AN ABSTRACT OF THE THESIS OF

Robert W. Doerner for the degree of Master of Science in Agricultural Education presented on May 5, 1992.

Title: The Effect of Inservicing Teachers on Student Achievement in Integrated Pest Management

Redacted for Privacy

Abstract approved

Herschel P. Weeks

The primary purpose of this study was to determine if inservicing Agriculture Science and Technology (AST) teachers over a new curriculum, resulted in increased student achievement. Specific objectives were to: 1) determine the subject areas (lessons) for a curriculum for teaching Integrated Pest Management (IPM); 2) develop a curriculum for an introductory course on IPM from the determined subject areas; and 3) compare student's achievement scores to determine the effect of inservicing teachers on student achievement.

The research instrument used in this study was an Integrated Pest Management curriculum developed by the researcher based on objectives determined from the literature, texts, and other sources of technical information pertaining to IPM. The curriculum was validated by a panel of experts in the fields of IPM and secondary education.

The population for this study consisted of 20 Oregon AST

teachers who were identified by a panel of five experts as the innovators and early adopters among their peers. These innovators and early adopters represented a distinct population of individuals within the general population of AST teachers in Oregon. The students of the 20 teachers provided the sample data for the study. The 20 teachers in the study were randomly divided into two groups. The experimental group received one hour inservice instruction over the IPM curriculum at their schools, and consultation via telephone during the 3 to 4 week period when the curriculum was taught to their students. The teachers in the control group only received the IPM curriculum in the mail. They were not inserviced, and they did not receive consultation via telephone regarding use of the curriculum.

The students in both groups were examined over the material with an exam developed by the researcher and the student's mean test scores from the two groups were compared. The null hypothesis that no difference existed between the student's mean test scores was rejected at alpha = 0.01. The results indicated a highly significant difference between the student's mean test scores. The alternate hypothesis that the student's mean test score was higher in the teacher experimental group (those who were inserviced) than the teacher control group (those not inserviced) was retained.

The conclusion drawn from this research is that inservicing Oregon Agriculture Science and Technology teachers over new curricula increases student achievement.

THE EFFECT OF INSERVICING TEACHERS ON STUDENT ACHIEVEMENT IN INTEGRATED PEST MANAGEMENT

by

Robert W. Doerner

A THESIS

submitted to

Oregon State University

in partial fulfillment of

the requirements for the

degree of

Master of Science

Completed May 5, 1992

Commencement June 1992

APPROVED:

Redacted for Privacy

Assistant Professor of Agricultural Education and General Agriculture in charge of major

Redacted for Privacy

Head of department of Agricultural Education and General Agriculture

Redacted for Privacy

Dean of Graduate School

Date thesis is presented May 5, 1992

Typed by Robert W. Doerner

ACKNOWLEDGEMENTS

Several individuals deserve recognition for their support in this study. First of all I wish to express my sincere gratitude to Dr. Herschel Weeks, who served as my major professor. His leadership and sense of humor were instrumental in guiding this research to its completion. I also wish to thank Dr. Lee Cole, Dr. Ralph Berry, and Dr. Les Fuchigami for their advise and assistance as members of my graduate committee.

I would like to thank Mr. Joe Clokey of San Luis Video Publishing Company for generously allowing me to make copies of their IPM videos for use in this study. Appreciation is extended to the following: Dr. Glen Fisher, Dr. Ken Johnson, Dr. Herb Hansen, Mr. Myron Shenk, Mr. Jeff Mitchell, Mr. John Jeans, and Mr. Gordon Galbraith, who served as panel members in this study. Many thanks to the Agriculture Science and Technology teachers who participated in this study.

I am deeply grateful to Dr. Kim Hummer, my employer who generously provided both financial support and time away from work allowing me to attend classes and complete my studies.

Finally, I wish to thank my wife Kathleen, for her constant love and encouragement and for the many sacrifices she made so that I could complete this degree.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

THE EFFECT OF INSERVICING TEACHERS ON STUDENT ACHIEVEMENT IN INTEGRATED PEST MANAGEMENT

CHAPTER I

INTRODUCTION

The development of professional skills is a lifelong process. For teachers the formal process begins during their preservice training. In Oregon, this involves completing a baccalaureate program and an internship of student teaching. While the pre-service training is essential, it is merely an introduction to the teaching profession. "Only entry skills and knowledge can be developed in the time allotted preservice training, the competent teacher is developed over time and in the crucible of experience" (Schmid and McAdams, 1985).

If teachers are to understand and teach new and increasingly complex curriculum materials, they must build upon their pre-service training. Fischer (1971) warns that "the moment a teacher leaves professional school, he is enroute to a state of obsolescence".

Inservice teacher education (ITE) is that portion of a teacher's education following their initial certification and employment. Since learning is a lifetime process, teachers are lifetime students. For the majority of teachers, ITE can help provide the knowledge and skills necessary to avoid becoming obsolete. Inservice education can help teachers build on their preservice education so that they can further develop their professional knowledge and skills and become more effective teachers.

Teachers have received much criticism for being mediocre and incompetent (Kramer and Betz, 1987). There is extreme dissatisfaction with student achievement (Dillon, 1976). Charges of "educational malpractice" have been leveled against teachers (Ryan, 1987). There is a clear message being sounded throughout this land. From elementary schools all the way to the White House, the message is "the education of America's youth must be improved"! This message is so resounding, that even our president has labeled himself "the education president".

An important goal of ITE is the improvement of teaching. Although ITE is not a panacea for all weaknesses in the education system, it recognizes that "teachers" are the key to improving instruction, and that behind every improved curriculum, is this vital human element (NEA, 1966). Teachers have more influence on student learning than any other factor associated with learning. Barrett and Walla (1987) stated that: "By changing nothing but the ability of the teacher to teach, we can bring about a more dramatic change in the success of a child in learning than through the manipulation of any other factor in his or her environment". Eisner (1985), emphasizes the importance of ITE in preparing teachers for new curriculum with an analogy between potentially educational curricula and a musical score:

> In the last analysis, it is what teachers do in classrooms and what students experience that define the educational process...[Curriculum] materials, like a brilliantly composed musical score, need skillful and sensitive interpretation and a group of people who can interact meaningfully with what has been created. If any of these components is missing, the process fails. If the score is poor, it will be poorly received. If the audience is ill-prepared to deal with it, it will fall on deaf ears...And the fit between the teacher's "score" and the students remains as critical in the classroom as it is in the concert hall--probably even more so.

Agricultural education is "the scientific study of the principles and methods of teaching and learning as they pertain to agriculture" (Barrick, 1988). Most university agricultural education departments in the U.S. resulted from the Smith-Hughes Act of 1917, for the purpose of training teachers (Williams, 1990). According to Hillison (1987), "teacher education was a major point of emphasis in the Smith-Hughes Act, it encouraged the full professional development of agriculture teachers".

The rapidly changing technologies in agriculture today make ITE more important than ever. Agriculture Science and Technology teachers need to receive inservice training when new and specialized subject matter is introduced. If teachers are expected to maintain or improve the quality of their instruction, they need additional training as new information and technologies are developed. ITE can play a major role in the process of educational change by promoting the professional growth and development of teachers (NEA, 1966; Goodlad and Klein, 1974; Fullen and Pomfret, 1977; Lieberman and Miller, 1979; Swenson, 1981; Kramer and Betz, 1987).

Romberg and Price (1982) pointed out that "it has become a tradition in education to make change by adopting or developing new curricula". We must realize that change is not an event, but a continuous process. Preservice education provides teachers with a foundation of professional skills. Teachers need to build upon their preservice training as the beginning of a continuum of professional development (Dillon, 1972). ITE can help teachers build upon their preservice training and serve as an essential element in the continuum of educational change.

Statement of the Problem

The primary purpose of this study was to determine if inservice training of a new curriculum for Agricultural Science and Technology teachers in secondary educational programs in Oregon increased student achievement scores.

Objectives

1. Determine the subject areas (lessons) for a curriculum for Integrated Pest Management (IPM).
2. Develop a curriculum for an introductory course in IPM from the determined subject areas.
3. Compare student's achievement scores to determine the effect of inservicing teachers on student achievement.

Rationale

Technology and information are changing rapidly. New curriculums are developed almost daily. In an effort to help teachers utilize the materials, teacher educators and curriculum developers often "inservice" teachers over the new materials. The motivation for this study was based on a need to determine whether current efforts to inservice AST teachers in Oregon over new curriculum materials is worthwhile. ITE is expensive and time consuming for everyone involved. Teachers have busy schedules and often it is difficult for them to attend ITE programs.

There are thousands of different inservice education programs which range from traditional university courses to school based workshops to overall school improvement programs (ERIC, 1980). Teacher educators and inservice planners are faced with the need to find the most efficient way to present new information to teachers so that time and resources are not wasted.

When new curricula materials are developed, often they are received by teachers in the mail with little background information or instruction on how to use the curriculum. Unfortunately the curriculum often winds up on the shelf collecting dust and is never utilized. This study is an attempt to evaluate the effect of "inservicing" teachers over new curriculum on student achievement.

ITE is a key to increasing the effectiveness of teachers (Fielding and Schalock, 1985). While the effectiveness of ITE programs has been evaluated, conclusions nearly always address the issue of whether skills were acquired and demonstrated by the teachers. The question of transfer at the classroom level (students) is addressed in relatively few studies (Nicholson et al., 1976).

The evaluation of most ITE efforts are descriptive or opinionative in nature (Wehmeyer, 1974; TEA, 1978). There is a need to objectively evaluate the effect of ITE on student achievement (McDonald, 1978; Berman and Friederwitzer, 1982). Wade (1984-85) points out that "effectiveness should be measured not only at the level of the teacher-participant, but also at the level of the students with whom teachers interact". Kelly and Dillon (1978), suggested that it is the direct effects in terms of student outcomes that should constitute evidence of success or failure. This is the real test of the effectiveness of ITE programs.

Mork (1953) reported a significant difference in student learning as a result of ITE efforts. Other studies (Barr, 1940; Anderson, 1950; and Brown, 1968) indicated little or no significant increase in student learning as a result of ITE.

It is hoped that the results of this study will provide some direction for future inservice efforts when new curricula are introduced.

CHAPTER II

LITERATURE REVIEW

This chapter contains a review of the literature on in-service teacher education (ITE) germane to this study. Since this study is concerned with the effect of inservice education of teachers on student achievement, the literature reviewed focuses on the areas most related to the individual teacher (inservice teacher education). Staff development literature was selectively reviewed for generalizations and findings relevant to the individual teacher.

The literature does not provide a consensual definition of inservice education. A variety of terms are used by scholars and practitioners when communicating about inservice education. To some (Hass, 1957; NEA, 1966; Harris and Bessent, 1969; Orrange and van Ryn, 1975; Schiffer, 1980; Joyce and Showers, 1988), inservice education is a means of developing an entire school staff. In this context, several different terms: staff development, human resource development, renewal, continuing education, professional growth, and professional development are used throughout the literature (Harris, 1989). Staff development according to Lieberman (1978) "suggests a different approach to improvement, one that considers the effects of the whole school (the staff) on the individual (the teacher) and the necessity for long-term growth possibilities (development)". As Schiffer (1980) pointed out "staff development implies that changes in teacher performance should be linked with other aspects of school renewal such as improvements in curricula, programs, administrative procedures, and school-community relations".

Others (Goldhammer, 1969; Cogan, 1975; NEA, 1975; Edelfelt, 1976; Yarder, 1976; Howsam, 1977; Boyan and Copeland, 1978; Wolf, 1981, Harris and Hill, 1982; Sergiovanni and Starratt, 1983; Matthews, 1984;) view inservice education in a more limited capacity, emphasizing development of the individual teacher. Inservice education according to a report by James (1972), "includes the whole range of activities by which teachers can extend their personal education, develop their professional competence and improve their understanding of educational principles and techniques". Edelfelt and Johnson (1975), describe inservice education as "any professional development activity that a teacher undertakes singly or with other teachers after receiving her or his initial teaching certificate and after beginning professional practice".

A few have chosen to combine the most commonly used terms, inservice education and staff development, and come up with "inservice staff development: those activities planned for and/or by teachers designed to assist them in more efficiently and effectively planning and attaining designated educational purposes" (Ryan, 1987), and "inservice education for staff development: any planned program of learning opportunities afforded staff members of schools, colleges, or other educational agencies for purposes of improving the performance of the individual in already assigned positions" (Harris, 1989).

One explanation of why the term inservice education has not been universally accepted is offered by Nicholson, Joyce, Parker, and Waterman, (1976):

> To some it has become repugnant because most of what is done in its name is so terribly boring; to others, who cherish the goal of full professional stature for teaching, the term lacks the proper dignity; to others still, "inservice" is either derogatory or meaningless or out of date.

Thus, according to the literature, inservice education has a variety of meanings to different people. However, the differences in terminology are associated with the goal of the activity being performed. When the goal includes development of an entire school staff, terms like staff development, human resource development, school renewal, and professional development are used. When the goal of the activity is directed to the "development of the individual teacher", the terms inservice education, inservice training and inservice teacher education are used to describe this activity. The use of these terms "almost interchangeably" has created considerable confusion in the minds of those trying to describe inservice practices and concepts (Harris, 1989).

For the purpose of this study, Inservice Teacher Education is defined as **"any organized effort to improve the performance of teachers in already assigned positions".**

The literature reviewed is divided into three sections: 1) Historical Perspective on Inservice Teacher Education in the U.S.; 2) Research-Based Information on Inservice Teacher Education; 3) Inservice Teacher Education and the Dissemination\Implementation of New Curriculum.

Historical Perspective On Inservice Teacher Education

Organized inservice teacher education in the U.S. is about 140 years old. Throughout its' history, the goals of ITE have changed to meet the changing role(s) of the teacher. In this sense it has been reactive rather than proactive. Inservice teacher education, was based on the assumption that "training before teaching begins cannot adequately prepare teachers for the task of teaching" (Schiffer, 1980).

The earliest form of ITE was the Teachers' Institute. During the 1850's, thousands of untrained teachers were hired to fulfill a commitment to universal elementary education. Many of these people were poorly educated and did not even have a high school education (Tyler, 1971). In an effort to "bridge" the gap between the knowledge teachers had and the knowledge they were expected to have, Teachers' Institutes were established.

This early form of ITE was largely remedial. The teachers' institutes consisted of two or three day short courses which focused on correcting deficiencies in subject matter and professional skills (Schiffer, 1980). "The institutes usually included a review of the common branches, arithmetic, spelling, geography, and history, with components on points of difficulty, a statement of principles of discipline, and recommended approaches to the teaching of reading, writing, and numbers" (Tyler, 1971).

By 1860 it was evident that the changing needs of the agricultural communities were not being met by the colleges of the day. In response to these needs, Congress passed the Morrill Act of 1862. This legislation helped establish a college in each state for the purpose of teaching agriculture and related subjects that were relevant back on the farm. According to Tyler (1971), "the success of the new land grant colleges gave powerful support to the development of the doctrine that education must and can change to meet the changing needs of a modern society".

