Data for the study were collected through mail questionnaire. The design and mailing procedures were based on the recommendations of Dillman (1978). All questionnaires were coded to allow for necessary follow-up contact. The instrument, a cover letter, and a stamped, self-addressed return envelope were mailed to the 127 commercial apple growers on September 11, 1994. After a period of three weeks from the first mailing, a second instrument was sent to all non-respondents with a cover letter and self-addressed, stamped envelope. October 10, 1994 was selected as the final date for data collection.

To control nonresponse error, a list of non-respondents was prepared. Ten non-respondents were randomly selected and their demographic characteristics were collected from the Executive Director, Ohio Fruit and Vegetable Growers' Association. These data were compared to corresponding data from the respondents to determine if there were statistically significant differences. This method of comparing respondents to non-respondents is an appropriate method of controlling for non-response error (Miller & Smith, 1983).

Analysis of Data

Descriptive and correlational statistics were used to analyze the data collected using SPSS/PC+ statistical software. General measures of association were described according to
Davis' (1971) conventions (see Table 1). Statistical significance was set a priori at .05.

Objective one consisted of eight variables grouped into three levels of measurement (i.e., nominal, ordinal, and interval). For nominal and ordinal data, percentages and frequencies were used to describe apple growers on educational level and level of gross sales. Interval data were analyzed using means and standard deviations to describe the growers on the variables of age, years as commercial grower, size of orchard, percent labor, number of hours worked, and sources of income.

Table 1

<table>
<thead>
<tr>
<th>Davis' Conventions of Number Magnitude</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>r</strong></td>
</tr>
<tr>
<td>1.00</td>
</tr>
<tr>
<td>0.70 - 0.99</td>
</tr>
<tr>
<td>0.50 - 0.69</td>
</tr>
<tr>
<td>0.30 - 0.49</td>
</tr>
<tr>
<td>0.10 - 0.29</td>
</tr>
<tr>
<td>0.01 - 0.09</td>
</tr>
</tbody>
</table>

Source: J.A. Davis (1971)
Percentages, frequencies, means, and standard deviations were used to determine the level of adoption of IPM practices by Ohio apple growers.

Percentages, frequencies, means, and standard deviations were used to determine the attitude of Ohio apple growers toward IPM technologies.

Pearson's r and Spearman rank correlation coefficients were used to determine the relationships between selected demographic characteristics and grower attitude toward IPM.

Pearson's r and Spearman rank correlation coefficients were used to determine the relationships between selected demographic characteristics, attitudes toward IPM, and level of adoption of IPM practices by Ohio apple growers.
CHAPTER IV
FINDINGS

This chapter provides information pertaining to Ohio apple growers. The findings of the study will be presented according to the objectives of the study under the following sections: a) summary of the data sample, b) a description of the apple growers based upon selected demographic characteristics, c) description of the apple growers' adoption levels, d) description of the apple growers' attitudes toward IPM, e) the relationship between demographic characteristics and grower attitudes toward IPM and, f) the relationships between selected demographic characteristics, attitude toward IPM, and level of adoption of IPM practices by Ohio apple growers.

Data Sample

Data were collected during September and October, 1994. The first mailing was dispatched with a cover letter, a self-addressed stamped envelope and the questionnaire on September 11, 1994. Fifty-six percent of the apple growers returned their questionnaires by the first week. On September 27, 1994, a second copy of the questionnaire, a cover letter, and a self-
addressed stamped envelope were mailed to the nonrespondents. The final date for collecting data was October 10, 1994. Of the 127 orchard growers selected for the study, 91 (72%) returned the questionnaire. Usable data were provided by 85 (67%) apple growers.

The 36 nonrespondents were scattered throughout the state. As shown in Table 2, when compared on four demographic characteristics, no statistically significant differences were found between respondents and nonrespondents. The results of this study can be generalized to the population of apple growers in Ohio.
Table 2

Differences Between Respondents and Nonrespondents on Selected Demographic Characteristics

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>S.D.</th>
<th>t</th>
<th>df</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Respondents (n=84)</td>
<td>56</td>
<td>11.80</td>
<td>-.26</td>
<td>10</td>
</tr>
<tr>
<td>Non-respondents (n=10)</td>
<td>57</td>
<td>13.95</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Years Experience</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Respondents (n=85)</td>
<td>26</td>
<td>14.27</td>
<td>.40</td>
<td>93</td>
</tr>
<tr>
<td>Non-respondents (n=10)</td>
<td>24</td>
<td>9.82</td>
<td></td>
<td></td>
</tr>
<tr>
<td># of Acres</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Respondents (n=81)</td>
<td>47</td>
<td>48.59</td>
<td>.50</td>
<td>17</td>
</tr>
<tr>
<td>Non-respondents (n=10)</td>
<td>10</td>
<td>27.48</td>
<td></td>
<td></td>
</tr>
<tr>
<td>#of Trees</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Respondents (n=81)</td>
<td>5,698</td>
<td>6,960</td>
<td>.97</td>
<td>88</td>
</tr>
<tr>
<td>Non-respondents (n=9)</td>
<td>3,417</td>
<td>3,422</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Description of Apple Growers

Age

A description of apple grower demographic characteristics can be found in Tables 3 to 13. The mean age of the growers was 56 years. Sixty-one percent of the growers were between the ages of 51 and 70. The youngest grower was 32 years old and the oldest grower was 89 years.

Table 3

Age Breakdown of the Apple Growers (n=84)

<table>
<thead>
<tr>
<th>Age (Years)</th>
<th>f</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>31-40</td>
<td>10</td>
<td>11</td>
</tr>
<tr>
<td>41-50</td>
<td>16</td>
<td>19</td>
</tr>
<tr>
<td>51-60</td>
<td>28</td>
<td>34</td>
</tr>
<tr>
<td>61-70</td>
<td>23</td>
<td>27</td>
</tr>
<tr>
<td>71-80</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>81 and over</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>

TOTAL 85 100

X = 56 years
S.D. = 11.80
Min = 32 years
Max = 89 years
Education of Apple Growers

Five academic degree categories were used to capture the highest educational degree of the study participants. Data in Table 4 show that 55% of the apple growers hold either an Associate's or Bachelor's degree.

Table 4
Educational Level of Apple Growers (n=85)

<table>
<thead>
<tr>
<th>Education Level</th>
<th>f</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than High School</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>High School Degree</td>
<td>30</td>
<td>35</td>
</tr>
<tr>
<td>Two-Year Associate's Degree</td>
<td>13</td>
<td>15</td>
</tr>
<tr>
<td>Bachelor's Degree</td>
<td>34</td>
<td>40</td>
</tr>
<tr>
<td>Master's Degree</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Other</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

Total 85 100
Experience of Orchard Growers

As shown in Table 5, 9% of the apple growers have less than 10 years of apple growing experience, while 33% of the growers have 31 or more years of experience. The average experience growing apples was 26 years.