During the period from 1880 to the 1930's, the teachers' institute continued to flourish. However, ITE became concerned with upgrading teachers' cultural and professional skills and knowledge. Several new ITE activities including: summer normal schools, extension courses, and teachers' reading circles emerged during this period. Of these, the summer normal schools became the most important. Normal schools were teacher training institutes supported by states, counties, or cities. They were established for the purpose of training elementary teachers "preservice" (Schiffer, 1980). The curriculum was two years in length and reviewed subjects taught in common schools with courses in teaching. The term "normal" was derived from "ecole normale", French for a professional school for the preparation of teachers (Moore, 1987). Several of the normal schools offered courses in agriculture to prepare agricultural teachers. By 1915-16, agriculture was being taught in 124 public normal schools (Moore, 1987).

Throughout the U.S. many new ideas from Darwin, Dewey, Montessori, and others were presented through the summer normal schools. They were strategically the most important agencies of inservice education in America from 1880 to the First World War (Tyler, 1971).

The emergence of quantitative standards for teaching certificates after World War I created a new focus for ITE. Educators felt that the key to improving the quality of education in public schools was to require all teachers to obtain a bachelor's degree (Tyler, 1971). This required a considerable investment in inservice courses that would count towards a bachelor's degree because the majority of teachers had only the equivalent of two years of college. For the next twenty years ITE was concerned with filling gaps in college degree requirements rather than helping teachers meet new problems. This shift in strategy, according to Tyler (1971):

> "had a deleterious effect both on the institutions and on the teacher enrolled. Instead of planning for summer courses that were new and exciting to the professor who offered them, colleges and universities sought to identify and offer old courses that teachers had not taken previously. The

> teachers came not with the purpose of getting new insight, understanding, and competence, but rather with the purpose of getting certificates renewed by patching up their backgrounds."

The Smith-Hughes Act of 1917 established the teaching of Vocational Agriculture in secondary institutions and "was instrumental in guiding the development of teacher education in agriculture" (Key and Price, 1987).

By 1920, inservice activities were beginning to be regarded as "those that would lead to the growth of the entire staff, not just to the improvement of the individual teacher" (Schiffer, 1980). The author points out that this new approach was based on the belief that the overall school program as well as teacher performance would improve as teachers worked together to solve problems significant to them.

In the late 1930's, ITE was concerned with developing curricula and educational procedures. Projects like the Eight-Year-Study, the establishment of the Commission on Teacher Education, and other similar teacher education activities were a major function of ITE during this period (Ward, 1972). Tyler (1971) observed that an important lesson of this period was "constructive involvement of teachers in attacking real educational problems that they face is a powerful instrument of continuing education."

There was an acute shortage of teachers following World War II and once again the focus of ITE was on providing courses that would satisfy certification requirements.

Throughout the 1960's inservice education was concerned with the problems of school desegregation and how to educate disadvantaged children (Tyler, 1971).

In the 1950's two major types of ITE activities emerged: the workshop and action research. With the exception of college and university courses, the workshop was the most widespread ITE activity. The workshop, according to Schiffer (1980):

> normally consisted of a number of teachers acting in concert with resource persons and a director under conditions that were designed to provide for individual growth via group interaction. In theory there was no planned or arbitrary schedule of activities; participants worked on problems of their choice under the leadership of workshop members.

A desire for ITE programs responsive to individual needs with an emphasis on self-evaluation brought about a new approach called "action research". This involved research conducted by teachers in order to improve their performance (Cory, 1953). By collaborating with each other, teachers were able to design, plan, and evaluate solutions to problems they had identified. This was in contrast to the conventional wisdom of the day which said that administrators and supervisors were in a better position to identify the teacher's needs than was the teacher (Schiffer, 1980).

During the post-sputnik era, from 1957 to 1967, there was a major effort to improve education in the U.S. through curriculum reform. Large amounts of money were provided by the National Science Foundation and the National Defense

Education Act (NDEA) for improvements in the teaching and course content of the physical and natural sciences. During this curriculum reform movement, ITE played an integral role in training teachers how to use the new curriculum materials (Schiffer, 1980).

The current status of ITE according to Harris (1989) is not reassuring:

> Despite a long history of recognition as an essential part of the ongoing operation of the school program, in-service education seems constantly ensnared or diverted by less fundamental, but seemingly more urgent, development efforts. More recently, statewide programs and even national commission reports stressing "excellence," "reform," or "school improvement" under other banners have abandoned inservice education, giving it little or no attention. Instead, the current emphasis of both state and national policy-making seems to be on mandates for monitoring, testing, rewarding, regulating, dismissing, and promoting.

Research-Based Information On Inservice Teacher Education

The research-based information on ITE contains "very little hard research and what does exist is not very useful" (Nicholson et al., 1976). In a comprehensive review of the literature on ITE, these authors found less than twelve reviews of research. After discussing the strengths and weaknesses of these, the authors concluded: "the only review of research found which may properly deserve the name is one conducted by Lawrence and others in 1974 for the Florida Department of Education". Others (Denemark and MacDonald, 1967; Griffin, 1983; Wade, 1984, 1985; Daresh, 1986; and Ryan, 1987) are equally critical of the lack of research on ITE in the literature. Most of what is reported as experimental, is really loosely evaluated demonstrations based on opinion and anecdotal descriptions (Denemark and MacDonald, 1967).

Nicholson et al. (1976) made two important conclusions about ITE: 1) "the process of inservice teacher education has been neglected in the research literature in favor of the content of inservice teacher education." 2) "traditional inservice teacher education programs have consisted almost entirely of information-gathering activities: attending workshops and institutes, taking college courses, and reading professional journals. Programs that stress utilization of that information or practice of techniques with feedback have been distinctly in the minority".

Studies (Glass, 1976, 1977; Joslin, 1980; Lawrence, 1981; and Wade, 1984, 1985) involving meta-analysis techniques in ITE research have provided objective data in the literature. Meta-analysis (Glass, 1976) provides a systematic method for integrating results across independent studies by converting them to a common base. Meta-analysis compares all quantitative studies on a particular topic (e.g. inservice education of teachers) using a common method of averaging. The qualitative effects of a particular treatment variable (e.g. a particular aspect of inservice such as effects on student learning) can be compared with other procedures and the differences expressed quantitatively. Effect size is the difference between the means of treatment and control group divided by the standard deviation of the control group (Glass 1977).

Results of meta-analysis research (Wade, 1984-85) relevant to this study are summarized as follows:

> Effect levels. Attempts to increase participant's learning through inservice teacher training are highly effective; while attempts to demonstrate results by looking at the students of participants are only mildly effective.
>
> Duration. Length of treatment resulted in no significant difference.
>
> Training Group Characteristics. Voluntary or required attendance, size of training group, and composition of group (whether participants were a faculty unit or a group of unrelated individuals) showed no difference.
>
> Location and Scheduling. No variables resulted in significantly different effect size.
>
> Sponsorship. Training programs initiated, developed, or funded by the state or federal government or a university were significantly more effective than those initiated within the school, either by teachers, administrators, or supervisors.
>
> Participant Incentives. When a participant was selected to take part in training, either by being designated as a representative of a particular group or through a competitive selection process, the effect size was significantly greater than for all other incentives studied.
>
> Structure. Independent study produced the highest effect size. There do not appear to be important differences in the effect sizes among workshops, courses, mini-courses, or institutions, all of which are moderately effective.
>
> Instructional Technique. The most effective instructional methods are observation of actual classroom practice, microteaching, video/audio feedback, and practice. The least effective are discussion, lecture, and games/simulations. Various combinations of techniques resulted in "no magical" combination which was more effective. Higher effects were produced by

practical rather than theoretical teaching. Support staff and college personnel as instructors are moderately effective, while teachers and state department of education representatives produced only small gains.

These findings by Wade are consistent with other studies (Joslin, 1980; Lawrence and Harrison, 1980; and Daresh, 1986) using meta-analysis. Most ITE research nearly always addresses the issue of whether skills were acquired and demonstrated. The question of transfer at the classroom level (students) has been addressed in relatively few studies (Wade, 1984, 1985).

ITE and the Dissemination\Implementation of New Curriculum

Swenson (1981), observed that the content of most ITE activities deals with curricular improvements and teaching methodologies. In order for new curriculum materials to be utilized, teachers must be made aware of their value and familiarized with their content (Mullinix, Weston, and Linhardt, 1987; Boardman, 1980; Finch and Crunkilton, 1979; and Marks, 1978). According to Mullinix et al. (1987) "It should behoove the commissioners and developers of new high school agriculture curriculums to provide a speedy, and efficient method for the dissemination and adoption of those materials in Vocational Agriculture programs. Instructors must be introduced to and familiarized with the new curriculum materials as well as provided with the technical background necessary for successful implementation."

In an extensive review of the literature on "educational change", Cantrell (1987) reported that "inservice education and staff development were most often cited (Unruh and Unruh, 1984; Fullan, 1982; Hall and Loucks, 1978; McLaughlin and Marsh, 1978; Fullan and Pomfret, 1977; Berman and McLaughlin, 1976; Horn and Marsh, 1976; Mullen, 1975; Shipman, 1974) as important strategies. Others (Fullen, 1982; Goodlad and Klein, 1970; Joyce, Hersh, and McKibbin, 1983; Joyce and Showers, 1988) point out that implementation of curricular and technological changes are virtually impossible without very strong staff development.

Inservice workshops have been recommended as a means of introducing new curriculum to teachers (Palmer, 1971; Pepple, 1982) and increasing teacher utilization of new innovations in curriculum materials (Blezek and Dillion, 1980). Pepple (1982) believes that workshops should emphasize the purpose and organizational sequence of new materials, so that new concepts are less threatening to the teachers. This can also serve to promote a higher use rate and implementation.

Summary

A variety of widely used terms are found in the literature, describing inservice education. The use of these terms "almost interchangeably" has created considerable confusion in the minds of those trying to describe inservice practices and concepts (Harris, 1989). An operational definition of inservice teacher education is "any organized effort to improve the performance of teachers in already assigned positions".

Inservice teacher education in the U.S. began about 140 years ago. It was based on the premise that "teachers had to overcome gross deficiencies in their attitudes, knowledge, and skills" (Schiffer, 1980). The earliest form of ITE was the Teachers'Institute. As society changed, the needs of teachers changed and ITE became more complex.

The Smith-Hughes Act of 1917 was very instrumental in guiding the development of teacher education in agriculture (Key and Moore, 1987). From 1920 to 1960, "the purpose of in-service education shifted from upgrading the individual teachers competency to that of promoting professional growth of the entire staff by engaging the staff in cooperative efforts to solve school problems" (Schiffer, 1980). The term "staff development" is currently used to describe those activities which focus on the development of an entire school staff by enhancing their academic knowledge and professional performance (Joyce and Showers, 1988).

The research-based information on ITE can be characterized by two statements: 1) there is very little hard research available, and 2) what does exist is not very useful (Nicholson et al., 1976). More recently (Joslin, 1980; Lawrence, 1981; and Wade, 1984, 1985) quantitative research using meta-analysis has provided more objective information on what makes ITE effective. Most findings nearly always address the issue of whether skills were acquired and demonstrated. The question of transfer at the classroom level (students) was addressed in relatively few studies.

Korinek, Schmid, and McAdams, (1985) point out three reasons why ITE should continue:

1) college training is but an introduction to the world of teaching. Only entry level skills and knowledge can be developed in the time allotted preservice training.

2) our accelerating acquisition of knowledge makes some teaching strategies and tactics obsolete while creating a need for new ones.

3) teaching is a dynamic profession in which the individual must continually regenerate to be effective. Inservice is a medium for stimulating regeneration.

Inservice teacher education is an important strategy for implementing educational change (Cantrell, 1987). However, ITE has historically been reactive rather than proactive to teachers needs. Today's teachers face enormous challenges in keeping up with the rapid changes in our modern society. Effective ITE programs are needed now more than ever before, so that teachers are prepared not for the past, but for the present and future (Kramer and Betz, 1987).

CHAPTER III

MATERIALS AND METHODS

This chapter is divided into four sections: 1) Development of the Instrument; 2) Identification of the Population; 3) The In-service Training; and 4) The Research Design.

Development of the Instrument

A curriculum for teaching an introductory course on Integrated Pest Management (IPM) was developed as the instrument for this study. "Integrated Pest Management is a strategy of pest containment which seeks to maximize natural control forces such as predators and parasites, and to utilize other tactics only as needed and with a minimum of environmental disturbance" (Glass, 1975). Of the 12 priorities identified by the Joint Council on Food and Agricultural Sciences for agriculture in FY 1991, IPM can play a major role in achieving every one. At the time of this study, there was no curriculum available for teaching IPM in AST classes in Oregon. The topic "Integrated Pest Management" is well suited for this study because it represents an "innovation" for most teachers. Therefore, it was hoped that teacher bias associated with more traditional AST subjects would be reduced.

The initial content for the IPM curriculum was determined by reviewing the literature, texts, and other sources of technical information. An outline with a set of objectives for each lesson was prepared by the researcher. The objectives for each lesson were designed to cover the basic concepts of IPM in a three to four week period of time. It was felt that a curriculum longer than this would not be utilized by teachers due to their time constraints. A practical "hands-on" learning approach was emphasized in each lesson. The objectives were foundational so that the curriculum could be used in many diverse teaching/learning situations.

The outline containing the objectives and a cover letter explaining the study were mailed to a modified Delphi panel of five experts (Kramer and Betz, 1987) in the fields of IPM and AST education. The panel members were selected by an expert in integrated pest management from Oregon State University. A copy of the correspondence sent to the panel members is found in appendix B.

Each panel member reviewed the curriculum outline independently. They were asked to modify the outline and objectives in any way, reflecting their professional opinion on content and order. Consensus on the validity of the content for the curriculum was reached by the panel. A curriculum was developed based on the panel's validated objectives. The curriculum developed during this study is found in appendix C.

Identification of the Population

Individuals in any social system can be grouped according to their degree of "innovativeness". Innovativeness is "the degree to which an individual is relatively earlier in adopting new ideas than other members of his system" (Rogers and Shoemaker, 1971). The five adopter categories include: 1) innovators; 2) early adopters; 3) early majority; 4) late majority; and 5) laggards (Rogers and Shoemaker, 1971). The population for this study consisted of the innovators and early adopters among AST teachers in Oregon Secondary Education. By working with the population of innovators and early adopters among AST teachers, the variability of teachers in the study was reduced.

The population was identified using a sample matrix developed by the researcher based on criteria for adopter categorization described by Rogers and Shoemaker, (1971). The sample matrix including a set of criteria for identifying teachers was mailed to a panel of five experts in the field of AST Education in Oregon.