Table 5

<table>
<thead>
<tr>
<th>Experience (years)</th>
<th>f</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 - 10</td>
<td>8</td>
<td>9</td>
</tr>
<tr>
<td>10 - 20</td>
<td>26</td>
<td>31</td>
</tr>
<tr>
<td>21 - 30</td>
<td>28</td>
<td>33</td>
</tr>
<tr>
<td>31 - 40</td>
<td>12</td>
<td>14</td>
</tr>
<tr>
<td>41 - 50</td>
<td>7</td>
<td>8</td>
</tr>
<tr>
<td>51 and over</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

TOTAL 85 100

\[ \bar{X} = 26 \text{ years} \]

S.D. = 1.13

Min. = 1 year

Max. = 89 years
Size of Orchard (Number of Trees)

As shown in Table 6, 55% of the apple growers have between 1,001 and 5,000 trees. Fourteen percent of the apple growers have less than 1,000 trees in their orchards. The average number of trees was 5,628. The smallest orchard had 340 trees and largest had 42,000. Table 6

**Number of Trees (n=82)**

<table>
<thead>
<tr>
<th>Size (No. Trees)</th>
<th>f</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 1,000</td>
<td>12</td>
<td>14</td>
</tr>
<tr>
<td>1,001 - 3,000</td>
<td>25</td>
<td>30</td>
</tr>
<tr>
<td>3,001 - 5,000</td>
<td>20</td>
<td>25</td>
</tr>
<tr>
<td>5,001 - 7,000</td>
<td>8</td>
<td>10</td>
</tr>
<tr>
<td>7,001 - 9,000</td>
<td>5</td>
<td>7</td>
</tr>
<tr>
<td>9,001 and over</td>
<td>12</td>
<td>14</td>
</tr>
</tbody>
</table>

| Total            | 82 | 100 |

\[ \bar{X} = 5,628 \text{ trees} \]
\[ \text{S.D.} = 6,946 \]
\[ \text{Min.} = 340 \text{ trees} \]
\[ \text{Max.} = 42,000 \text{ trees} \]
\[ \text{Mdn.} = 3,900 \]
\[ \text{Mode} = 2,000 \]
Size of Orchard (Number of Acres)

Table 7 indicates that 60% of the apple growers have an orchard from 1 to 40 acres. The smallest orchard is three acres while the largest has 280 acres. The mean number of acres is 46.

Table 7

<table>
<thead>
<tr>
<th>Size (Acres)</th>
<th>f</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 - 20</td>
<td>29</td>
<td>35</td>
</tr>
<tr>
<td>21 - 40</td>
<td>20</td>
<td>25</td>
</tr>
<tr>
<td>41 - 60</td>
<td>10</td>
<td>12</td>
</tr>
<tr>
<td>61 - 80</td>
<td>12</td>
<td>15</td>
</tr>
<tr>
<td>81 - 100</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>101 - and over</td>
<td>7</td>
<td>8</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>82</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>

\[ \bar{X} = 46.86 \text{ acres} \]

S.D. = 48.57

Min. = 3 acres

Max. = 280 acres

Mdn. = 30 acres

Mode = 25 acres
Percentage of Labor Provided by the Operator and Family Members in the Orchard Operation

Table 8 shows that 5% of the growers and their families provide between 1% and 20% of the labor in the orchards, while 47% of the growers provide between 61% and 100% of the labor in their orchards. The average percentage of labor provided by the operator and other family members was 67%.

Table 8

Percentage of Labor Provided by the Operator and Family Members in the Orchard Operation (n=85)

<table>
<thead>
<tr>
<th>% Labor</th>
<th>f</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-20</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>21-40</td>
<td>11</td>
<td>13</td>
</tr>
<tr>
<td>41-60</td>
<td>20</td>
<td>23</td>
</tr>
<tr>
<td>61-80</td>
<td>26</td>
<td>31</td>
</tr>
<tr>
<td>81-100</td>
<td>24</td>
<td>28</td>
</tr>
<tr>
<td>TOTAL</td>
<td>85</td>
<td>100</td>
</tr>
</tbody>
</table>

\[ \bar{X} = 67.13\% \]
\[ \text{S.D.} = 24.58 \]
\[ \text{Min.} = 5\% \]
\[ \text{Max.} = 100\% \]
Involvement of Owner in the Orchard Operation

Table 9 indicates that 75% of the growers work 40 to 90 hours per week in their orchards. Nine percent of the owners spend less than 20 hours per week working in their orchards. The average number of hours worked per week by growers was 44. The minimum number of hours worked by growers was 10 per week with a maximum of 90 hours.

Table 9

Hours Spent per Week in the Orchard by the Owner (n=82)

<table>
<thead>
<tr>
<th>Hours per Week</th>
<th>f</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Up to 19</td>
<td>8</td>
<td>9</td>
</tr>
<tr>
<td>20 - 39</td>
<td>13</td>
<td>16</td>
</tr>
<tr>
<td>40 - 59</td>
<td>42</td>
<td>51</td>
</tr>
<tr>
<td>60 and over</td>
<td>19</td>
<td>24</td>
</tr>
<tr>
<td>TOTAL</td>
<td>82</td>
<td>100</td>
</tr>
</tbody>
</table>

\[
\bar{X} = 44.22 \text{ hours}
\]

\[
\text{S.D.} = 17.12
\]

Min. = 10 hours

Max. = 90 hours
Gross Orchard Sales

As shown in Table 10, 53% of the apple growers had gross sales between $40,000 and $249,999 in 1993. Seven percent of the growers grossed less than $10,000 per year and 5% grossed over $500,000 in 1993.

Table 10

Gross Sales of Apple Growers (n=83)

<table>
<thead>
<tr>
<th>Gross sales (Dollars)</th>
<th>f</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; $10,000</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>$10,000 - $39,999</td>
<td>21</td>
<td>26</td>
</tr>
<tr>
<td>$40,000 - $99,999</td>
<td>16</td>
<td>19</td>
</tr>
<tr>
<td>$100,000 - $249,999</td>
<td>28</td>
<td>34</td>
</tr>
<tr>
<td>$250,000 - $499,999</td>
<td>7</td>
<td>9</td>
</tr>
<tr>
<td>&gt; $500,000</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td>83</td>
<td>100</td>
</tr>
</tbody>
</table>
Sources of Income - Orchard

As shown in Table 11, 15% of the growers in Ohio earn up to 20% of their income from their orchards, while 24% earn between 81% and 100% of their income from their orchards. The average income earned from the orchard operation was 48%.

Table 11
Percent of Income from Orchard (n=85)

<table>
<thead>
<tr>
<th>Orchard Income (Percent)</th>
<th>f</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>12</td>
<td>14</td>
</tr>
<tr>
<td>1 - 20</td>
<td>13</td>
<td>15</td>
</tr>
<tr>
<td>21 - 40</td>
<td>15</td>
<td>19</td>
</tr>
<tr>
<td>41 - 60</td>
<td>16</td>
<td>19</td>
</tr>
<tr>
<td>61 - 80</td>
<td>8</td>
<td>9</td>
</tr>
<tr>
<td>81 - 100</td>
<td>21</td>
<td>24</td>
</tr>
<tr>
<td>TOTAL</td>
<td>85</td>
<td>100</td>
</tr>
</tbody>
</table>

\[ X = 48.01\% \]
\[ \text{S.D.} = 36.03 \]
\[ \text{Min.} = 0\% \]
\[ \text{Max.} = 100\% \]
Sources of Income - Off-Farm

Table 12 indicates that 22% of the Ohio apple growers earn 41% or more of their income from off-farm sources. Sixty percent of the growers do not receive any income from off-farm income. The average percent of income earned off-farm was 20%.

Table 12

<table>
<thead>
<tr>
<th>Percent Income from Off-Farm Sources (n=85)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Off-Farm Income (Percent)</td>
</tr>
<tr>
<td>--------------------------</td>
</tr>
<tr>
<td>0</td>
</tr>
<tr>
<td>1 - 20</td>
</tr>
<tr>
<td>21 - 40</td>
</tr>
<tr>
<td>41 - 60</td>
</tr>
<tr>
<td>61 and over</td>
</tr>
<tr>
<td>TOTAL</td>
</tr>
</tbody>
</table>

$X = 20.45\%$

S.D. = 32.29%

Min. = 0%

Max. = 100%
Sources of Income - Other

Table 13 indicates that 40% of the orchard growers in Ohio do not receive any income from other sources. Approximately one fourth (27%) of the growers receive more than 40% of their income from other sources. The average percent of income received from other sources was 25%.

Table 13
Percent Income from Other Sources (n=85)

<table>
<thead>
<tr>
<th>Other Income (Percent)</th>
<th>f</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 1</td>
<td>34</td>
<td>40</td>
</tr>
<tr>
<td>1 - 20</td>
<td>13</td>
<td>15</td>
</tr>
<tr>
<td>21 - 40</td>
<td>15</td>
<td>18</td>
</tr>
<tr>
<td>41 - 60</td>
<td>10</td>
<td>12</td>
</tr>
<tr>
<td>61 - and over</td>
<td>13</td>
<td>15</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td>85</td>
<td>100</td>
</tr>
</tbody>
</table>

\[ X = 25.52\% \]

\[ S.D. = 30.73 \]

\[ \text{Min.} = 0\% \]

\[ \text{Max.} = 100\% \]
Level of Adoption

The second objective was to determine the level of adoption of IPM practices. Level of adoption was measured with 54 statements under seven domains: nutrient management and cultural practices, pesticide application and records, insect management, disease management, weed management, weather and crop monitoring, and education. Scores could range from 0 to 1,956. The minimum score for the 85 respondents was 243 and a maximum score of 1,505 with a mean of 1,018 and a standard deviation of 331. Table 14 shows the 10 IPM techniques most frequently practiced by Ohio apple growers. These techniques can be characterized as basic orchard management practices, such as calibrating sprayers, pruning, controlling weeds, applying dormant oils, and visual monitoring and sampling for insect levels.

Table 15 illustrates the 10 IPM techniques least practiced by Ohio apple growers. As indicated in the table, six of the 10 techniques less frequently practiced involve a form insect traps.
<table>
<thead>
<tr>
<th>Rank</th>
<th>Practice</th>
<th>f</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.</td>
<td>At least one application of dormant or delayed-dormant oil is applied.</td>
<td>64</td>
<td>75</td>
</tr>
<tr>
<td>3.</td>
<td>Orchard sprayer for insecticides and fungicides is calibrated at the start of the season.</td>
<td>53</td>
<td>62</td>
</tr>
<tr>
<td>4.</td>
<td>Foliage is sampled for mites or mite predators.</td>
<td>52</td>
<td>61</td>
</tr>
<tr>
<td>5.</td>
<td>Herbicide sprayer is calibrated at the start of the season.</td>
<td>50</td>
<td>59</td>
</tr>
<tr>
<td>7.</td>
<td>Prunings are removed or destroyed such that no pruning residue is present after one year.</td>
<td>44</td>
<td>52</td>
</tr>
<tr>
<td>8.</td>
<td>Terminal foliage is monitored for aphids or aphid predators.</td>
<td>44</td>
<td>52</td>
</tr>
<tr>
<td>9.</td>
<td>Trees are pruned so that spray penetration and air circulation are adequate.</td>
<td>42</td>
<td>49</td>
</tr>
<tr>
<td>10.</td>
<td>Leaf-miners are monitored by foliar inspection for first generation mines.</td>
<td>41</td>
<td>48</td>
</tr>
</tbody>
</table>

**Note.** Frequencies and percentages were calculated by the number of growers who indicated they "Always" practiced the technique.
Table 15

<table>
<thead>
<tr>
<th>Rank</th>
<th>Practice</th>
<th>f</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Orchard is surrounded by odor-baited red sphere traps at a rate of 1 trap per 15 ft. in lieu of pesticide application.</td>
<td>55</td>
<td>65</td>
</tr>
<tr>
<td>2.</td>
<td>Summer oil is used as a substitute for other acaricides in suppressing mites after petal fall.</td>
<td>49</td>
<td>58</td>
</tr>
<tr>
<td>3.</td>
<td>Tarnished plant bug adults are monitored by white visual traps.</td>
<td>48</td>
<td>57</td>
</tr>
<tr>
<td>4.</td>
<td>Orchard is monitored with pheromone traps for red-banded or oblique-banded leaf rollers.</td>
<td>40</td>
<td>47</td>
</tr>
<tr>
<td>5.</td>
<td>Leaf wetness is monitored.</td>
<td>35</td>
<td>41</td>
</tr>
<tr>
<td>6.</td>
<td>Apple maggot is monitored by red sphere traps.</td>
<td>34</td>
<td>40</td>
</tr>
<tr>
<td>7.</td>
<td>San Jose scale is monitored by black tape traps or pheromone, where there is a history of problems with these pests.</td>
<td>34</td>
<td>40</td>
</tr>
<tr>
<td>Rank</td>
<td>Practice</td>
<td>f</td>
<td>%</td>
</tr>
<tr>
<td>------</td>
<td>-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>----</td>
<td>----</td>
</tr>
<tr>
<td>8.</td>
<td>Orchard is monitored with pheromone traps for codling moth.</td>
<td>34</td>
<td>40</td>
</tr>
<tr>
<td>9</td>
<td>Experimental block of disease-resistant trees is planted.</td>
<td>33</td>
<td>39</td>
</tr>
<tr>
<td>10</td>
<td>Border spray is used for one or more of the pesticide applications against plum curculio.</td>
<td>32</td>
<td>38</td>
</tr>
</tbody>
</table>

**Note.** Frequencies and percentages were calculated by the number of growers who indicated they "Never" practiced the technique.
Attitudes Toward Adoption

The third objective was to determine the apple growers' attitudes toward IPM. Scores could range from a minimum of 17 to a maximum of 102. The average attitude score was 64, with a standard deviation of 13.54. The minimum score was 33 and the maximum score was 96. Under this objective, in first part of the section, growers' knowledge about IPM was measured by putting different definitions of IPM. Majority of the growers (47%) selected the adoption C.

Relationships Between Grower Characteristics and Attitudes toward IPM

The fourth objective was to determine the relationships between selected demographic characteristics and grower attitudes toward IPM. As shown in Table 16, moderate and low positive relationships were found between grower attitude toward IPM and gross sales of the orchard and number of trees. As the number of trees and gross sales increase, scores on the attitudinal scale also increase.
Table 16

Relationship between Demographic Characteristics and Grower Attitudes toward IPM  (n= 85)

<table>
<thead>
<tr>
<th>Demographic Characteristic</th>
<th>r</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age&lt;sup&gt;a&lt;/sup&gt;</td>
<td>-0.17</td>
</tr>
<tr>
<td>Education Level&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.14</td>
</tr>
<tr>
<td>Years Experience&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.05</td>
</tr>
<tr>
<td>Number of Acres&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.27</td>
</tr>
<tr>
<td>Number of Trees&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.28*</td>
</tr>
<tr>
<td>% Labor by Owner and Family&lt;sup&gt;a&lt;/sup&gt;</td>
<td>-0.21</td>
</tr>
<tr>
<td>Hours Worked per Week&lt;sup&gt;a&lt;/sup&gt;</td>
<td>-0.04</td>
</tr>
<tr>
<td>Gross Sales&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.38*</td>
</tr>
<tr>
<td>Income from Orchard&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.02</td>
</tr>
<tr>
<td>Income Off-Farm&lt;sup&gt;a&lt;/sup&gt;</td>
<td>-0.01</td>
</tr>
<tr>
<td>Other income&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.04</td>
</tr>
</tbody>
</table>

Note:  
<sup>a</sup>Pearson's product moment correlation  
<sup>b</sup>Spearman-Rank correlation  
* p < .01
Relationships Between Grower Characteristics, Attitudes Toward IPM, and Level of Adoption

The fifth objective was to determine the relationships between selected demographic characteristics, attitudes toward IPM practices, and level of adoption of IPM practices by Ohio apple growers. Moderate positive correlations were found between number of acres, gross sales, off-farm income, grower attitude toward IPM and level of adoption of IPM practices. A substantial negative correlation was found between percentage of labor provided by the owner and other family members and level of adoption of IPM practices. Higher levels of IPM adoption are associated with growers who have a higher number of acres, a more positive attitude toward IPM, higher gross sales, higher off-farm income, and lower percentages of labor provided by the owner/family.
Table 17

Relationships Between Demographic Characteristics, Growers Attitudes Toward IPM, and Level of Adoption (n = 85)