This modified Delphi panel identified the population of innovators and early adopters among AST teachers in Oregon. Using the criteria provided in the sample matrix, each panel member was asked to assign a score of 1 to 5 to each teacher based on the panel members' perceptions of the teachers. The criteria included: group involvement, history of adoption, group leadership, and level of credibility. The sample matrix used to identify the innovators and early adopters is found in appendix B.

The total population of AST teachers in Oregon were ranked according to their scores assigned by the panel. The top twenty teachers in the state with the lowest scores were identified as the innovators and early adopters. The number of teachers (20) identified for the study is based on the adoption model developed by Rogers and Shoemaker, (1971). The model predicts that innovators make up 2.5% and early adopters 13.5% of a social system. Thus, validation of the population for this study was achieved through the modified Delphi panel.

The Inservice Training

The identified population of innovators and early adopters were contacted with correspondence (appendix B) describing the study and inviting them to participate. Implied consent to participate in the study was verified by a follow up telephone call one week after mailing the letters. A date and time were arranged for the teachers receiving inservice training.

The inservice training was conducted with individual teachers or in groups of two or three in the teacher's classroom. An outline of the material to cover during the inservice was prepared and followed to maintain consistency. The format was informal, each teacher inservice lasted one hour and involved a short discussion over each of the ten lessons in the curriculum. All the materials recommended in the curriculum were displayed and their use demonstrated. Suggestions were made for making and incorporating these materials into the lessons. The teachers were given an opportunity to examine all materials and ask questions about any aspect of the curriculum.

The Research Design

The research design of this study was devised to determine the effect of inservice training of Agriculture Science and Technology (AST) teachers on student learning when new curriculum materials are introduced. The dependent variable for this study is the student's achievement score on the IPM examination. The student's scores represented the sample data used to make conclusions about the population of AST teachers in this study.

The identified population of innovators and early adopters were randomly divided into two equal groups. This was accomplished by listing the teachers last names in alphabetical order and choosing every other name for group A and the remaining names for group B. The treatment received by the groups consisted of:

Group A (experimental)

These teachers received a copy of the IPM curriculum and in-service training over the materials and recommended methods. This familiarized the teachers with the content of the curriculum and suggested ideas for presenting the material in class. A cover letter explaining the purpose of the study was included with the curriculum. In addition, these teachers were encouraged to call if they had any questions regarding further instruction on the use of the curriculum.

Group B (control)

These teachers received a copy of the IPM curriculum in the mail, but did not receive inservice training over the curriculum or recommended methods. A cover letter was provided explaining the purpose of the study and asked the teachers to call if the instructions were unclear. These teachers did not receive additional consultation regarding the use of the curriculum.

The teachers from both groups were asked to teach the curriculum as soon as possible in the fall of 1991 and give their students the exam provided with the curriculum. The student's post-test scores were collected and statistically analyzed (experimental vs control). The sampling design for the student's post-test scores is shown in table III.1 below.

Table III.1 The Sampling Design for Student's Post-Test Scores

# Students	Group A Experimental	Group B Control
	$\mu_A =$	$\mu_B =$

Hypotheses

The following null hypothesis (Ho) was tested: "Inservice training of teachers on use of the new curriculum does not result in increased learning by the students of teachers receiving inservice training."

$$Ho: \mu_A = \mu_B$$

If the null hypothesis (Ho) is rejected, it indicates there is a significant difference between the two sample means (experimental vs. control). If a significant difference is found for the sample data, then the inference is justified for the innovator and early adopter teacher population means as well. When the null hypothesis is rejected, a second type of hypothesis called the "alternate hypothesis" becomes important.

The alternate hypothesis contains a directional statement which speculates the direction of the treatment (Courtney, 1991). The alternate hypothesis for this study is as follows: "Inservice training of teachers on use of the IPM curriculum results in increased student achievement by the students of teachers receiving inservice training".

$$Ho: \mu_A > \mu_B$$

If the null hypothesis is rejected, the alternate hypothesis is assumed.

The Statistical Model

The intent of this study was to contrast the difference between two sets of interval scale data. The data for this study consisted of the student's mean post-test scores from the IPM exam. The t-test was used as the statistical method for analyzing the data. The t-test is the most commonly used method to examine the hypothesis of no difference between two means. There are three important assumptions which must be made when using the t-test. These assumptions are:

1. Normality of test scores.
2. Random Assignment of Subjects.
3. Homogeneous Variances.

There are three different formulas for computing a t-test, depending on whether the data are correlated, uncorrelated, or from a single sample. Correlated data are sample data which are collected from the same individual, such as when pre and post tests are administered. In contrast, uncorrelated data are data collected from different individuals, such as the typical experimental-control group design. The third use of the t-test is when a single sample mean is contrasted with a known or estimated population mean (Courtney, 1987). The formula one uses depends on the type of sample data. The data generated in this study are said to be uncorrelated, or independent, because they are derived from different individuals.

The formula for calculating "t" with uncorrelated data is given below:

$$t = \sqrt{\frac{\bar{X}_A - \bar{X}_B}{SD\ \bar{X}}}$$

Degrees of Freedom (DF) $\doteq N_1 + N_2 - 2$.

$\propto = 0.05$

For uncorrelated data, the denominator of the formula is derived by:

$$SD\ x = (S\ \bar{X}_A)^2 + (S\ \bar{X}_B)^2$$

Where: $S\ \bar{X}_A$ is the standard error of the sample mean of group A.

$S\ \bar{X}_B$ is the standard error of the sample mean of group B.

After the t value is calculated (tcal), it is then compared with the theoretical tabular t value (ttab) from a t-table using the calculated degrees of freedom and the predetermined alpha level (0.05). If tcal is greater than or equal to ttab, the null hypothesis is rejected. If tcal is less than the ttab, the null hypothesis is retained.

CHAPTER IV

RESULTS AND DISCUSSION

Results

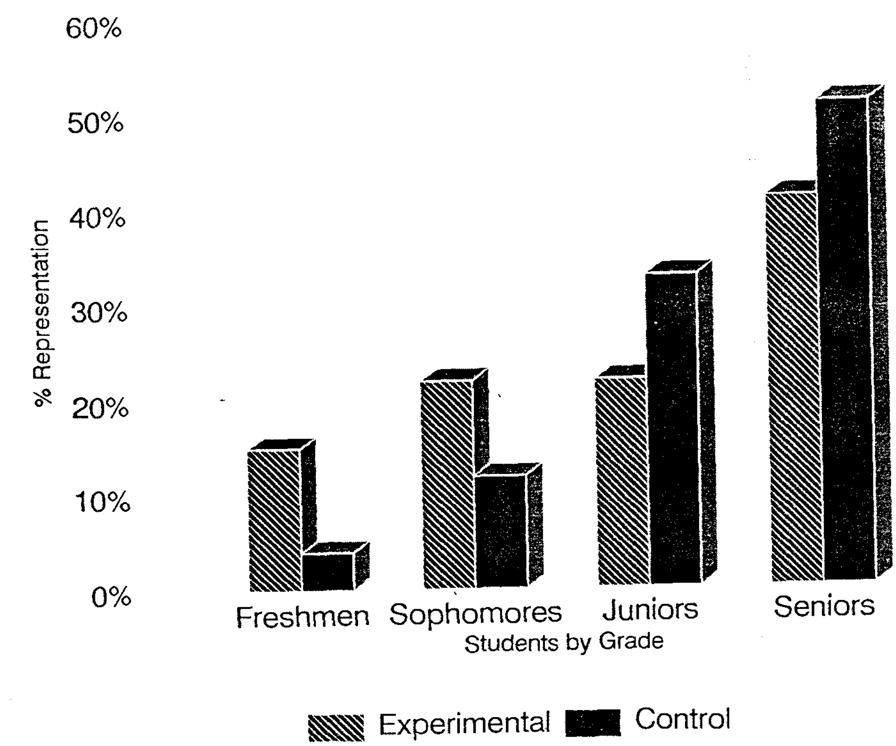
The goal of this study was to determine the effect of in-servicing AST teachers on student achievement when a new curriculum is introduced. As the literature pointed out, the best indication of the effectiveness of ITE is student achievement. For this reason, students provided the sample data for this study. The teachers identified as innovators and early adopters in this study, represented a distinct subgroup among the total population of AST teachers in Oregon. This distinct population of teachers identified as innovators and early adopters represented the population for this study. Therefore, the sample data (student test scores) collected were used to draw conclusions concerning this population of teachers.

Of the twenty AST teachers chosen for this study, seven in the experimental group and eight in the control group taught the IPM curriculum and tested their students over the material.

The students' test scores were received via mail from the teachers. The experimental group included 122 test scores, and consisted of: 15% freshmen, 22% sophomores, 22% juniors, and 41% seniors. The control group included 132 test scores, and consisted of: 4% freshmen, 12% sophomores, 33% juniors, and 51% seniors.

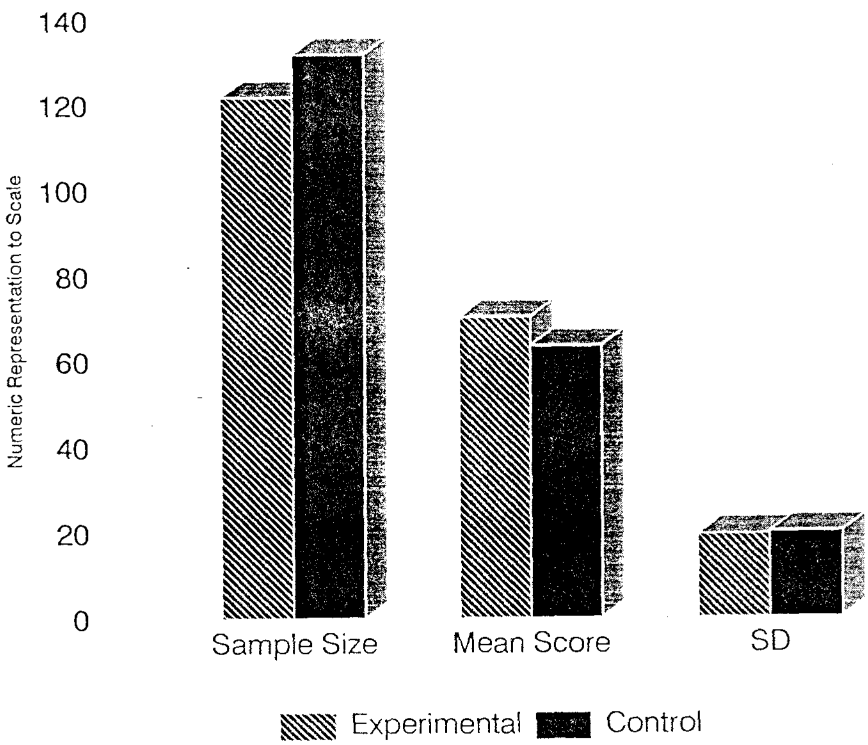
No attempt was made to standardize the student grade levels between both groups because many teachers indicated this was not feasible. The teachers were asked to teach the IPM curriculum to any class they felt was appropriate. This was thought to be more typical of the way curricula is utilized by AST teachers in Oregon. This contributed to the high variance of students in different grade levels. The distribution of students according to grade levels in the study is displayed in Figure IV.1.

Fig. IV.1 Distribution of Students
According to Grade Levels in the Study



The student's test scores were converted to a percentage of 100 and recorded. The sample size, mean score, and standard deviation for student data are illustrated in figure IV.2.

Fig. IV.2 Sample Size, Mean Score, and Standard Deviation for Student Data



The student's test scores were analyzed using the t-test (see Chapter III) to determine if there was a significant difference between the mean test scores of the two groups. The results of the t-test are summarized in table IV.1.

Table IV.1 Results of the t-test

$\bar{X}a$	$\bar{X}b$	Na	Nb	SDa	SDb	df	tcal	ttab
70.3	63.7	122	132	19.5	20.0	252	2.65	1.96

$\bar{X}a$ = Mean student test score for the experimental group of teachers.

$\bar{X}b$ = Mean student test score for the control group of teachers.

Na = Number of samples (student test scores) in the experimental teacher group.

Nb = Number of samples (student test scores) in the control teacher group.

SDa = Standard deviation for the experimental group.

SDb = Standard deviation for the control group.

df = Degrees of freedom.

tcal = Calculated t-value.

ttab = Table t-value.

The data in Table IV.1, shows the calculated t-value (tcal = 2.65) is greater than the table t-value (ttab = 1.96), with alpha = 0.05, and df = infinity. This indicates a significant difference in the student's mean test scores between the experimental and control groups. Therefore, the null hypothesis: "inservice training of teachers on use of a new curriculum does not result in increased learning by the students of teachers receiving inservice training", was rejected.

A second t-test was calculated with alpha = 0.01, and df = infinity. The calculated t-value (tcal = 2.65) was still greater than the table t-value (ttab = 2.58). These results indicate that the difference between the experimental and control means is highly significant. Once again, the null hypothesis was rejected! Since the null hypothesis was rejected, the alternate hypothesis was retained. The alternate hypothesis stated that the student's mean test scores in the teacher experimental group is greater than that for the teacher control group.

Discussion

The data indicates that inservicing the population of innovators and early adopters among AST teachers in Oregon over new curriculum materials, increased student achievement. It is interesting to note that a higher percentage of the students in the teacher experimental group consisted of freshmen and sophomores (15% and 22% respectively) than in the teacher control group (4% and 12% respectively). Consequently, the teacher control group consisted of a higher percentage of juniors and seniors (33% and 51% respectively) than the teacher experimental group (22% and 41% respectively).

It is not clear from this study, what difference if any the disproportion in the number of upper classmen to lower classmen between the two sample groups of students had on the test scores. Perhaps the student mean test scores in the teacher experimental group would have been higher if a lower percentage of freshman and sophomores were included? Additional research is needed to determine student grade level effect on student achievement.

The alternate hypothesis that the students' mean test score in the teacher experimental group was greater than that for the teacher control group was retained. Several teachers who were inserviced (experimental group), indicated either through personal conversations or written correspondence positive feedback regarding the inservice. Most indicated that the inservice instruction provided a necessary introduction and overview of the curriculum. One teacher stated "I have a shelf full of curricula I have received through the mail but have never used because I don't have time or the technical background to familiarize myself with the content or adapt it to my situation".

One possible reason for the effectiveness of the in-service provided in this study was that it was conducted either individually or with groups of two or three teachers. This gave teachers the opportunity to ask questions and use materials that they might not otherwise take advantage of in a larger group setting. The informal approach of sitting down with the teacher in "their" classroom at their convenience, seemed important in generating interest in the curriculum. Since each inservice presentation lasted only an hour, the teachers were more attentive than they would be in a longer more formal inservice.

The IPM curriculum developed for this study emphasized "hands-on" learning activities. This made inservicing the teachers much easier and more enjoyable for the researcher who provided the inservice. Curricula developers should try to incorporate as many hands-on learning activities as possible. Likewise, people providing teacher inservice should also incorporate hands-on learning activities, because it is effective as a teaching/learning method of technology transfer.