<table>
<thead>
<tr>
<th>Demographic Characteristics</th>
<th>r</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age(^a)</td>
<td>-0.34</td>
</tr>
<tr>
<td>Educational Level(^b)</td>
<td>0.14</td>
</tr>
<tr>
<td>Years Experience(^a)</td>
<td>-0.01</td>
</tr>
<tr>
<td>Number of Acres(^a)</td>
<td>0.36 *</td>
</tr>
<tr>
<td>Number of Trees(^a)</td>
<td>0.18</td>
</tr>
<tr>
<td>% Labor by Owner and Family(^a)</td>
<td>-0.51 *</td>
</tr>
<tr>
<td>Hours Worked per Week(^a)</td>
<td>-0.04</td>
</tr>
<tr>
<td>Gross Sales(^b)</td>
<td>0.45 *</td>
</tr>
<tr>
<td>Income from Orchard(^a)</td>
<td>-0.14</td>
</tr>
<tr>
<td>Income Off-Farm(^a)</td>
<td>0.30 *</td>
</tr>
<tr>
<td>Other Income(^a)</td>
<td>0.04</td>
</tr>
<tr>
<td>Grower Attitude toward IPM(^a)</td>
<td>0.42 *</td>
</tr>
</tbody>
</table>

Note: \(^a\)Pearson's product moment correlation
       \(^b\)Spearman-Rank correlation
       * \(p < 0.01\)
Summary of Written Comments

Twenty-six percent of the growers provided written comments regarding their attitudes toward and use of IPM practices. The comments can be summarized as follows:

Many growers are seeking more information and training about the adoption of different IPM practices. Some growers indicated in their comments that they are not familiar with the basics of IPM. One grower stated "I have heard some about it [IPM], but not really seen a lot of hard information on it [IPM]." Another grower displayed a keen interest in complete adoption of IPM practices and said "We had better get started for fullscale IPM operations. Growers need to know what the successful growers are using (chemicals) early in the season to avoid mite problems in the summer. There are growers in Ohio who do not have any mite problems and have not used mite sprays other than dormant oils for several years. What are they doing, that we should be doing? Red mites are my biggest concern and problem in growing red delicious and sometimes other varieties." In similar words, one grower stated "We need more information sources concerning IPM, I would like to use IPM more, but need help."

To know more about the monitoring aids, one of the growers mentioned "Being in a county where we are probably the only commercial growers, I feel distant from good monitoring
Another grower also desired information on handling monitoring equipment saying "I need more training regarding monitoring equipment." One of the apple growers pointed toward the lack of education in IPM for the growers. He stated "there is a lack of teaching education (i.e. classes) or training available for this kind of program [IPM]. You learn by trial and error."

IPM adoption costs a lot of money and takes a high degree of energy. IPM is a complicated process, needs a high capability of understanding and education to handle. These impressions were recorded from the comments of apple growers during this study. One of the grower stated that "I feel that much of the scouting and monitoring practices are good and necessary, but some of the controls are not commercially economical. We use soil samples, not leaf samples for fertilizers." Another grower mentioned that "IPM is in the right direction: it [IPM] will control all problems in the orchard if we have enough scientific studies and cooperation from everyone in the industry."

Growers consider IPM as risky. Farmers are reluctant to adopt IPM practices, probably due to lack of knowledge and unfamiliarity with the handling of IPM equipment. One of the growers stated that "I am not opposed to IPM. I need convincing on the subject. How would I control apple maggot, curculio and leaf minor in a dependable fashion. I have grown up using a sprayer and following the Ohio recommendations on spraying and am reluctant
to try. Something new may be risky. I just had a season in which I had a lot of hail damage. It required a very substantial reduction in price to move my crop. I am otherwise open minded."
CHAPTER V
SUMMARY, DISCUSSION, AND RECOMMENDATIONS

This chapter is presented in the following manner:
a) problem statement, b) purpose and objectives of the study,
c) methodology, d) summary of findings, and d) conclusions and recommendations.

Problem Statement

Diffusion is defined as the process by which an innovation spreads among members of a social system. Rogers defines diffusion as: “the process of spreading a new idea from its source of invention or creation to its ultimate users or adopters” (Rogers, 1983, p. 5). Four crucial elements comprise the diffusion of innovation: a) the innovation, b) which is communicated through certain channels, c) over time, d) among the members of a social system.

An innovation is an idea, practice, or object perceived as new by an individual. "Newness" does not necessarily mean the idea is new in terms of the time-lapse since its initial discovery. Instead, newness of an idea is perceived by the individual. If the idea seems new and different to the individual it is an innovation. Lionberger defines innovation as "an idea or practice which
departs from those general prevailing among an aggregate of people who may be regarded as targets of change with definitions of its use" (Lionberger, 1971).

The adoption and use of improved technology is a central issue in the technology transfer process. The degree to which a recommended new technology has been adopted is critical for successful technology utilization (Rogers, 1983). Utilization of new agricultural technology can be divided into two main areas: the adoption and use of improved technology and the accessibility and availability of physical inputs to the orchard growers (Green, 1986). IPM in apples is a technology which passes through different channels and is diffused among the apple growers.

**Purpose and Research Objectives**

The purpose of this study was to describe the adoptive behavior of Ohio apple growers on selected IPM practices. The following objectives were designed to guide the study:

1. describe Ohio apple growers on the following demographic characteristics: a) age, b) educational level c) years as grower, d) number of acres, e) number of trees, f) level of gross sales, g) percentage of labor performed by grower and family members, h) number of hours worked per week in orchard by the owner, and i) sources of income.

2. determine the level of adoption of IPM practices by Ohio apple growers.

3. determine attitudes toward IPM by Ohio apple growers.
4. determine relationships between demographic characteristics and grower attitudes toward IPM.

5. determine the relationships between selected demographic characteristics, attitudes toward IPM, and level of adoption of IPM practices by Ohio apple growers.

**Methodology**

A descriptive-correlation design was used in the study. The target population was commercial apple growers in Ohio. The accessible population was the list of 190 apple growers included in the 1993 Directory of the Ohio Fruit and Vegetable Growers' Association. Out of the accessible population (N=190), a random sample was drawn (n=127).

The instrument selected for this study was designed by the Massachusetts' Department of Extension (Hollingsworth et al. 1992), and was adopted by the researcher. The instrument consisted of three parts. The first part measured the level of adoption of IPM practices by apple growers and consisted of 54 statements with weighted scores. The second part consisted of 17 statements that measured grower attitudes toward IPM. The third part gathered selected demographic characteristics of Ohio apple growers.

Content validity of the instrument was established by a panel of experts and a field test, while reliability was established by 20 randomly selected apple growers. The instrument was revised on the basis of suggestions of the panel.
of experts. Measures of internal consistency using Cronbach's alpha were calculated at $r=.89$ for Part One and $r=.90$ for Part Two of the instrument.

Data were collected by mail questionnaire. A cover letter, a questionnaire with a self-addressed, stamped envelope were mailed during September, 1994. Two weeks after the initial mailing a second copy of the questionnaire, a cover letter, and a self-addressed, stamped envelope were mailed to nonrespondents. October 10, 1994 was selected as the final date for data collection. Of the 127 apple growers, 85 (67%) returned useable questionnaires. A random sample of nonrespondents was selected and compared with respondents on selected demographic characteristics. No statistically significant differences were found between respondents and nonrespondents.

Descriptive and correlational statistics were used to analyze the data collected using the SPPSS/PC+ computer program. Descriptive statistics of means, standard deviations, frequencies, and percentages were used to describe and summarize demographic characteristics, attitudes toward IPM and level of adoption of IPM practices. Pearson r and Spearman rank correlations were used to describe the strength and the nature of the relationships between demographic characteristics, attitudes toward IPM, and levels of adoption. Relational statistics calculated were tested for statistical significance at
the .05 level. Qualitative data were analyzed and summarized by the researcher.

**Summary of Findings**

Objective 1. Describe apple growers on the following demographic characteristics: a) age, b) educational level c) years as grower, d) number of acres, e) number of trees, f) level of gross sales, g) percentage of labor performed by grower and family members, h) number of hours worked per week in orchard by the owner, and i) sources of income.

The apple grower's mean age was 56 years. Forty percent of the growers had a Bachelor's degree while 35% had a high school degree. The average number of years worked in apple production was 26. Thirty-five percent of the growers had an orchard less than 20 acres, with the mean acreage being 47. Fifty-six percent of the growers had orchards with the number of trees ranging from 1,000 to 5,000; the mean number of trees was 5,628.

The growers and their families were highly involved in the orchard operation. Fifty-nine percent of the growers and their families provided between 61% and 100% of the labor in the orchard operation. The average amount of labor provided by the owners and their families was 67%. The average number of hours worked per week by the owner was 45.

Fifty-three percent of the apple growers had gross sales between $40,000 and $250,000 in 1993. Seven percent of the
growers had gross sales less than $10,000 and 5% had gross sales more than $500,000. The apple growers received an average of 48% of their income from their orchard operation. Sixty percent of the apple growers did not receive any income from off-farm sources. The average amount of income received from off-farm sources was 20%. Forty percent of the Ohio apple growers received income from other sources. The average amount of income received from other sources was 35%.

Objective 2: To determine the level of adoption of IPM practices by Ohio apple growers.

The level of adoption of IPM practices by the apple growers was measured by 54 statements under seven domains. Scores ranged from 243 to 1,505 with a mean score of 1,018. The ten most frequently practiced IPM techniques by apple growers were characterized as basic orchard management practices, such as access to current information on pesticides, calibrating sprayers, pruning, controlling weeds, applying dormant oils, and visual monitoring, and sampling for mites, aphids, and leafminers. The majority of the ten least practiced techniques by Ohio apple growers involved practices using insect traps.

Objective 3: To determine attitudes toward IPM practices by Ohio apple growers.

Attitudes of apple growers toward IPM were measured by 17 statements. Scores could range from 17 to 102, with higher
scores indicating a more positive attitude toward IPM. The average attitude score was 64.

Objective 4: To determine relationships between demographic characteristics and grower attitudes toward IPM.

A low positive relationships was found between grower attitudes toward IPM and number of trees, while a moderate positive relationship was found between growers attitude toward IPM and gross sales. Growers with higher gross sales and a higher number of trees had higher scores on the attitudinal scale.

Objective 5: To determine the relationships between selected demographic characteristics, attitudes toward IPM, and level of adoption of IPM practices by Ohio apple growers.

Moderate positive relationships were found between number of acres, gross sales, off-farm income, grower attitude toward IPM and level of adoption of IPM practices. Percent labor provided by the owner was having a substantial negative relationship with the level of adoption of IPM practices. Growers with higher number of acres, higher gross sales, higher percentages of off-farm income, more positive attitudes toward IPM, and a lower percentage of labor provided by self and family members tended to have higher levels of adoption of IPM practices.
Conclusions/Implications

Conclusions resulting from the study may be generalized to the population of apple growers in Ohio. The following conclusions are based upon the findings of the study:

1. Level of adoption of IPM practices:
   There is a wide gap between the scores on the scale measuring the adoption level of apple growers. This wide range shows that there are growers adopting IPM practices and those who are still at the preliminary stages of adoption. A general look at the data shows that 50% of the recommended practices were adopted by the growers. Apple growers are not adopting IPM practices extensively; some IPM practices are regularly used/applied while other practices are not readily applied.

2. Attitudes toward IPM:
   There is also a big gap between scores on growers' attitudes toward IPM. However, the scores on the attitudinal scale indicate the tendency toward more positive attitudes toward IPM. Data from this study indicate that growers do not demonstrate strong negative attitudes toward IPM; even though adoption levels may not be high, growers appear to have positive attitudes toward IPM.

3. Relationships between attitude and demographics:
Research data indicate that growers with a higher number of trees and higher gross sales have more positive attitudes toward IPM. Higher number of trees and higher gross sales are positively related with attitudes toward IPM practices. Large-scale growers have more positive attitudes toward IPM; small-scale growers appear to have less positive attitudes toward IPM.

4. Relationships between level of adoption, attitudes, and demographics:
The findings from the study also showed that growers with higher gross sales, a higher number of acres, higher percentages of off-farm income, more positive attitudes toward IPM, and a lower percentage of self and family labor had higher levels of adoption. Large-scale growers tend to have higher adoption levels of IPM practices; whereas, small-scale growers tend to have lower adoption levels.

Recommendations
The following recommendations are based upon the findings and conclusions of the study:

1. Attempt to increase adoption levels by additional information that clearly explain how practices can be applied in all types of orchard operations; especially techniques that are less frequently practiced. Extension educators can learn from this study that clear, easy-to-
understand practices have higher adoption rates compared to more complex practices. If Extension educators can make the practices easy to understand, then adoption rates would be higher.

2. Target educational programs toward large and small-scale orchards; identify needs of each group. Growers' needs are different under different situations. If Extension educators are familiar with the techniques and finances required for adoption of IPM practices on the priority basis, and find a solution, this will accelerate the adoption rate. Risk and uncertainties are hindering the adoption rate.

3. Encourage continued and increased use of the most frequently practiced techniques. If Extension educators familiarize the growers who are less adopting, with the results of adoption of the adopters of the same practice, can increase the adoption rate.
Need for Further Study

1. Measure knowledge of IPM practices: If Extension educators know the knowledge level about the particular skills in IPM, they can make a successful plan for further education of the apple growers.

2. Determine why IPM practices are not being applied; identify barriers to adoption of IPM. To overcome the barriers in adoption of IPM practices, growers' knowledge and possible solutions are necessary.

3. Identify the cost and benefits of adopting IPM practices; determine whether IPM is practical from an economic standpoint. To increase the adoption rate of IPM practices, a complete package of their knowledge, cost of adoption and benefits are important. In this way growers could be prepared before-time for the cost.

4. Determine the major pest problems faced by growers and identify ways to incorporate IPM to reduce problems. There are many pests which remain as minor pests of the crops due to the adoption of IPM practices and other natural factors, while some other minor pests become major pests due to the environmental disturbance. A complete survey of the pests and their economic threshold level and strategies for their management should be studied before recommendation of specific IPM practices.
APPENDIX A

LOCATION OF SAMPLE
Note: Location of the Sample
APPENDIX B

INSTRUMENT
INTEGRATED PEST MANAGEMENT PRACTICES FOR APPLE

PART I. IPM PRACTICES

Directions: Please read each statement and circle your response using the following scale:

If the statement describes a technique that you ALWAYS practice in your orchard operation please circle A.

If the statement describes a technique that you VERY OFTEN practice in your orchard please circle VO.

If the statement describes a technique that you SOMETIMES practice in your orchard operation, please circle S.

If the statement describes a technique that you RARELY practice in your orchard operation please circle R.

If the statement DOES NOT apply to your orchard operation, please circle N.

If the statement DOES NOT APPLY to your orchard operation, please circle NA.

A. NUTRIENT MANAGEMENT AND CULTURAL PRACTICES

1.05 Trees are pruned so that spray penetration and air circulation are adequate.
A = Always  R = Rarely  
VO = Very Often  N = Never  
S = Sometimes  NA = Not Applicable

---

2.05 Pruning are removed or destroyed such that no pruning residue is present after one year.

3.10 Summer pruning is done on densely foliated, vigorous trees.

4.10 A complete leaf tissue analysis is performed each year.

5.10 Fertilizer amendments are applied according to previous year's leaf tissue analysis.

6.10 Orchard renovation (4% of the orchard or greater) includes dwarfing rootstocks (M.26 or smaller) in at least 50% of the new plantings.