The the state of the art of ITE was described as inadequate in the literature. Teachers, administrators, and college personnel were not satisfied with current inservice programs (Ryan, 1987). Woods and Thompson (1980) stated:

> "inservice teacher training, as it is now constituted, is the slum of contemporary education, it is disadvantaged, poverty stricken, neglected, and has

> little effect. Most staff development programs are irrelevant and ineffective, a waste of time and money."

Edelfelt (1974) has called ITE "the neglected stepchild of teacher training". He pointed out that the majority of resources and effort in teacher education have gone into preservice preparation. He went on to say that:

> "inservice education for teachers remains a wasteland of evening, Saturday, and summer courses or workshops mandated by school districts and state departments of education. Inservice education takes place almost entirely on the teacher's time and in advanced collegiate study at the teacher's expense. It is planned and executed by educators other than teachers. Too often it is taught in a manner that violates almost every principle of good teaching. Perhaps most important, too little of its emphasis has been on improving teacher performance."

Joyce et al. (1976) reported that too much time was spent on the process of organizing inservice programs and that too little attention was given to determining the substance and process of the inservice activity. Are inservice planners spending more effort on the "trappings" (e.g., planning the coffee breaks) and not enough on planning the actual activities?

CHAPTER V

SUMMARY, CONCLUSION, AND RECOMMENDATIONS

The first section of this chapter contains a brief summary of this study. The next section presents the conclusions drawn from this research along with recommendations. The final section offers implications for future research.

Summary

Inservice teacher education, in the broadest sense, is that portion of a teacher's professional education which occurs after they become certified. The concept is based on the fact that every teacher is also a career long student.

A variety of terms such as professional development, continuing staff development, staff renewal, staff development, and continuous teacher education are used almost synonymously with inservice teacher education. The lack of a universally accepted term or definition describing this aspect of a teacher's professional education is a source of confusion when trying to generalize about the effect of inservice teacher education programs.

The importance of ITE evaluation is strongly emphasized in the literature. "Evaluation is essential both for assessing the degree of success of past inservice programs and for guiding the direction of future programs" (Nicholson et al., 1976). Most evaluation attempts are descriptive involving opinion questionnaires. The literature indicated a need for evaluation of the effects of the ITE program on student achievement. If the bottom line of ITE is "improved instruction", then student achievement is the real test of the effectiveness of an ITE program. Most of the research on the effectiveness of ITE is limited to the effect on teachers. Very little research has been conducted on the effect of ITE on student achievement. What has been done is inconclusive.

The purpose of this study was to determine if in-servicing Agriculture Science and Technology teachers over a new curriculum, resulted in increased student achievement. Specific objectives were to: 1) determine the subject areas (lessons) for a curriculum for teaching Integrated Pest Management (IPM); 2) develop a curriculum for an introductory course on IPM from the determined subject areas; and 3) compare student's achievement scores to determine the effect of inservicing teachers on student achievement.

The instrument used in this study was an Integrated Pest Management curriculum developed by the researcher based on objectives determined from the literature, texts, and other sources of technical information pertaining to IPM. The objectives were validated by a panel of experts in the field of IPM and secondary education.

The population for this study consisted of twenty Oregon AST teachers who were identified by a panel of five experts as the innovators and early adopters among their peers. These innovators and early adopters represent a distinct population of AST teachers in Oregon. The students of the twenty teachers provided the sample data for the study. The population of twenty teachers were randomly divided into two groups, ten in the experimental group and ten in the control group.

The teachers in the experimental group received one hour inservice instruction over the IPM curriculum at their schools, and consultation via telephone during the 3 to 4 week period when the curriculum was taught to their students. The teachers in the control group only received the IPM curriculum in the mail. They were not inserviced, and they did not receive consultation via telephone regarding use of the curriculum.

Seven of the teachers in the experimental group and eight in the control group taught the curriculum. The students in both groups were examined over the material with an exam developed by the researcher. The sample data for analysis consisted of 122 student post-test scores in the teacher experimental group, and 132 in the teacher control group. The sample data were analyzed using a t-test for uncorrelated data (see chapter III).

The null hypothesis that no difference exists between the student's mean test scores was rejected at alpha = 0.01. The results indicated a highly significant difference between the student's mean test scores. The alternate hypothesis that the student's mean test score was higher in the teacher experimental group (those who were inserviced) than the teacher control group (those not inserviced) was retained.

Conclusion

Based on the data reported in this study, inservicing Oregon Agricultural Science and Technology teachers over new curriculum increased student achievement. Although this study was limited to the innovators and early adopters among AST teachers in Oregon, this finding could be applied to planning professional development (inservice) activities for other groups of people besides teachers. For example, the Extension Service utilizes inservice training to help their agricultural extension agents keep up to date on new information so they remain credible (Smith, 1985).

A curriculum for teaching an introductory course on Integrated Pest Management was developed, and field tested by the innovators and early adopters among AST teachers in Oregon. Prior to this study, there was not a curriculum for teaching IPM in AST classes in Oregon. While the curriculum developed in this study is in need of further revision for improvement, it is at least a beginning for future IPM curriculums in Oregon high schools. It is hoped that the teachers who participated in this study will share the strengths of the curriculum with other teachers so that this important innovation becomes more widely adopted across the state. Recently, the Oregon Legislature passed legislation requiring all state agencies to develop and implement an IPM program for their lands. This legislation underscores the need for an IPM curriculum in Oregon high schools. Thus, the three primary objectives for the study were achieved.

Recommendations

Inservice teacher education is an essential element in the process of educational development and change. Although there is no magical combination of methods for successful inservice, the following recommendations are based on a review of the literature and as a result of this study:

1. AST teachers in Oregon should receive inservice training whenever a new curriculum is introduced.

2. If a new curriculum cannot be properly inserviced, it shouldn't be made available to teachers.

3. If educators expect newly developed curriculum materials to be utilized, teachers must be made aware of their value and familiarized with their content.

4. Teachers need to be introduced to and familiarized with new curriculum materials because often they lack the technical background necessary for successful implementation.

5. Teacher educators should conduct a needs assessment before planning inservice programs. If possible involve teachers in the planning, implementation, and evaluation.

6. Inservice training should emphasize "hands-on" learning activities that allow teachers to try out new techniques and ask questions. The inservice should address the specific on-the-job needs of the individual teacher.

7. Evaluation of ITE programs should utilize experimental research designs more often.

8. Increased funding for ITE programs is needed at the state level.

9. Teacher inservice activities should be offered at convenient times and locations for participants.

10. Inservice activities should be conducted so that participants can directly relate the content to their individual classroom situations.

11. Providers (teacher educators) of ITE should have incentives for providing inservice.

Implications for Future Research

This study focused on the population of innovators and early adopters among AST teachers in Oregon. Innovators and early adopters were chosen for this study because they are the most influential among their peers. It was felt that through these teachers a "multiplier" effect would in time result and other teachers would become interested in adopting the new curriculum.

The conclusion drawn from this study may not apply to the general population of AST teachers in Oregon. A similar study should be conducted using a more heterogeneous sample of the total AST teacher population in Oregon.

The inservice strategy utilized in this study consisted of visiting each teacher individually or in small groups of two or three. While this type of inservice was effective, it is probably not feasible for teacher educators in higher education.

Research studies investigating more cost effective methods are needed. The use of video tape to record inservice activities, which could be made available to teachers for viewing at their leisure is an area which requires future study.

The use of satellite and electronic audio/video synchronous and asynchronous communications technology hold great potential for ITE programs. These type of technologies can reach large or small groups over a large geographical area and still maintain quality delivery. Are their use feasible for ITE? These and other questions need to be asked and efforts made to provide viable alternatives to traditional methods of curriculum delivery and ITE.

BIBLIOGRAPHY

Anderson, Robert H. 1950. The influence of an in-service improvement program upon teacher test behavior and classroom program. Journal of Educational Research, 44, 205-215, November.

Barr, A. S. 1940. Some problems in the measurement of teaching ability. Journal of Educational Research. 33, 363-365, January.

Barrick, Kirby R. 1988. The discipline called agricultural education. Professorial Inaugural Lecture presented at The Ohio State University. Columbus, Ohio, October 31, 1988. (ERIC Document Reproduction Service No. ED 313 515.)

Berman, Barbara, and Friederwitzer, F. 1982. A pragmatic approach to inservice education. Action in Teacher Education. 4, 51-56.

Berman, P., and McLaughlin, M. W. 1976. Implementation of educational innovation. Educational Forum. 40, 345-370.

Blezek, A. G., and Dillion, R. 1980. A summary of an evaluation of the first year of the nebraska vocational agriculture core curriculum. The Journal of the American Association of Teacher Educators in Agriculture. 21 (2), 35-40, July.

Boardman, David J. 1980. Dissemination strategies in four geography curriculum projects. Journal of Curriculum Studies. 12 (2) 109-121.

Boyan, Norman J., and Copeland, W. D. 1978. Instructional supervision training program. Columbus, Ohio: Charles E. Merrill.

Brown, William J. 1968. The effect of in-service education and resource unit components on teacher and student learning. (ERIC Document Reproduction Service No. ED 042 885.)

Cantrell, Diane C. 1987. A case study of curriculum implementation as exemplified by project WILD in one midwestern state. (Doctorial Dissertation, The Ohio State University, 1987), (ERIC Document Reproduction Service No. ED 287 676.)

Cogan, Morris L. 1975. Current issues in the education of teachers. Kevin Ryan, ed., Teacher Education: The Seventy-fourth Yearbook of the National Society for the Study of Education, Part II p. 220. Chicago: NSSE.

Cory, N. D. 1953. Incentives used in motivating professional growth of teachers. Chicago: North Central Association of Colleges and Secondary Schools, (ERIC Document Reproduction Service No. ED 027 254.)

Courtney, E. W. 1988. A guide to empirical research in education. p. 10. Sanderling Press, Corvallis, Oregon, 1988.

Courtney, E. W. 1991. Hypotheses. Sanderling Press, Corvallis, Oregon, 1991.

Daresh, J. C. 1986. Research trends in staff development and insevice education. Journal of Education for Teaching. 13, (1), 3-11.

Denemark, G. W., and MacDonald, J. B. 1987. Preservice and inservice education of teachers. Review of Educational Research. 37 (3), 233-48.

Dillion, Elizabeth. 1976. Staff development: Bright hope or empty promise? Educational Leadership. 34, 165-170.

Edelfelt, Roy A. 1974. Inservice education of teachers: Priority for the next decade. The Journal of Teacher Education. 25, (3), Fall, 250-252.

Edelfelt, Roy A. 1976. Can competency-based teacher education be applied to in-service education? Should it be? A draft manuscript prepared for the Association for the Accreditation of Teacher Education (July).

Edelfelt, Roy A., and Johnson, Margo eds. 1975. Rethinking in-service education. Washington, D. C.: National Education Association.

Eisner, E. W. 1985. The educational imagination: On the design and evaluation of school programs (2nd ed.). New York: MacMillan Publishing Company.

Fielding, G. D., and Schalock, H. D. 1985. Promoting the professional development of teachers. Eugene, Oregon: ERIC Clearinghouse on Educational Management.

Finch, Curtis R. and Crunkilton, John R. 1979. Curriculum development in vocational and technical education. Newton, Mass.: Allyn and Bacon, 211-218.

Fischer, Louis. 1971. In-service education: An immodest proposal. In Improving In-Service Education. (ed). Louis Rubin. Boston: Allyn and Bacon, Inc. 227-243.

Fullen, M. 1982. The meaning of educational change. New York: Teachers College Press.

Fullen, M. and Pomfret A. 1977. Research on curriculum and instruction implementation. Review of Educational Research. 47 (1), 335-397.

Glass, E. H. (Coordinator) 1975. Integrated pest management: Rationale, potential, needs and improvement. Entomol. Soc. Am. Special Publ. 75-2. 141 pp.

Glass, G. 1977. Integrating findings: The meta-analysis of research. In Shulman, L. S. (Ed.) Review of Research in Education. Itasca, Ill.: Peacock Publishing.

Goldhammer, Robert. 1969. Clinical Supervision. New York: Holt, Rinehart and Winston.

Goodlad, J. I. and Klein, M. F. 1970. Looking behind the classroom door. Worthington, OH: Charles A. Jones.

Griffin, G. A. 1983. Implications of research for staff development programs. Elementary School Journal. 83, 414- 425.

Hall, G. E. and Loucks, S. F. 1978. Teacher concerns as a basis for facilitating and personalizing staff development. Teachers College Record. 80, 36-53.

Harris, Ben M. 1989. In-Service Education for Staff Development. Boston: Allyn and Bacon, Inc.

Harris, Ben M., Bessent, E. W., and McIntyre, K. E. 1969. In-Service Education: A Guide to Better Practice. Englewood Cliffs, N.J.: Prentice-Hall, Inc.

Harris, Ben M., and Hill, Jane. 1982. Developmental Teacher Evaluation Kit. Austin, Tex.: Southwest Educational Development Laboratory.

Hass, C. G. 1957. Inservice education today. In N. B. Henry (Ed.), Inservice education for teachers, supervisors and administrators: The fifty-six yearbook of the National Society for the Study of Education. Chicago: University of Chicago Press. pp. 13-34.

Hillison, John. 1987. The Smith-Hughes Act at 70. The Agricultural Education Magazine. 59, (8), p.4, (February).

Horn, J. G., and Marsh, M. A. 1976. Elementary science curriculum implementation: As it was and as it should be. Paper prepared as part of Project Tape, University of So. Dakota. (ERIC Document Reproduction Service No. ED 135 639)

Howsam, Robert B. 1977. The profession of teaching. In Issues in-Service Education: State Action for In-Service. pp. 9-13. Syracuse, N.Y.: National Council of States on In-Service Education, Syracuse University, College of Education (November).

James Report, 1972. Teacher Training and Education: A Report by a Committee of Inquiry Appointed by the Secretary of State for Education and Science, Under the Chairmanship of Lord James of Rusholme. p. 5, para. 2.2. London: Her Majesty's Stationary Office.

Joslin, P. A. 1980. Inservice education: A meta-analysis of the research. Unpublished doctoral dissertation, University of Minnesota.

Joyce, Bruce, and Beverly Showers. 1988. Student Achievement Through Staff Development. Longman Inc., White Plains, N.Y.

Joyce, B., Hersh, R., and McKibbin, M. 1983. The structure of school improvement. New York: Longman.

Kelley, E. A., and Dillon, E. A. Staff development: It can work for you. NASSP Bulletin. 62, (417), 1-8. (April).

Key, James P., and Price, Robert, R. 1987. Teacher education in agriculture provisions of the Smith-Hughes legislation. The Agricultural Education Magazine. 59, (8), 19-20, (February).