B. PESTICIDE APPLICATION AND RECORDS

1.10 Orchard sprayer for insecticides and fungicides is calibrated at the start of the season.

2.10 Herbicide sprayer is calibrated at the start of the season.
3.10 Orchard sprayer is recalibrated at mid-season. A VO S R N NA

4.05 Tree-row volume is calculated for each block. A VO S R N NA

5.05 Pesticide applications conform to tree-row volume calculations. A VO S R N NA

C. INSECT MANAGEMENT

a. Monitoring

1.10 Tarnished plant bug adults are monitored by white visual traps. A VO S R N NA

2.20 Fruit is monitored for plum curculio injury. A VO S R N NA

3.10 Foliage is sampled for mites or mite predators. A VO S R N NA

4.20 Apple maggot is monitored by red sphere traps. A VO S R N NA

5.10 Leafminers are monitored by foliar inspection for first generation mines. A VO S R N NA

6.10 Terminal foliage is monitored for aphids or aphid predators. A VO S R N NA
A = Always
VO = Very Often
S = Sometimes
R = Rarely
N = Never
NA = Not Applicable

---

7.10 Foliage is monitored for white apple leafhopper.

8.10 Bark of trunk and limbs are monitored for San Jose scale, woolly apple aphid, or borers, where there is a history of problems with these pests.

9.05 San Jose scale is monitored by black tape traps or pheromone, where there is a history of problems with these pests.

10.05 Orchard is monitored with pheromone traps for codling moth.

11.05 Orchard is monitored with pheromone traps for red-banded or oblique-banded leafrollers.

12.05 Fruit and foliage are monitored for leafroller larvae or fruitworms.

b. Control

1.25 Insecticides are applied when insect pest populations reach threshold levels specified in apple IPM publications.
2.10 At least one application of dormant or delayed-dormant oil is applied.  

3.10 Border spray is used for one or more of the pesticide applications against plum curculio.  

4.10 Biological control, by naturally occurring predators, is used for control of aphids, when conditions permit.  

5.10 Synthetic pyrethroids (i.e., Ambush, Pounce, Asana) are not applied.  

6.10 At least one insecticide or miticide application is made by alternate row spraying.  

7.10 Summer oil is used as a substitute for other acaricides in suppressing mites after petal fall.  

8.20 Orchard is surrounded by odor-baited red sphere traps at a rate of 1 trap per 15 ft in lieu of pesticide application.
<table>
<thead>
<tr>
<th>A</th>
<th>= Always</th>
<th>R</th>
<th>= Rarely</th>
</tr>
</thead>
<tbody>
<tr>
<td>VO</td>
<td>= Very Often</td>
<td>N</td>
<td>= Never</td>
</tr>
<tr>
<td>S</td>
<td>= Sometimes</td>
<td>NA</td>
<td>= Not Applicable</td>
</tr>
</tbody>
</table>

Circle One

9.20 Apple maggot presence is reduced by removing dropped fruit from the orchard within 10 days of dropping.

10.10 Apple maggot presence is reduced by removing dropped fruit from the orchard before end of harvest.

11.15 All abandoned apple trees within 100 yards of the orchard border are removed to prevent codling moth immigration.

D. DISEASE MANAGEMENT

1.10 A fixed-copper fungicide was applied either the previous fall or before bud break.

2.15 First fungicide spray is delayed for an appropriate time according to ascospore development or from previous year's ascospore density or scab incidence.

3.15 Fungicides for scab management are applied only until the end of primary scab season (as defined by ascospore maturity and release) unless visible infections develop.
A  =  Always  
VO  =  Very Often  
S  =  Sometimes  
R  =  Rarely  
N  =  Never  
NA  =  Not Applicable

4.10 Mill’s infection periods are used to guide fungicide application decisions.  
A  VO  S  R  N  NA

5.05 A curative fungicide program is used based on ascospore maturity, tree phenology, and/or environmental information for primary scab management.  
A  VO  S  R  N  NA

6.05 The number of fungicide applications per season is between 2 and 7 per year, depending on conditions.  
A  VO  S  R  N  NA

7.03 Trees are monitored for cedar apple rust, where cedar apple rust is a problem.  
A  VO  S  R  N  NA

8.02 Where cedar apple rust is a problem, red cedar and juniper within 100 yards surrounding the orchard have been removed.  
A  VO  S  R  N  NA

9.02 Litter chopping is practiced to reduce scab residue.  
A  VO  S  R  N  NA

10.03 Chemical treatment is practiced to reduce scab residue.  
A  VO  S  R  N  NA

11.05 Experimental block of disease-resistant trees is planted.  
A  VO  S  R  N  NA
A = Always  
VO = Very Often  
S = Sometimes  
R = Rarely  
N = Never  
NA = Not Applicable  

E. WEED MANAGEMENT

1.10 Herbicides of the same class are not used in successive years.  

2.05 Nonchemical weed management techniques (e.g., mowing, mulches) are used.  

3.05 Spot treatment of noxious weeds (e.g., poison ivy, bindweed) is used.  

F. WEATHER AND CROP MONITORING

1.07 High and low daily temperatures (modified hygrothermograph or equivalent) are monitored.  

2.07 Leaf wetness is monitored.  

G. EDUCATION

1.05 One or more OSU Extension educational programs (such as sessions at Grower's congress, summer fruit tour, or regional fruit meetings) are attended during the current year.
<table>
<thead>
<tr>
<th></th>
<th>Always</th>
<th>Rarely</th>
<th>Very Often</th>
<th>Never</th>
<th>Sometimes</th>
<th>Not Applicable</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>A VO S R N NA</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>V</td>
<td>Grower possesses current Ohio Commercial Tree Fruit Spray Guide.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>O</td>
<td>3.03 Grower possesses current Midwest Tree Fruit Handbook.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>V</td>
<td>4.05 Grower subscribes to the &quot;Ohio ICM (Integrated Crop Management) Newsletter.&quot;</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
PART II  IPM UNDERSTANDING AND BARRIER

1. Which definition best describes your understanding of Integrated Pest Management (IPM)? (please check one)
   a. An ecologically-based pest control strategy that relies heavily on natural mortality factors, such as weather and enemies.
   b. A system of varying control strategies which seeks to eliminate the use of chemical insecticides.
   c. A system of pest control encompassing a variety of techniques and methods that are both environmentally sound and compatible with the farmer's existing practices.
   d. A program designed to reduce pest infestations to an economically tolerable level in an ecologically acceptable way.

Directions: Please read each statement and RESPOND TO EVERY ITEM. Draw a circle around the letter which represents your own reaction to the item. The letters in this part of the questionnaire represent the following statements:

If you FIRMLY DISAGREE with the statement, circle FD.
If you DISAGREE with the statement, circle D.
If you SLIGHTLY DISAGREE with the statement, circle SD.
If you SLIGHTLY AGREE with the statement, circle SA.
If you AGREE with the statement, circle A.
If you FIRMLY AGREE with the statement, circle FA.

Circle One
IPM practices require too much time.  FD  D  SD  SA  A  FA
FD = Firmly Disagree  SA = Slightly Agree
D = Disagree  A = Agree
SD = Slightly Disagree  FA = Firmly Agree

Circle One

I do not have enough information about IPM practices.

I do not have access to the equipment needed to implement IPM practices.

IPM practices require too much record keeping.

Obtaining information about IPM practices is too costly.

IPM practices are too complicated to implement.

IPM practices are not cost effective.

IPM practices are labor-intensive.

IPM practices require a long-term investment.

Technical assistance regarding IPM practices is readily available.
FD = Firmly Disagree  
D = Disagree  
SD = Slightly Disagree  
SA = Slightly Agree  
A = Agree  
FA = Firmly Agree

---

IPM practices require high-level managerial skills.

Information regarding IPM practices is confusing and conflicting.

Current information regarding IPM practices is not relevant to my orchard operation.