Korinek, L., Schmid, R., and McAdams, M. 1985. In-service types and best practices. In Journal of Research and Development in Education. 18, 33-38, (Winter).

Kramer, P. J. and Betz, L. E. 1987. Effective Inservice Education in Texas Public Schools. (ERIC Document Reproduction Service No. ED 290 205)

Lawrence, G. 1981. A synthesis of research on the effectiveness of staff development programs, ERIC Clearinghouse. (ERIC Document Reproduction Service No. ED 211 499)

Lawrence, G. and others. 1974. Patterns of effective inservice education: A state of the art summary of research on materials and procedures for changing teacher behaviors in inservice education. Tallahassee: Florida Department of Education.

Lawrence, Gordon, and Harrison, D. 1980. Policy implications of the research on the professional development of education personnel: An analysis of fifty-nine studies. Washington, D.C.: Feistzer Publications.

Lieberman, A. 1978. Staff development: New demands, new realities, new perspectives. Teachers College Record. 80, (1), pp. 1-3.

Lieberman, A. and Miller, L. (Eds.). 1979. Staff development: New demands, new realities, new perspectives. New York: Teachers College Press.

Marks, Mary V. 1978. Curriculum materials dissemination. American Vocational Journal. 53, (5), 22-24, (May).

Matthews, Doris B., Hill, H., and Casteel, J. F. 1984. Staff development: A matter of survival. A paper presented at the annual conference of the Association for Supervision and Curriculum Development. New York (March). (ERIC Document Reproduction Service No. ED 241 510.)

McDonald, Frederick J. 1978. Criteria and methods for evaluating inservice training programs. Inservice Education: A Guide to Resources and Information, Clearing House. pp. 32-39.

McLaughlin, M. W., and Marsh, D. D. 1978. Staff development and school change. Teachers College Record. 80, (1), 69-94.

Moore, Gary. 1987. The status of agricultural education prior to the Smith-Hughes Act. The Agricultural Education Magazine. 59, (8), 8-10.

Mork, G. M. 1953. Effects of an In-Service Teacher Training Program on Pupil Outcomes in Fifth and Sixth Grade Science. (Doctoral Dissertation, University of Minnesota, 1953). Dissertation Abstract International, No. 5364.

Mullen, G. J. 1975. History and analysis of curriculum thought, 1940-1975. Paper presented at the annual meeting of the American Educational Research Association, Washington, D.C. (ERIC Document Reproduction Service No. 103 969).

Mullinix, M. K., Weston, C. R., and Linhardt, R. E. 1987. Workshop Effect on Curriculum Implementation. (ERIC Document Reproduction Service No. 278 784).

National Education Association. 1966-S1. Inservice Education of Teachers: Research Summary. Washington D.C.: NEA Research Division. ERIC Clearing House on Teacher Education. (ERIC Document Reproduction Service No. ED 022 728).

Nicholson, A., Joyce, B.R., Parker, D., and Waterman, F.T. 1976. The literature on inservice teacher education: An analytic review. ISTE Report III. Palo Alto, Calif., (Monograph sponsored by National Center for Educational Statistics and Teacher Corps.) (ERIC Document Reproduction No. ED 129 734).

Orrange P. A., and van Ryn, M. 1975. Agency roles and responsibilities, Roy A. Edelfelt and Margo Johnson, eds., Rethinking In-Service Education. p. 47, Washington, D.C.: National Education Association.

Palmer, L. 1971. An appraisal of the teaching materials for vocational agriculture I developed by the Teaching Materials Center at Texas A & M University. Dissertation Abstracts International. 32/03-A, 1196-A, University Microfilms No. 71-72, 700, 221.

Pepple, J. D. 1982. Factors Associated with the Use and Effectiveness of the Illinois Core Curriculum in Agriculture. (Doctoral dissertation, University of Illinois, 1982.) Agricultural Education Division, University of Illinois, Champaign, Illinois.

Rogers, E. M., and Shoemaker, F. F. 1971. Communication of innovations: A cross-cultural approach. (2nd ed.) New York: The Free Press.

Romberg, T. A., and Price, G. G. 1982. Curriculum implementation and staff development as cultural change. In G. A. Griffin (Ed.), Staff Development: Eighty-second yearbook of the National Society for the Study of Education, Part II. pp.154- 184. Chicago: The University of Chicago Press.

Ryan, R. L. 1987. The Complete Inservice Staff Development Program. Englewood Cliffs, N.J.: Prentice-Hall.

Sackman, Harold. 1975. Do staff development practices make a difference? Improving Inservice Education. ed. Louis Rubin. Boston: Allyn and Bacon, Inc.

Schiffer, Judith. 1980. School Renewal Through Staff Development. New York: Teachers College Press.

Schmid, R., Korinek, L., and McAdams, M. 1985. Inservice types and best practices. Journal of Research and Development in Education. 18, (2), 33-38.

Sergiovanni, T. J., and Starratt, R. J. 1983. Supervision: Human perspectives. (3rd ed.). New York: McGraw-Hill Book Company.

Shipman, M. D. 1974. Inside a curriculum project: A case study in the process of change. London: Methuen & Co. Ltd.

Smith, K. L. 1985. Does in-service make a difference? Journal of Extension. 23, (Winter), 5-7.

Swenson, Thomas L. 1981. The state-of-the-art in inservice education and staff development in K-12 schools. Journal of Research and Development in Education. 15, (Fall): 2-7.

Texas Education Agency. 1978. A Review of Inservice Education in Texas. Austin: Agency Printing Office.

Tyler, Ralph W. 1971. Inservice education of teachers: A look at the past and future. In Improving Inservice Education. ed. Louis Rubin. Boston: Allyn and Bacon, Inc.

Unruh, G. G. and A. Unruh. 1984. Curriculum Development. Berkely, CA: McCutcheon Publishing Corporation.

Wade, Ruth K. 1984. What makes a difference in inservice teacher education: A meta-analysis of research. Educational Leadership. 42, 48-54.

Ward, William. 1972. A Review of Literature and Research on Inservice Training for Teachers with Emphasis on Vocational and Technical Teachers. (ERIC Document Reproduction Service No. ED 073 244).

Wehmeyer, Lillian M. 1974. Evaluation of in-service education: A survey of Methods. California Journal of Teacher Education. 2, (2), (October), 102-110.

Williams, David L. 1990. Focusing Agricultural Education Research: Strategies For the Discipline. A paper presented as the keynote address at the Central States Agricultural Education Research Conference, Chicago, Illinois, February 24, 1990.

Wolf, Steven. 1981. The Alaska Special Education In-Service Training Center. Journal of Staff Development. 2, 2-18, (November).

Yarder, Sam. 1976. An exploratory model for program development in inservice education. In Creative Authority and Collaboration. A collection of position papers by Sam Yarger et.al. Report No. 4. Palo Alto, Calif.: In-Service Teacher Education Concepts Project (June).

APPENDICES

APPENDIX A

Definition of Terms

Definition Of Terms

Delphi technique: a research tool which utilizes a panel of experts to elicit professional opinion without bringing the experts together in a face to face meeting. Information from each of the panel members is collected by the researcher using successive questionnaires. Feedback of results accompanies each iteration of the questionnaire, which continues until convergence of opinion, or a point of diminishing returns, is reached. The end product is the consensus of experts, including their commentary, on each of the questionnaire items. (Kramer and Betz, 1987)

Early adopters: are a more integrated part of the local social system than are innovators. They represent successful and discrete use of new ideas and are highly respected by their peers. The early adopter is considered by many as "the person to check with" before using a new idea. (Rogers and Shoemaker, 1971)

Expert: is one whose knowledge and experience make him/her an authoritative specialist. (Kramer and Betz, 1987)

Innovation: an idea, practice, or object perceived as new by an individual. (Rogers and Shoemaker, 1971)

Innovators: are the first to try new ideas, they seek and even create innovations. They are considered venturesome because they assume risks that others are not willing to take. (Rogers and Shoemaker, 1971)

Inservice teacher education: any organized effort to improve the performance of teachers in already assigned positions.

Modified Delphi technique: for the purpose of this study, involves altering the first phase of the Delphi technique by beginning with a list of elements from the literature rather than asking the panelists to formulate an original list. (Kramer and Betz, 1987)

Preservice training: the education or training that a teacher receives prior to becoming a certificated teacher. (Kramer and Betz, 1987)

APPENDIX B

Correspondence

Dear (name):

Ralph Berry suggested I contact you as an expert member of a panel to review an IPM (integrated pest management) curriculum for use in secondary schools. Would you please consent to being on this panel?

This curriculum is part of a study being conducted for Agricultural Education in Oregon.

We have included the objectives for a series of twelve lessons covering the foundations of IPM. Each proposed lesson would constitute one fifty-minute period for a group of advanced secondary students enrolled in agriculture. As a reviewer we need your help in determining appropriate content and volume of material with these lessons. At your earliest convenience would you please review the enclosed lesson objectives for this curriculum, marking suggestions, changes, and comments on this copy and return to me within two weeks of receiving this document. If you would like a copy of the revised document, please include a note with your review.

Our time schedule dictates that we in-service this curriculum in August 1991, therefore it is essential that we receive your review as soon as possible. We appreciate your help with this project and we're looking forward to your professional assistance in developing a valid and sound curriculum in IPM for use in secondary schools.

We sincerely appreciate your cooperation in this study.

Sincerely,

Bill Doerner
Graduate Student

Herschel Weeks
Assistant Professor

May 30, 1991

Joe Clokey
San Luis Video Publishing
P.O. Box 4604
San Luis Obispo, CA 93403

Dear Joe,

Thank you very much for allowing me to make copies of your IPM video tapes. Your interest and cooperation regarding the IPM curriculum I am putting together for my master's research project is greatly appreciated. The tapes will make the curriculum much more meaningful and interesting for the students.

I will make sure that all of the copies are erased as soon as the curriculum has been taught. Enclosed is a draft of the letter I will send to each of the teachers explaining the conditions under which the tapes are to be used. Please feel free to edit the draft and return to me so I can make corrections before sending it out.

In order for me to have copies of your tapes made I must provide written proof of your consent. Please send a waiver for copying your three IPM tapes for use in this study only to:

Dr. Herschel Weeks
Assistant Professor
Dept. of Agricultural Education and General Agriculture
College of Agricultural Sciences
Strand Agriculture Hall 112
Oregon State University 97331-2204

If you have any questions concerning this request or this study please call me or Herschel Weeks (503) 737-2661.

We are fast approaching the end of our fiscal year in this department so it is critical that we receive the waiver as soon as possible while money still exists.

Thanks again Joe for your generous cooperation and interest in this study. I will be happy to send you a copy of the completed curriculum when it is finished.

Sincerely,

Bill Doerner
Graduate Student

May 30, 1991

Joe Clokey
FYI: This is a draft of the letter I will send to the teachers who will be using copies of your IPM video tapes.

Dear (teacher's name):

Enclosed are copies of three IPM video tapes to supplement the curriculum. The originals were produced by the San Luis Video Publishing Company. This company has generously allowed me to make copies of their tapes for use in this study only.

Please do not duplicate these tapes, the quality of these copies is much lower than that of the originals. The high quality originals are available for a very reasonable price from the company. The tapes must be returned to me upon completion of this study. Your compliance with this request is very important.

I am extremely grateful to the San Luis Video Publishing Company for allowing me to make these tapes available to you for this study. If you wish to purchase these tapes or any other of their excellent educational and training videos, you may write for their free catalog to the following address:

San Luis Video Publishing
P.O. Box 4604
San Luis Obispo, CA 93403

Thank you very much for your cooperation.

Sincerely,

Bill Doerner
Graduate Student

Herschel Weeks
Assistant Professor

Table B.1 A Matrix for *Identifying the Early Adopters Among Agriculture Science and Technology (AST) Teachers in Secondary Education in Oregon.

Name	Group Involvement	History of Adoption	Group Leadership	Level of Credibility	Total Score

* Scale for identifying teachers.

1 = innovator (venturesome)

2 = early adopter (respectable)

3 = early majority (deliberate)

4 = late majority (skeptical)

5 = laggard (traditional)

Identification of Innovators and Early Adopters Among Agriculture Science and Technology (AST) Teachers in Secondary Education in Oregon.

The following is a matrix of the AST teachers currently working in Oregon high schools and criteria for identifying innovators and early adopters.

Please identify each of the teachers by placing a score of 1-5 in each of the columns based on the following criteria:

1 = innovator.
2 = early adopter.
3 = early majority.
4 = late majority.
5 = laggard.

<u>Age.</u>

Most innovators and early adopters are under the age of 50. Mark the age column for each teacher according to the following:

age 30 or less = 1.
age 30-40 = 2.
age 41-50 = 3.
age 51-60 = 4.
age 61+ = 5.

<u>Group Involvement.</u>

Consider the following elements:
- -professional meetings attended.
- -local student contests\competition.
- -state level contests\competition.
- -local committees.
- -state level committees.

Based on "your perceptions" of the teacher's involvement in these areas please mark 1-5 in the appropriate column.

<u>History of Adoption.</u>

What is the teacher's history of adoption of:
- -new curriculum (update and revision).
- -new practices.
- -new equipment.
- -new techniques.
- -program structures.

Based on "your perceptions" of the teacher's history of adoption in these areas, please mark 1-5 in the appropriate column.

Group Leadership.

Does the teacher display a high degree of group leadership at the following levels:

1. Informal Settings.
   -do peers follow teacher's lead?

2. Formal Settings.
   -offices held in organizations?

Based on "your perceptions" of the teacher's group leadership evidence please mark 1-5 in the appropriate column.

Level of Credibility.

Is the teacher credible among his\her peers?

Based on "your perceptions" of the teacher's level of credibility please mark the appropriate column as follows:

very high degree of credibility = 1.

high degree of credibility = 2.

moderate degree of credibility = 3.

low degree of credibility = 4.

very low degree of credibility = 5.

Total Score.

Please leave this column blank.

References

Lionberger, Herbert F. and P.H. Gwin. 1982. Communication Strategies: A Guide for Agricultural Change Agents. University of Missouri, Columbia Campus. Copyright 1982, Interstate Printers and Publishers, Inc. pp 57-90.

Rogers, E. M., and Shoemaker, F. F. 1971. Communication of innovations: A cross-cultural approach. (2nd ed.) New York: The Free Press.

August 8, 1991

Dear (AST Teacher),

You have been identified as an Innovator/Early Adopter in the field of Agriculture Science and Technology in secondary education in Oregon. Congratulations on your excellent record of achievement.

Herschel Weeks and I are conducting a study to determine if in-service training of teachers results in increased learning by students when new curriculum is introduced. We have decided to work with the Innovators and Early Adopters like yourself in order to make this research more meaningful. Would you please participate in this research endeavor?

We have developed a short curriculum (10 lessons) for teaching the fundamentals of Integrated Pest Management (IPM). Our plan is to in-service one experimental group of teachers with the curriculum at the 1991 Oregon State Fair and ask them to teach it this fall. The control group of teachers will also receive the curriculum but not receive in-service training and will then be asked to teach it this fall.