Implementing IPM practices in my orchard operation would be easy.

Implementing IPM practices is not practical in my physical setting.

IPM practices are too risky to implement.

Chemicals are the best method of controlling pests in my orchard operation.
PART III.

A. Demographic Information

1. In what year were you born?

________________

2. What is your highest level of education? (Please check highest level)

___________ Less than high school
___________ High School Degree
___________ Two-year Associate's Degree
___________ Bachelor's Degree
___________ Master's Degree
___________ Doctoral Degree
___________ Other, please specify________________________

3. How many years have you grown apples for commercial use?

________________ years

4. a. How many apple trees do you currently have in commercial production?

___________Number of Trees

b. How many total acres do you own?

___________Acres
5. What percent of the labor used in your orchard operation is provided by yourself and other family members?

__________________ percent

6. On the average, how many hours per week do you work in your orchard operation?

__________________ hours

7. What were the gross sales, from your orchard operation in 1993? (Circle the appropriate range)

   a. Less than $10,000
   b. $10,000 -- $39,999
   c. $40,000 -- $99,999
   d. $100,000 -- $249,999
   e. $250,000 -- $499,999
   f. $500,000 or more

8. What percent of your total family income for 1993 was derived from:

   a. Orchard operation __________ percent
   b. Off-farm employment __________ percent
   c. Other non-farm income __________ percent

   TOTAL 100 percent
9. Please provide any comments and/or concerns you have regarding the adoption of integrated pest management technologies by Ohio apple growers.

Thank you for your assistance!
APPENDIX C

PANEL OF EXPERTS
PANEL OF EXPERTS

Dr. Janet L. Henderson
Associate Professor
2120 Fyffe Road
Agricultural Education
The Ohio State University
204 Agricultural Administration Building
Columbus, Ohio 43210

Dr. Celeste Welty
Assistant Professor, OSUE-Entomology
Assistant Professor, OARDC
Assistant Professor Entomology
1991 Kenny Rd #111
The Ohio State University
Columbus, Ohio 43210

Dr. Richard W. Hall
Associate Professor, Entomology
Associate Dean, Biological Science Administration
Associate Professor, OARDC
103 B & Z 1735 Neil Ave
Department of Entomology
The Ohio State University
Columbus, Ohio 43210

Dr. Linda M. Lobao
Associate Professor, Rural Sociology
Associate Professor OARDC
Ag Adm 2120 Fyffe Road
The Ohio State University
Columbus, Ohio 43210
Mr. Mike Pullins, Executive Director
Ohio Fruit & Vegetable Growers Association
Two Nationwide Plaza, P.O. Box 479
Columbus, Ohio 43216.

Dr. Michael A. Ellis
Professor, OARDC
Professor, OSUE-Plant Pathology
Professor Plant Pathology
224 Selby OARDC-Wooster
Wooster, Ohio 44691.

Dr. Diane D. Miller
Associate Professor, Horticulture
Associate Professor, OARDC
216 Gourley OARDC-Wooster
Wooster, Ohio 44691.
APPENDIX D

CORRESPONDENCE
September 10, 1994

Howard R. Adae Jr.
A and M Farm
22141 StR1251
Midland, OH 45148

Dear Mr. Adae,

The past few years have brought many changes to apple growers, particularly in the field of Integrated Pest Management (IPM). Little information is available about how growers have adjusted to these changes. We are conducting a state-wide study on adoption of IPM technologies among Ohio apple growers. Selected growers are being asked to complete a questionnaire regarding certain IPM practices.

You have been randomly selected from a list of Ohio apple growers to participate in the study; your input is very important. The information you provide will be used by researchers, the Ohio Fruit Growers’ Society, Extension specialists, and other professionals who deliver services and programs to Ohio apple growers. Your responses will be kept in strict confidence.

Please complete and return the enclosed questionnaire in the self-addressed stamped envelope by **Friday, September 23, 1994**. We sincerely hope you will participate in the study. If you have any questions, please call (614) 292-0450. Thank you very much for your assistance and cooperation.

Sincerely,

Ashraf Qureshi,  
Graduate Student  
Department of Agricultural Education

Dr. Janet L. Henderson  
Associate Professor  
Department of Agricultural Education

Dr. Celeste Welty  
Assistant Professor  
Department of Agricultural Entomology
September 28, 1994

Jeff Brunsman
Brunsman Fruit Farm
5729 North River Rd
Geneva, OH 44041-4041

Dear Mr. Brunsman,

We are studying the adoption of IPM technologies among Ohio apple growers. On September 1, 1994 we sent you a questionnaire with a self-addressed, stamped return envelope. To complete this study, we need your response. We would appreciate your reply as soon as possible. We have enclosed another questionnaire with a self-addressed, stamped return envelope. Please return your completed questionnaire by Monday, October 10, 1994. If you have already completed and returned your questionnaire, please disregard this letter. Please call (614) 292-0450, if you have any questions. Thank you so much for your assistance with our study.

Sincerely,

Ashraf Qureshi,  
Graduate Student  
Department of Agricultural Education

Dr. Janet L. Henderson  
Associate Professor  
Department of Agricultural Education

Dr. Celeste Welty,  
Assistant Professor  
Department of Entomology
APPENDIX E

GROWERS COMMENTS
Chemical prices are ridiculously high.

When better pest management can be demonstrated - not sold as a "pie in the sky" cure all like "IPM and "organic" - it will be adopted. Until then you will get the B.S. response you requested for this IPM report. The public needs to know the truth - not be mistakenly led into blind alleys. When we can have a better program, it will be adopted, not shaved down our throats. Would you really go to a doctor with your sick child and ask for an IPM type of treatment? "Integrated" is just a buzz word. Pest management is what required. We do all the things you mention. Call them what ever you want to. The fact is when you produce lousy fruit your business will fail.

I cannot speak for other growers. We are trying and have cut down on chemical control. We no longer have to spray for red mite or green and black aphids.

Main concerns are cost of traps and time involved in installing, monitoring and application of such things as ties/tapes to disrupt mating.

I have heard some about it but not really seen a lot of hard information on it.
We had better get started for full scale IPM operation. Growers need to know what the successful growers are using (chemicals) in early season to avoid mite problems in the summer. There are growers in Ohio who do not have any mite problems have not used mite sprays other than dormant aids for several years. what are they doing. That we should be doing? red mites are my biggest concern and problem in growing red delicious and sometimes other varieties.

We need more information sources of information, concerning IPM- would like to use PM more but need help.

Being in a county where we are probably the only commercial growers I feel distant from good monitoring aids. How do we get our hands on these traps for monitoring.

Agricultural educational department gentleman, please forgive me for loosing the first questionnaire. We never knew what a fruit mite was until we used DDT then we had mite until we started (IPM) which did away with mite the only time we had mite on peaches. When we used it, of course we stopped it as far fungicide,, we find one of our best scale contrast is ch. 2-4 bard I feel the calcium in it. the lime helps to control cark spot also your respectfully, God bless all of you
I have been raising apples for 62 years. Never had cedar rust, 20 year for scab infection, nor leaf roller, codling moth, apple maggot, scale, plum curculio, leaf miners, and woolly aphids. Why IPM, my crop runs 99.5% clean.

We are trying to implement IPM - not much success.

1993 was a drought year, hence small apples and reduced income. My sprayer is a low volume air blast; spraying is by A.I. per A. Selling is mostly to grocery stores. Apples must be 100% clean of scab and damage. I am leery at this time to rely too heavily on IPM, but strongly feel it should be adopted if possible. sorry, the last copy you sent me got misplaced and simply couldn't find it even after repeated searching.

Would need more training and monitoring equipment

Very hard time to ask fruit growers to respond. Need to have more consideration and appreciation of the busy times for fruit growers if one is trying to understand this industry and be helpful to it.
In our area, the implementation of an IPM program through OSU extension has been very helpful in pursuing individual problems to my new way of doing pest control.

There is a lack of teaching education (i.e. classes) or training available for this kind of program. You learn by trial and error.

I am not opposed to IPM. I need convincing on the subject. How would I control apple maggot, curculio and tuntifrom leaf minor in a dependable fashion. I have grown up using a sprayer and following the Ohio recommendations on spraying and am reluctant to try. Something new and may be risky. My questioner are very particular. I just had a season "1993", in which I had a lot of hail damage. It required a very substantial reduction in price to move my crop. I am otherwise open minded.

IPM is in the right direction: it will control all problems in the orchard if we have enough scientific studies and cooperation from everyone in the industry.

I feel that much of the scouting and monitoring practices are god and necessary, but some of the controls are not commercially economical, we also use soil samples and not leaf samples for fertilizers.
162

I think it is only normal progress for the Ohio fruit industry in today's agriculture. Next time don't send out this type of questionnaire during the busy harvest season.

163

Red mite: If we left trees unsprayed cannot find predators. What is point of IPM now?

185

I think IPM is very good but, need a lot more information and education on scouting and trapping. I never heard of ICM news letter, I would like to receive it where do I subscribe.
APPENDIX F

THIRTY-FOUR INTERMEDIATE PRACTICES
Thirty Four Techniques (of intermediate frequency) Practiced by Ohio Apple Growers (n= 85)

<table>
<thead>
<tr>
<th>Rank</th>
<th>Practice</th>
<th>f</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>11.</td>
<td>Nonchemical weed management techniques (e.g., mowing, mulches) are used.</td>
<td>41</td>
<td>48</td>
</tr>
<tr>
<td>12.</td>
<td>One or more OSU Extension educational programs (such as sessions at Grower's congress, summer fruit tour, or regional fruit meetings) are attended during the current year.</td>
<td>39</td>
<td>46</td>
</tr>
<tr>
<td>13.</td>
<td>The number of fungicide applications per season is between 2 and 7 per year, depending on conditions.</td>
<td>38</td>
<td>45</td>
</tr>
<tr>
<td>14.</td>
<td>Foliage is monitored for white apple leafhopper.</td>
<td>37</td>
<td>46</td>
</tr>
<tr>
<td>15.</td>
<td>Grower subscribes to the &quot;Ohio ICM (Integrated Crop Management) Newsletter.&quot;</td>
<td>36</td>
<td>42</td>
</tr>
<tr>
<td>16.</td>
<td>Fruit and foliage are monitored for leafroller larvae or fruitworms.</td>
<td>30</td>
<td>35</td>
</tr>
</tbody>
</table>
17. Insecticides are applied when insect pest populations reach threshold levels specified in apple IPM publications.

18. Orchard renovation (4% of the orchard or greater) includes dwarfing rootstocks (M.26 or smaller) in at least 50% of the new plantings.

19. Litter chopping is practiced to reduce scab residue.

20. Chemical treatment is practiced to reduce scab residue.

21. All abandoned apple trees within 100 yards of the orchard border are removed to prevent codling moth immigration.

22. A fixed-copper fungicide was applied either the previous fall or before bud break.

23. Pesticide applications conform to tree-row volume calculations.

24. Apple maggot presence is reduced by removing dropped fruit from the orchard before end of harvest.

<table>
<thead>
<tr>
<th>Rank</th>
<th>Practice</th>
<th>f</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>17</td>
<td>Insecticides are applied when insect pest populations reach threshold levels specified in apple IPM publications.</td>
<td>29</td>
<td>34</td>
</tr>
<tr>
<td>18</td>
<td>Orchard renovation (4% of the orchard or greater) includes dwarfing rootstocks (M.26 or smaller) in at least 50% of the new plantings.</td>
<td>28</td>
<td>33</td>
</tr>
<tr>
<td>19</td>
<td>Litter chopping is practiced to reduce scab residue.</td>
<td>27</td>
<td>32</td>
</tr>
<tr>
<td>20</td>
<td>Chemical treatment is practiced to reduce scab residue.</td>
<td>26</td>
<td>31</td>
</tr>
<tr>
<td>21</td>
<td>All abandoned apple trees within 100 yards of the orchard border are removed to prevent codling moth immigration.</td>
<td>26</td>
<td>31</td>
</tr>
<tr>
<td>22</td>
<td>A fixed-copper fungicide was applied either the previous fall or before bud break.</td>
<td>26</td>
<td>31</td>
</tr>
<tr>
<td>23</td>
<td>Pesticide applications conform to tree-row volume calculations.</td>
<td>25</td>
<td>29</td>
</tr>
<tr>
<td>24</td>
<td>Apple maggot presence is reduced by removing dropped fruit from the orchard before end of harvest.</td>
<td>24</td>
<td>28</td>
</tr>
</tbody>
</table>
25. Orchard sprayer is recalibrated at mid-season.

26. Fruit is monitored for plum curculio injury.

27. High and low daily temperatures (modified hygrothermograph or equivalent) are monitored.

28. Tree-row volume is calculated for each block.

29. A curative fungicide program is used based on ascospore maturity, tree phenology, and/or environmental information for primary scab management.

30. Spot treatment of noxious weeds (e.g., poison ivy, bindweed) is used.

31. Bark of trunk and limbs are monitored for San Jose scale, woolly apple aphid, or borers, where there is a history of problems with these pests.

32. Trees are monitored for cedar apple rust, where cedar apple rust is a problem.
<table>
<thead>
<tr>
<th>Rank</th>
<th>Practice</th>
<th>f</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>33.</td>
<td>Herbicides of the same class are not used in successive years.</td>
<td>19</td>
<td>22</td>
</tr>
<tr>
<td>34.</td>
<td>Mill's infection periods are used to guide fungicide application decisions.</td>
<td>18</td>
<td>21</td>
</tr>
<tr>
<td>35.</td>
<td>Synthetic pyrethroids (i.e., <em>Ambush</em>, <em>Pounce</em>, <em>Asana</em>) are not applied.</td>
<td>18</td>
<td>21</td>
</tr>
<tr>
<td>36.</td>
<td>Apple maggot presence is reduced by removing dropped fruit from the orchard within 10 days of dropping.</td>
<td>16</td>
<td>19</td>
</tr>
<tr>
<td>37.</td>
<td>Fungicides for scab management are applied only until the end of primary scab season (as defined by ascospore maturity and release) unless visible infections develop.</td>
<td>16</td>
<td>19</td>
</tr>
<tr>
<td>38.</td>
<td>Fertilizer amendments are applied according to previous year's leaf tissue analysis.</td>
<td>15</td>
<td>18</td>
</tr>
<tr>
<td>39.</td>
<td>At least one insecticide or miticide application is made by alternate row spraying.</td>
<td>15</td>
<td>18</td>
</tr>
<tr>
<td>40.</td>
<td>Biological control, by naturally occurring predators, is used for control of aphids, when conditions permit.</td>
<td>14</td>
<td>17</td>
</tr>
<tr>
<td>Rank</td>
<td>Practice</td>
<td>f</td>
<td>%</td>
</tr>
<tr>
<td>------</td>
<td>--------------------------------------------------------------------------</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>41.</td>
<td>First fungicide spray is delayed for an appropriate time according to ascospore development or from previous year's ascospore density or scab incidence</td>
<td>14</td>
<td>17</td>
</tr>
<tr>
<td>42.</td>
<td>Where cedar apple rust is a problem, red cedar and juniper within 100 yards surrounding the orchard have been removed.</td>
<td>14</td>
<td>17</td>
</tr>
<tr>
<td>43.</td>
<td>A complete leaf tissue analysis is performed each year.</td>
<td>13</td>
<td>15</td>
</tr>
<tr>
<td>44.</td>
<td>Summer pruning is done on densely foliated, vigorous trees.</td>
<td>9</td>
<td>11</td>
</tr>
</tbody>
</table>