We would certainly appreciate your participation in this study. Please contact us as soon as possible if you do not want to participate. If you do not contact us we will assume you have agreed to be a part of this research. More details on this study will be sent to you next week.

Once again, congratulations on your accomplishments and thank you for your cooperation. If you have any questions please don't hesitate to call us.

Sincerely,

Bill Doerner Graduate Student	Herschel P. Weeks Assistant Professor

September 5, 1991

Dear (AST Teacher),

We want to thank you for being a part of this study to determine the value of in-service training when new curriculum is introduced. You were selected based on your outstanding record of accomplishments as a teacher.

Enclosed is the IPM curriculum (10 lessons) introduced to you in an earlier letter. This material needs to be taught as soon as possible, to a class or classes of your choice. Many lessons require the collection of insects, weeds, and disease specimens by the students which will be difficult to find later in the season. After the completion of the lessons please give your students the enclosed final exam and send us their ages and scores. We need ages and scores so we can compare scores of students in the same age group for more accurate results.

Also enclosed are copies of three IPM video tapes to supplement the curriculum. The originals were produced by the San Luis Video Publishing Company, San Luis Obispo, CA. This company has generously allowed me to make copies of their tapes for use in this study only. Please do not keep or duplicate these videos. Information on where you can get an original is provided. Please return the tapes to Herschel or myself upon completion of this study.

Your suggestions and constructive comments for improvement of this curriculum are most welcome and will be incorporated when this study is complete. It is hoped that with improvements, the curriculum can be distributed to AST teachers throughout the state sometime later.

Finally, we would like to thank you very much for taking time out of your busy schedule to cooperate with us. Integrated Pest Management is an extremely important subject and yet there has not been an IPM curriculum available to AST teachers. We hope you and your students find the IPM material interesting and challenging. Please feel free to call Herschel or I if you have any questions concerning this study or the curriculum.

Sincerely,

Bill Doerner
Graduate Student

Herschel Weeks
Assistant Professor

05 February 1992

Dear AST Teacher,

Just a note to remind you to please send me your results from the IPM experimental curriculum you taught. I need your student's test scores and their ages. Your results are very important for this study. Please take a moment and send me your data. Thanks so much for your continued cooperation.

Sincerely,

Bill Doerner
Graduate Student
Agricultural Education

APPENDIX C

IPM Curriculum

INTEGRATED PEST MANAGEMENT

An Experimental Curriculum
for
Agricultural Science and Technology

by

Robert W. Doerner

Agricultural Education and General Agriculture
Oregon State University

1991

TABLE OF CONTENTS

LESSON PLAN

Area and/or Course ______________________ Unit ______________________

Lesson Title **Introduction to Pest Management.** No. Periods 02 Date ________

Upon completion of this lesson, the student will be able to:

Objectives:

1. Define\explain the following terms: pest, key pest, secondary pest outbreak, natural control, monoculture, pest resurgence, pesticide resistance, integrated pest management (IPM).

2. Describe the four major categories of agricultural pests.

3. List four environmental factors which influence pest populations.

Student Activity.

4. Discuss how consumer demand for blemish-free produce contributes to pest management problems.

   Students will bring in examples of fresh fruit/vegetables from various sources: grocery store, garden, organic grower, etc. for discussion/comparison of fruit.

Materials, Equipment, Audio-visual aids:

1. Several examples of fresh fruit and vegetables from various sources showing signs of cosmetic damage (slight blemishes) , also examples of consumer demanded "blemish-free" produce. (apples, pears, oranges)

2. Pocket knife and cutting board.

3. "Integrated Pest Management (IPM)" , a videotape available from: San Luis Video Publishing Inc. P.O. Box 4604 San Luis Obispo, CA 93403.

4. Color TV and VCR (for VHF videotape)

References:

Bottrell, Dale R. 1979. Council on Environmental Quality: Integrated Pest Management.

Davidson, Ralph H. and William F. Lyon. 1987. Insect Pests of Farm, Field, and Orchard. John Wiley & Sons Inc. pp 1-3.

Higley, Leon G., Karr, Laura L., and Larry P. Pedigo. 1989. Manual of Entomology and Pest Management. Macmillian Publishing Company New York. pp. 282.

Hurley, Katherine A. 1990. Texas Agriculture Science and Technology Curriculum.

Olkowski, William, Olkowski, Helga, and Sheila Daar. 1988. What is IPM? Common Sense Pest Control IV(3) Summer.

U.S. Environmental Protection Agency Office of Research and Development Research Summary: Integrated Pest Management. 1980. EPA-600/8-80-044 September 1980. pp 1-5.

Introduction -- Motivation -- Interest Approach:
(Application is laced in at this point).

What is a pest? The term **"pest"** is a label applied by humans and has no ecological validity. Whether an organism is considered helpful, harmful, or neutral depends very much on whether humans are cooperating, competing, or indifferent to their presence. The concepts of pest management dictate a tolerant approach to pest status. <u>Not all pests or their damage is intolerable!</u>

Problem Stated, Solutions to Problem, Steps Sequenced, Subject Matter Points, Student Learning Activities, Artful Questions: (Application is laced in at this point, lessons designed to meet the objectives set forth)	Strategy - How are you going to proceed through the lesson: (What objectives are you meeting here?)
What is IPM?	Show the IPM video.
	Discuss the new terms.
What are the four major categories of agricultural pests?	Discuss the categories of pests: arthropods, pathogens, weeds, and vertebrates.
	(see attached material)
What is natural control?	Discuss the types of natural control: weather conditions,

geographical barriers, natural enemies, etc.
(see attached material)

The overuse of pesticides has contributed to several important problems such as: pesticide resistance, secondary pest outbreaks, and environmental contamination. Much of the pesticides applied to fruits and vegetables in the U.S. are for aesthetic reasons. As consumers we have come to expect "blemish-free" produce. In doing so we have forced farmers to apply more pesticides than are really necessary to produce healthy good tasting produce.

As a group activity, have students bring to class examples of fruit from different sources: i.e. grocery store/supermarket organic farm or backyard orchard for comparison.

compare fruit for visual quality vs price vs taste

cut and peel fruit to remove blemishes, then taste and compare. conduct a group discussion.

Summary -- Conclusion to the Problem: (Application is re-emphasized here and as many students as possible are drawn into the class).

IPM is an interdisciplinary approach incorporating the judicious application of the most efficient methods of maintaining pest populations at tolerable levels. The ultimate goal of IPM is to manage pests in an economically efficient and environmentally sound manner.

We have seen that IPM offers a more rational approach to pest management. IPM concepts dictate a tolerant approach to pest status, not all pest damage is intolerable.

Evaluation: (Questions and/or activities which reflect the objectives of the lesson).

1. Define\explain the following terms:

pest: any organism that may adversely affect human activities.

key pest: those pests which occur in large numbers on a regular basis for a given crop.

secondary pest : other less important pests which usually occur in low numbers and are controlled by natural forces.

natural control: control measures which occur without the intervention of humans.

monoculture: the practice of growing the same crop in the same area on a continuing basis.

pest resurgence: a rapid resurgence of the target pest following a pesticide application which makes further pesticide applications necessary to control the resurgence.

pesticide resistance: the genetic ability of some organisms to tolerate normally lethal doses of a pesticide.

Integrated Pest Management: a decision making process for determining: IF you need pest suppression treatments, When you need them, Where you need them, and What strategy and mix of tactics to use to provide cost-effective, environmentally sound control.

Assignments: (Designed to meet lesson objectives).

Each student will bring two examples of a fruit or vegetable to class which show the following:

1. Some kind of mild to moderate damage (blemish) caused by a pest. An example would be an orange with red scale (an insect) on the fruit rind, or a worm "sting" on an apple or pear.

2. A blemish-free (clean) orange or apple which are commonly found in a local grocery store or supermarket.

The student will record the source of the fruit and the price/lb. paid. The student will also compare the aesthetic quality vs. price vs. taste. Is the difference in price worth the cosmetic appeal? Have a class discussion over this question encouraging students to consider both sides of the argument.

INTRODUCTION TO PEST MANAGEMENT

Since the beginning of recorded history humans have been plagued by an assortment of pests. The Bible refers to frogs, gnats, flies, locusts, blights, blasts, and mildews as pests over 2000 years ago. The word pest is a general term for any organism that may adversely affect human activities. We may think of an agricultural pest as one that competes with crops or livestock for nutrients and water, defoliates plants, or transmits plant or animal diseases. Damage by pests to agricultural crops in the United States has been estimated to be one-third of the total crop production potential.

1. Major Types of Pests.

The major types of agricultural pests include:

A. **Weeds.**

examples include: Bull thistle Cirsium vulgar
Canada thistle Cirsium arvense
Field bindweed Convolvulus arvensis
Tansy ragwort Senecio jacobaea

B. **Arthropods** (insects and their relatives).

examples include: Codling moth Cydia pomonella
Lygus bugs Lygus spp.
Spider mites Tetranychus spp.
Apple maggot Rhaguoletis pomonella

C. **Pathogens** (disease causing organisms).

examples include: mildew various fungi
Eastern Filbert Blight Anisogramma anomala
Apple scab Ventura inaequalis
Crown gall Agrobacterium radiobacter
Nematodes

D. **Vertebrates.**

examples include: Rats (Muridae)
Pocket gophers (Geomyidae)
Rabbits (Leporidae)
Nutria Mycocaster coypus

2. Natural Control.

Natural control measures are those which occur without the intervention of humans. Listed below are some of the naturally occurring factors which influence pest populations and their damage to crops.

A. **Weather.**

Weather conditions include temperature, relative humidity, light intensity, daylength, wind/air currents.

Temperature is the most important factor for insect growth and development, at high temperatures insect complete their life cycle in less time. Light, temperature, and relative humidity affect a pests life cycle. Warm, humid weather conditions provide favorable conditions for rapid disease development. Periods of hot dry weather are usually unfavorable for disease and insect development. Cold weather, especially temperatures below freezing, can reduce many arthropod pest populations.

Light intensity influences mating, egg laying, and dispersal by prompting a behavioral response or change in growth and development of insects.

B. **Physical Conditions.**

Physical conditions include mountains, bodies of water, condition of the soil, presence of a food supply.

The physical condition of the soil influences the kinds of plants which grow in a particular area. This in turn, influences the food supply for pests. For example a hard pan or compacted soil makes it difficult for insects to burrow through the soil, lay eggs, or complete development. It also influences the population of predators which feed on the insects.

The food supply influences the distribution and numbers of insects. When the food supply decreases, insects die or migrate to new locations. When a variety of plants exists in an area, insects turn to alternative food sources. This enables insects to complete their life cycles.

Oceans and mountains are barriers to insect migration. Increasing altitude changes the temperature, moisture content, light intensity, and food supply.

C. **Biotic Factors.**

Pests have many natural enemies. Birds, fish, mammals, and reptiles consume arthropods and weeds. Several insects feed on other insects (parasites and predators) and weeds. Disease organisms attack and destroy other disease organisms, weeds, and arthropods.

3. Factors Which Contribute to Pest Problems.

A. Monoculture.

The practice of growing the same crop in the same area on a continuing basis is referred to as monoculture.

Growing acres and acres of a single crop such as corn, wheat, or soybeans creates an almost unlimited food supply for insects which feed on these crops. Insects that are not pests under normal circumstances become pests in a monoculture environment because the crop becomes the only major source of food in the area.

B. **High Consumer Demand for Blemish-free Produce.**

The emphasis on cosmetic appearance or "perfect produce" has forced many farmers to use pesticides more frequently than necessary. As consumers we could tolerate more damage on the produce we buy. This would help farmers decrease the amount and frequency of pesticide used to promote a healthy environment.

C. **Overreliance on Pesticides.**

Before the Second World War, relatively small amounts of chemicals were used for pest control. Production of pesticides in 1945 was less than 200 million pounds. The development of synthetic chemicals during the war resulted in a dramatic increase in the production and use of pesticides. During the next 30 years, pest management became increasingly dependent upon chemicals, with 1.6 billion pounds of pesticides being produced in 1975.

The rapid rise in the popularity of pesticides was due primarily to their increased effectiveness, low cost, and availability. Because pesticides were initially so successful, farmers came to rely much less on traditional pest control measures such as tillage, crop rotation, and use of the pests' natural enemies. Regular application of pesticides became standard practice.

Unfortunately, such widespread use of pesticides has been accompanied by unforseen problems. The impact of these problems is far reaching and concerns not only the agricultural community but the general population as well.

In order to meet the demands of a rapidly increasing world population, more food and fiber crops are required each year. As demand increases, prevention or reduction of crop loss becomes even more critical. Today, despite the tremendous amount of pesticides being used, approximately one-third of all crops planted in the U.S. fail to reach harvest because of pests.

There are at least three problems which may result when pesticides are the only method used to control pests.

1. **Pesticide Resistance.**

Pesticide application seldom results in the total eradication of a pest population. A few individuals, due to their genetic makeup, will be resistant to the pesticide. When these survivors reproduce some of the next generation will inherit this resistance. The next time the pesticide is applied, a larger percentage of the pest population will survive and reproduce, increasing the number of resistant pests. Eventually, a highly resistant population will be produced which cannot be controlled by the pesticide developed for its management.

2. **Secondary Pest Outbreak.**

Every agroecosystem contains a number of **key pests** which occur in large numbers on a regular basis for a given crop. They are the targeted pests which usually require control every season. In addition to the key pests, there are a number of other less important, **secondary pests** which occur in low numbers and are controlled by natural forces. Pesticide applications do not kill only the target pests. Broad spectrum pesticides kill both the target pest (key pest) and the natural enemies which keep the secondary pests under control. The loss of these natural enemies following pesticide treatment may result in an increase in the population of a previously controlled pest. This "new" pest population may cause more damage to the crop than the initial (key) pest. This situation is referred to as a **secondary pest outbreak**.

A similar problem called **pest resurgence** results in a rapid resurgence of the target pest which makes further pesticide applications necessary to control the resurgence. These flarebacks occur from individuals surviving treatment or from individuals migrating into the treated area, where they can reproduce unhindered because their natural enemies have been eliminated.

3. **Environmental and Health Hazards**.

Perhaps the most significant problem associated with the overreliance on pesticides is the threat to human health and the environment. Some pesticides may be highly persistent; that is, slow to break down via natural environmental processes. Pesticides can filter into the soil or water where they are taken in by microorganisms. Since these microorganisms, in turn are consumed by other organisms, pesticides may enter the food chain and be concentrated. Pesticide residues are therefore detected not only in treated crops but also in fish, waterfowl, livestock, and humans.

DDT is an example of a highly persistent pesticide. Due to its widespread use in the years following World War II, tremendous amounts of DDT were introduced into the environment, entered the food chain, and accumulated in the fatty tissue of living organisms. In December 1972, following the discovery that DDT causes some birds to produce abnormally thin-shelled eggs and causes cancer in laboratory mice and rats, EPA (Environmental Protection Agency) placed a near-total ban on its domestic use. Despite this ban, DDT persists in the environment. Mussels and fish collected four years after the ban were still found to contain residues of DDT.

Integrated Pest Management (IPM).

Recognition of the problems associated with widespread pesticide application has encouraged the development and utilization of alternative pest management strategies. Rather than employing a single control tactic, attention is being directed to the coordinated use of multiple tactics, an approach known as **integrated pest management**. Integrated Pest Management (IPM) is a decision making process for determining: **IF** you need pest suppression treatments, **When** you need them, **Where** you need them, and **What** strategy and mix of tactics to use in order to provide cost effective, environmentally sound control. IPM is by no means a new concept; some forms of integrated pest control have been practiced for centuries. The significance of today's IPM concept is that it is based on a scientific approach employing sophisticated control techniques.

Development and implementation of an IPM system requires an understanding of the crop-pest ecosystem and available control tactics. Understanding an entire crop-pest ecosystem is not a simple task. It requires not only simple identification of the crop and the pest to be managed, but also close examination of complex crop-pest interrelationships. Detailed study of a crop's botanical characteristics is essential to allow the IPM strategist to take full advantage of natural processes. The IPM approach emphasizes that almost every cropland, as compared to a meadowland, represents an unusual ecological setting composed of a single plant type. In such single plant communities, natural ecological balances are altered, leaving crops highly susceptible to pests.

Under IPM, the pest targeted for control is also studied in detail. Attention is given to the pest's life cycle and to precisely how it adversely affects the plant. An important consideration is the dynamic nature of pest populations; most pests reproduce frequently and produce numerous offspring, enabling them to adapt quickly to changing environments. Relationships between the pest and other organisms are also studied, with particular attention being given to the pest's natural enemies and to its role in controlling other pests. With an understanding of the characteristics of both the crop and the pest, the most desirable control tactic or combination of tactics can be selected.

Principles of IPM

The following principles are important in developing a cohesive system for managing pests.

1. **Potentially harmful species will continue to exist at tolerable levels of abundance.** The philosophy is to manage rather than to eradicate the pests.

2. **The ecosystem is the management unit.** Knowledge of the actions, reactions, and interactions of the components of the ecosystem is necessary in order for IPM programs to be effective.

3. **Use of natural controls is maximized.** IPM emphasizes the fullest practical utilization of existing natural controls in the ecosystem which serve to regulate a pests' population growth.

4. **Any control procedure may produce unexpected and undesirable consequences.** The overreliance on chemical pesticides has dramatized the point that any single control procedure can have unexpected and undesirable consequences.

5. **An interdisciplinary systems approach is essential.** Effective integrated pest management is an integral part of the overall management of a farm, a business or a forest.

LESSON PLAN

Area and/or Course ______________________________ Unit ________________________

Lesson Title **Sampling and Monitoring.** No. Periods 01 Date __________

Upon completion of this lesson, the student will be able to:

Objectives:

1. Define/Explain the following terms: monitoring, economic injury level, economic threshold, population equilibrium level, scouts.

2. Explain the four step process for monitoring pests.

Student Activities.

3. Demonstrate a sampling technique in the field.

4. Process alfalfa sweep net samples by sorting, counting, and recording the contents. (Note: If alfalfa is not a feasible crop, use whatever is available in your area.)

5. Collect samples of weeds and diseased plants for lessons 4 and 5. (see attached information)

6. Collect live Lepidoptera larvae for lesson 9. (see attached information)

Materials, Equipment, Audio-visual aids:

1. One or two sweep nets (depending upon number of students).

2. Plastic bags for samples (zip lock bags work very well for sweep net samples, almost any plastic bags work well for weed and disease samples, just make sure the bags are big enough to put plants in).

3. Marking pens for labelling samples (sharpie permanent markers work best).

4. Ice chest with frozen blue ice or chunk of dry ice for keeping insect samples cool (insects must be kept cool and inactive until they are killed).

5. Pocket knife or pruning shears for collecting plant material.

6. Access to a freezer to freeze and store the sweep net samples (insects) for lesson 3.

7. An alfalfa field to sample.

8. Two large glass jars (gallon size).

9. Small hand pump sprayer (quart size) for applying Bacillus thuringiensis.

References:

Cooper, Elmer L. 1990. AgriScience Fundamentals and Applications. Delmar Publications Inc. pp 174-175.

Davidson, Ralph and William F. Lyon. 1987. Insect Pests of Farm, Garden, and Orchard. Eighth Edition. John Wiley and Sons. New York pp 122-123.

Olkowski, William, Olkowski, Helga, and Sheila Daar. 1988. What is IPM? Common Sense Pest Control IV(3) Summer. pp 12-15.

Introduction -- Motivation -- Interest Approach:
(Application is laced in at this point).

Monitoring and sampling pest populations is a fundamental part of IPM. It is vital to know the status of a pest population before one can determine what control measures to apply, or if control measures are even necessary. Sampling gives us the information necessary to make intelligent pest management decisions. This lesson will focus on understanding some important concepts associated with sampling. The students will gain hands-on experience by using a sweep net to sample an area for pests.

Problem Stated, Solutions to Problem, Steps Sequenced, Subject Matter Points, Student Learning Activities, Artful Questions: (Application is laced in at this point, lessons designed to meet the objectives set forth)	Strategy - How are you going to proceed through the lesson: (What objectives are you meeting here?)
1. Why is monitoring and sampling an important part of any IPM program?	The students will read the attached background material before coming to class.
2. There are four questions that must be answered when monitoring for pests. WHO? (identify the organism(s) to look for) WHEN? (when to sample? what time of the year?)	The teacher will go over the four questions which apply to monitoring. The class will visit a near-by alfalfa field to collect samples of insects, weeds, and diseased plants.

WHERE? (where to sample in the habitat?)

SO WHAT? (importance? is treatment necessary?)

3. Demonstrate a sampling technique in the field. (sweep net)

4. Process alfalfa sweep net samples:

Working in pairs, the students will take turns sampling, one holds the bag while the other one sweeps. Each student should take 10 sweep net samples. Each sample will consist of 25, 180 degree sweeps in the upper 6" of the alfalfa plants. Samples should be labeled and placed in the ice chest. After returning from the field they will place their samples in the freezer until lesson 3. During this field trip the students should collect as many different weeds and diseases as possible.
The weed and disease samples will be used in lessons 4 and 5. It is important to collect as many as possible on this field trip so that the students will already have material to study in good condition. The students should be encouraged to collect as many weeds and diseased leaves, twigs, branches, etc. before the lessons on plant diseases and weeds. Weed samples should be dried and pressed before the lesson on weeds. See attached information on how to do this. The disease samples should be kept in the refrigerator in the plastic bags until ready to examine.

In addition to the sweep net samples, the students will collect several Lepidoptera larvae (20 - 30) and keep them alive in cages for an experiment with lesson 9 (see attached instructions).

Summary -- Conclusion to the Problem: (Application is re-emphasized here and drawn as many students in the class as possible).

Sampling and monitoring for pests is a necessary part of IPM. There are a wide range of sampling methods and tools available. In this lesson we looked at only one method; the sweep net sample. The methods and tools will vary depending upon the situation. The best sampling methods are practical and reliable. In other words the method should be one that is easily utilized by anyone and does not require expensive equipment or take an unreasonable amount of time. This is very important because pest management decisions must often be made quickly before serious economic loss occurs.

Evaluation: (Questions and/or activities which reflect the objectives of the lesson).

1. Define/explain what the following terms mean:

monitoring: the regular inspection of the areas where pest populations are a concern.

economic injury level: the lowest population density that will cause economic damage.

economic threshold: the density at which control measures should be initiated to prevent an increasing pest population from reaching the economic injury level.

population equilibrium level: the average density of a population over a long period of time in the absence of permanent environmental change.

scout: a person who monitors an area to determine pest activity.

2. What four questions should a person ask himself when monitoring/sampling pest populations?

   who?, when?, where?, so what?

Assignments: (Designed to meet lesson objectives).

Prior to this lesson the students should be instructed to collect weed specimens and examples of diseased or injured plants around their home or area. The weed specimens will need to be dried and pressed before lesson 5.

When collecting diseased plant material look for any type of symptom which looks abnormal. It is important to label the samples with the student's name, date collected, host (if known), and location collected. More details will be discussed in lessons 4 and 5, the important thing is to get the students to begin collecting early so more time can be spent examining the samples in class.

During the field trip for this lesson, the students will collect 20 to 30 (total) Lepidoptera larvae for an experiment demonstrating how microbial insecticides (B.t.) work.

Sampling and Monitoring.

For IPM to be successful, a monitoring (checking) or scouting procedure must be performed. Different sampling procedures have been developed for various crops and pest problems. The presence or absence of the pest, amount of damage, and stage of development of the pest are several visual estimates a scout must make. The method used must be speedy and accurate.

Scouts are people who monitor areas to determine pest activity. They must be well trained in entomology, pathology, agronomy, and horticulture.

Monitoring involves the inspection of the areas where pest problems might occur, and keeping records of what you observe. It means paying close attention to specific animal, plant, or microbial populations, as well as to human behavior and weather. A practical monitoring system does not need to meet the stringent requirements of a research project. Each monitoring system needs to be tailored to the particular situation, i.e., the level of effort should be appropriate to the amount of serious damage caused by the pest, the time available, and the level of the person who will be making the inspections, etc.

Monitoring a small system, such as a residential kitchen with a cockroach problem, may only require quick bi-weekly inspections of sticky traps used to track the rise or fall of roach populations. In large systems such as parks, wholesale nurseries, farms, or forests, where intolerable economic damage may result if pest populations are not controlled, a full scale monitoring program may be required.

This not only involves recording the population size of key pests and their natural enemies, but also may involve keeping track of other potential pest populations, and their natural enemies. The impact of cultural practices such as fertilizing, irrigating, pruning, and mowing on pest populations must be analyzed. The influence of heat, humidity, and such weather phenomena as rain, wind, and flooding on pest population size should also be taken into account. Management of garbage and domestic animals as well as other human behaviors affecting household pests may need to be monitored. Any of these factors may need to be recorded; the decision will depend on the purpose for which the monitoring is undertaken.

Determining Injury Levels.

A key concept in IPM is the use of an "injury" or "tolerance" level to determine if the problem is serious enough to justify some kind of treatment. **Economic injury level** is the lowest population density that will cause economic damage. The level will vary depending on the crop, season, area, and a human scale of values. **Economic (action) threshold** is the density at which control measures should be initiated to prevent an increasing pest population from reaching the economic injury level. **Population equilibrium level** is the average density of a population over a long period of time in the absence of permanent environmental change.

Two values comprise an injury level. The first is the amount of economic or aesthetic damage that can be tolerated. The second is the population size of the pest (insects, weeds, or vertebrates), or number of plants severely affected (in the case of plant pathogens) that must be present to cause unacceptable economic or aesthetic damage.

Setting an injury level may be fairly clean-cut in agricultural crops where the injury level concept was originally developed. For crop production systems, the question is: How much reduction in yield, or cosmetic damage to the product, can occur before the loss of profits is equal to or greater than the cost of pest control? In other words, how much pest damage will make pest management economically worthwhile?

In ornamental landscapes, or inside buildings, the direct economic damage is often difficult to assess. In such cases, injury or damage is a matter of opinion or aesthetic judgment. Opinions differ, and the realities of social systems are that not all opinion carries equal weight when determining policy. Thus, in the case of aesthetic damage, the question may become: How much of the following are the "important" people willing to tolerate:

* changes in appearance of the plant or site (including the loss of the host plant).

* visibility of the pest.

* evidence of pest activities.

* nuisance.

Pest treatments are usually based on some notion (often unspoken) of injury level. In parks, for example, managers frequently act on injury level concepts they have inherited from previous managers or casually accepted along with others in the same bureaucracy. In agricultural settings, the implied or explicit opinions of neighbors, pesticide salesmen, or dealers in agricultural products may influence decisions to take action against pests.

For the decision-making process to yield effective, economical, and environmentally sound pest management activities, however, memory or anecdotal information is not enough. The injury level should be determined, and then redetermined at frequent intervals, **for each pest and for each site.** When an

IPM program is first implemented for a particular pest/site, guidance on setting the injury level may be available from the literature on the pest, through oral discussions with those experienced in managing the pest elsewhere, or from your own or other local recollections of the problem in prior years. However, the initial level set should always be regarded as tentative because of the site-specific nature of the determination.

The process of determining an injury level and then comparing it with field observations or samples before taking action is crucial to the whole IPM program. In fact, a pest management program that is not based on a periodically re-evaluated injury level cannot properly be designated IPM. Pest management activities that are not absolutely necessary waste money and resources and may prolong or exacerbate the pest problem.

Developing A Monitoring Program.

1. Determine the PURPOSE of the monitoring. For example, one might establish a monitoring program to: determine injury levels; predict pest population levels or time treatments; or learn something specific about the biology or ecology of the pest or its natural enemies.

2. Determine WHICH POPULATIONS are to be sampled. For example, although there are many predators and parasitoids which could be monitored with respect to the management of most pests, some are more important to sample than others.

3. Decide which OTHER VARIABLES need to be sampled (i.e., height and frequency of mowing; temperature and humidity; soil fertility and moisture levels; kitchen sanitation, etc.).

4. Decide on the FREQUENCY of the monitoring visits. While once-a-week observation is a common choice, this may need to be varied to suit the season, the weather, the size of the pest population, or other variables. Frequency of visits are usually increased as pest populations approach the injury level.

5. Decide WHICH SITES should be inspected. High priority areas, or those offering examples of characteristic variation in the system, may be visited most frequently.

6. Determine the NUMBER of plants or locations to be sampled at each site.

7. Decide upon a PRECISE SAMPLING PROCEDURE. More than one technique or sample size may have to be tried to determine this. Recording numbers of plants or sites showing damage, and ranking them high, medium, or low; making counts of organisms at specific sites (e.g., the number of caterpillars on the last foot of a branch, five feet above the ground, selected at random on the north, south, east, and west of the tree); and counting or weighing organisms attracted into light or pheromone traps, are some of the many methods available.

8. Devise a RECORD-KEEPING SYSTEM that is easy and quick to use in the field.

9. Develop a system of DISPLAYING the information collected for ease in decision-making.

10. EVALUATE the sampling and decision-making system. For example, one might ask if the treatment actions taken had the desired effect upon the pest population without triggering other problems such as secondary pest outbreaks, or having undesirable effects upon the applicator or the environment.

11. MAKE CORRECTIONS in the overall process. Continue to monitor, and fine-tune the system based on information gained from monitoring.

Microbial Control Experiment.

During the field trip for lesson 2, collect 20 to 30 Lepidoptera larvae (caterpillars). The smaller the larvae the better. Handle them very gently so as not to injure any. Place these in a separate plastic bag for transporting back to school. In another bag collect some of the plant material the larvae were feeding on.

When you arrive back in the classroom, put half of the larvae into a one gallon glass jar with a screen or mesh cloth as a lid (fasten with a rubber band). Place several leaves and terminals of the host plant they were collected on into the jar with the larvae. Label this jar "Control" and record the date collected on the outside of the jar. Place the other half of the larvae into a second jar labeled "B.t. treatment".

Mix one teaspoon of Bacillus thuringiensis (Dipel 2X) into one gallon of water and stir until it becomes dissolved into solution. Place several leaves or terminal shoots of the plant material collected on paper towels. Pour the B.t. solution into your quart sprayer and spray the plant material. If you don't have access to a quart sprayer, just dip the plant material into the solution and let it dry.

After the plants material is dry (about 15 minutes), place the plant material into the jar labeled "B.t. treatment". Observe the larvae each day and record any observations. Continue to provide fresh plant material to the larvae in both cages as they need it. Each day record the number of living larvae in each jar.

LESSON PLAN

Area and/or Course ______________________ Unit ______________

Lesson Title **Insects and Their Relatives.** No. Periods 01 Date __________

Upon completion of this lesson, the student will be able to:

Objectives:

1. Define/Explain the following terms: entomology, arthropod, exoskeleton, instar, metamorphosis, entomophagous.

2. Describe the two general types of insect mouthparts and give an example of an insect with each type of mouthpart.

3. Describe two basic types of metamorphosis in insects and give an example of an insect for each type.

Student Activities.

4. Make the following insect collecting equipment: killing jar, sweep net, and display box.

5. Demonstrate how to collect, mount, label, and display insects by making an insect collection of 10 adult insects which are economically important in your area (identify to order).

Materials, Equipment, Audio-visual aids:

1. Refer to the sheet on how to make a sweepnet for list of materials.

2. Small glass jar with screw on lid, plaster of paris, sawdust, duct tape or masking tape.

3. Insect pins # 2 size, available from OSU Bookstore.

4. Clear finger nail polish.

5. Cigar box or similar size box with lid.

6. 10X handlens (optional).

References:

Capizzi, Joseph. 1987. Oregon 4-H Entomology Manual. Oregon State University Extension Service.

Davidson, Ralph H. and William F. Lyon 1987. Insect Pests of Farm, Garden, and Orchard. Eighth Edition. John Wiley and Sons. New York. p.l.

Pinkston, Ken and Stanley Coppock. Oklahoma 4-H Member's Guide. Lessons in Entomology. Lessons 1-6. Oklahoma State University Cooperative Extension.

People and Insects. Nature Scope vol.1 no. 1 1985. pp 45-54.

Introduction -- Motivation -- Interest Approach:
(Application is laced in at this point).

Insects are the most abundant form of life on the earth. They are found nearly everywhere in the world except in the open seas and some parts of the polar regions. They have been on the earth over 250 million years and seem destined to remain. Whether they are considered helpful, harmful, or neutral depends very much on whether humans are cooperating, competing, or indifferent to their presence.

Problem Stated, Solutions to Problem, Steps Sequenced, Subject Matter Points, Student Learning Activities, Artful Questions: (Application is laced in at this point, lessons designed to meet the objectives set forth)

What are insects?

What are the two general types of insect mouthparts? (chewing and sucking)

What is metamorphosis?

Describe two types of metamorphosis common to insects (complete, gradual).

How to pin (mount) and label insects.

Teachers/students can make small labels on a typewriter, then reduce on a xerox machine; entire sheets for everyone with the basic information, i.e.:

your county   Benton Co.

Strategy - How are you going to proceed through the lesson: (What objectives are you meeting here?)

The students will study the attached material on insects before coming to class. The students will take their sweep net samples collected during lesson 2 out of the freezer to thaw out (about 15 minutes at room temperature). During this time the teacher will review the reading material with students.

The instructor will demonstrate to the class how to pin insects (refer to the attached information). Give the students a chance to try pinning a few by them- selves (start with the larger ones, they're easier). When most of the students have pinned some larger insects, try pinning a few small ones on a paper point.

your city, state	Corvallis, OR
Date	Sept. 19
Collector	your name
Location/habitat	alfalfa

After pinning the insects, be sure to make at least a temporary label for each one refer to the attached material on how to label insects.

How to make a killing jar and sweep net for collecting insects.
(refer to the attached material)

Toward the end of class, the teacher will demonstrate how to make and use a killing jar. If time permits, the teacher will demonstrate how to make a sweep net.
Before leaving class, have the students save any insects they did not have time to pin in the plastic bag and return it to the freezer for use later.

Summary -- Conclusion to the Problem: (Application is re-emphasized here and drawn as many students in the class as possible).

Scientists estimate that there are over 1 million species of insects. Insects are considered to be one of the most successful groups of animals present on Earth. Their success in numbers and species is attributed to several characteristics, which include their anatomy, reproductive potential, and developmental diversity. In this lesson we have looked at some insects and in doing so have gained a better appreciation for their fascinating diversity and complexity. We have learned how to collect and preserve insects for study or enjoyment. The majority of insects are beneficial as predators and parasites as well as providing pollination for our crops worth over $1 billion per year.

Evaluation: (Questions and/or activities which reflect the objectives of the lesson).

1. Define\explain the following terms:

entomology: the scientific study of insects.

exoskeleton: a skeleton or supporting structure on the outside of the body composed of chitin.

metamorphosis: the changes that occur as insects develop from the egg stage to the adult reproductive stage.

life cycle: the period of time from hatching to the adult stage.

instar: the form of an insect between successive molts.

entomophagous: to feed upon insects.

2. List the two general types of insect mouthparts and give an example of an insect with each type of mouthpart.

chewing: grasshoppers.

sucking: aphids.

3. Describe two basic types of metamorphosis in insects and give an example of an insect for each type.

complete metamorphosis: egg, larva, pupa, adult.

Lepidoptera (moths, butterflies).
Diptera (flies)
Coleoptera (beetles).

gradual metamorphosis: egg, nymph, adult.

Orthoptera (grasshoppers, crickets).
Hemiptera (true bugs).
Homoptera (aphids, scales).

Assignments: (Designed to meet lesson objectives).

The students will study the background material on insects carefully before coming to class. Each student will bring a display box to class for storing his/her insects. The student should make their storage box prior to lesson 3 so they have something to store their insects in. The following materials are recommended for making a display box:

Materials:

1. Cigar box, 2 x 6 x 8 inches or similar size cigar box. If a cigar box is not available, use any small box (i.e. shoebox) with a lid.

2. Piece of corrugated cardboard, soft fiberboard or styrofoam.

3. Glue.

4. Moth crystals or moth balls mounted on straight pins to keep pests out of collections. (This is very important because there are tiny beetles called dermestids which feed on dead insects and will destroy an unprotected collection.)

5. Pill box or safety match box to hold moth crystals.
6. Insect pins of No. 2 or No. 3 size.
7. Insect labels.

Procedure:

1. Cut the cardboard to fit bottom of box.
2. Smear glue on bottom of box and insert cardboard.
3. Line box with white paper.
4. Fill match box or small pill box with moth crystals.
5. If the pill box is air tight, punch some holes in the lid.
6. Pin the box in a corner of the cigar box.

People and Insects.

Many people often ask "What good is an insect?" That's because most people connect insects with bad things, such as diseases, stings, and crop destruction. It's no wonder that the saying "The only good insect is a dead one" has become so popular. What most people don't stop to think about are the positive ways that insects have influenced our society and the reasons they are so important to people and other living things.

Below are some of the "good" and "bad" points about insects. The list indicates the importance of insects in our lives and how they fit in with other living things. (It's important to realize that these are people's value systems. There is no "good" or "bad" in nature.)

Why People Like Insects.

* insects are very important plant pollinators, especially of fruit and other crop plants.
* insects provide honey, shellac, wax, and silk.
* insects help control other pests.
* insects provide food for many birds, fish, and other animals--including people.
* insects are used to treat diseases in people.
* insects provide information on heredity, evolution, biochemistry, and other important science topics.
* insects are good indicators of water pollution.
* insects are fascinating to watch; inspiring to poets, writers, photographers, designers, and students.

Why People Don't Like Insects.

* insects attack and eat important crops.
* insects spread plant diseases.
* insects transmit diseases to people and other animals.
* insects infest households as pests.
* insects bite, sting, stink, etc.
* insects ruin stored crops, such as flour, popcorn, rice, etc.

* insects require use of pesticides and other poisons, which often harm other animals.

External Structure of Insects.

In order to be able to identify an insect properly, it is important to know something about its structure. The "skin" or outer covering of an insect is considerably different from that of other animals. Truly, it is not a skin at all, but is hardened into a stiff outer skeleton called the **exoskeleton**. The vertebrates, such as humans, have a skeleton inside the body called the endoskeleton.

The exoskeleton of the insect serves as a protective barrier and supporting framework for the body. This type of skeleton, of course, restricts growth of the insect once it has hardened. Consequently, the insect must shed its skin or molt in order to grow.

The exoskeleton of the insect is composed of many hardened plates or areas called sclerites. These plates are not flexible, so in order for the insect to move, these hardened areas are joined together by flexible portions of tissue called intersegmental membranes. These membranes are located throughout the insect's body at critical points, thus allowing the insect to move. For example, the abdomen of a mosquito can become quite enlarged during feeding because of these membranes. The body wall of insects can also be covered with a variety of structures such as hairs, scales, spines and spurs.

How Insects Live and Grow.

Through your collection activities, you will observe something about the habits of various insects. Everything you observe about an insect is of value in understanding its life history, biology and economic importance. By understanding its growth and development, you can determine the insect's present importance and can predict something about its future importance.

Entomology is the scientific study of insects. Scientists who study insects are called entomologists. Observations such as you will be making help entomologists check insect infestations, find good control measures and predict something about population increases or decreases. The following points are important to the entomologist:

1. How long does the insect take to complete the life cycle?
2. What are the injurious or beneficial stages?
3. What does the insect feed upon?
4. Where does it spend its life stages?

Insects grow and mature by a process of development called **metamorphosis**. Metamorphosis is the name given to the changes that occur as insects develop from the egg stage to the adult reproductive stage. A few insects, as some aphids, give birth to living young, but these are exceptions. The young insect hatches from the egg, grows and changes until it reaches the adult stage. It usually passes through a number of stages or instars, molting or shedding its skin at the end of each stage. An **instar** is the form of an insect between successive molts, the first instar being the stage between hatching and the first molt. Because the skin (exoskeleton) restricts the growth of each stage, molting is necessary to allow for increase in size.

Various insects undergo different types of metamorphosis in reaching adulthood. Each order of insects has a characteristic type of metamorphosis. In other words, all insects in the same order undergo the same type of metamorphosis.

The **life cycle** is the period of time from hatching to the adult stage. Insect life cycles vary from a few days to several years among different insects. However, most of the insects with which we are more familiar complete their life cycles in two to six weeks. Studying insect life cycles is not only interesting, but it also helps plan and apply control measures against economic pests. By learning more about the life history of an insect, weak phases during its life can be recognized. Effective control measures take advantage of these weak periods to accomplish better results.

Beneficial Insects.

The majority of insects are beneficial, or helpful to humans. For example, insects are necessary for plant pollination. In the United States it is estimated that bees pollinate more than $1 billion worth of fruit, vegetable, and legume crops per year. Honey, beeswax, shellac, silk, and dyes are just a few of the commercial products produced by insects. Many insects are entomophagous and help in natural control of other insect species. **Entomophagous** insects feed on other insects. Insects that inhabit the soil, act as scavengers, or feed on undesirable plants all play important roles. These insects increase soil tilth, contribute to nutrient recycling, and act as biological weed control agents. Finally, insects are at the lower levels of the food chain. Thus, they support higher life forms such as fish, birds, animals, and humans.

Insect Pests.

When compared to the total number of insect species, there are relatively few species that cause economic loss. However, it is estimated that crop losses due to such insects total more than $4 billion annually. Insects can cause economic loss by feeding on cultivated crops and stored products. They can also vector plant and animal diseases, inflict painful stings or bites, or act as nuisance pests.

Feeding Damage.

Insects have either chewing or sucking mouthparts. Damage symptoms caused by chewing insects are leaf defoliation, leaf mining, stem boring, and root feeding. Insects with sucking mouthparts produce distorted plant growth, leaf stippling, leaf burn, and transmit organisms (viruses, bacteria) that cause plant and animal diseases.

LESSON PLAN

Area and/or Course ______________________ Unit ______________

Lesson Title **Plant Disease Agents.** No. Periods 01 Date ________

Upon completion of this lesson, the student will be able to:

Objectives:

1. Define/Explain the following terms: plant pathology, plant disease, infectious plant disease, noninfectious plant disease, causal agent.

2. List four organisms which cause infectious plant diseases.

3. Describe the difference between a "sign" and a "symptom".

4. Describe the disease triangle concept.

Student Activity.

5. Demonstrate the ability to diagnose plant damage by determining whether the damage is caused by living or nonliving factors.

Materials, Equipment, Audio-visual aids:

1. Samples of plant damaged material (collected during lesson # 2).

2. Pocket knife for aid in examination of plant material.

3. Binocular dissecting scope (optional).

References:

Cooper, Elmer L. 1990. AgriScience Fundamentals and Applications. Delmar Publications Inc. pp 170-172.

Cudney, David W. 1989. Pacific Northwest Plant Disease Control Handbook: Diagnosis of Plant Diseases. pg.4.

Green, James L., Maloy, Otis, and Joe Capizzi 1986. A Systematic Approach to Diagnosing Plant Damage. 36 pp. Oregon State University Extension Bulletin.

Introduction -- Motivation -- Interest Approach:
(Application is laced in at this point).

Plants suffer from disease or disorders due to some abnormality in the functioning of their system. These abnormalities may be caused by biotic (living) factors or abiotic (nonliving) factors. The ability to diagnosis plant damage is a critical part of an IPM program. Accurate diagnosis must be made before corrective action can be taken.

In this lesson, students will learn how to determine if a plant disease is caused by living or nonliving factors. The students will gain hands-on experience in collecting and diagnosing plant damage by examining samples.

Problem Stated, Solutions to Problem, Steps Sequenced, Subject Matter Points, Student Learning Activities, Artful Questions: (Application is laced in at this point, lessons designed to meet the objectives set forth)	Strategy - How are you going to proceed through the lesson: (What objectives are you meeting here?)
1. What is a plant disease?	The students will read the attached background material before coming to class.
2. What is the difference between a "symptom" and "sign"?	The teacher will briefly discuss the difference.
3. What is meant by "the disease triangle"? a. A susceptible plant or host must be present. b. The disease organism or causal agent (pathogen) must be present. A causal agent is an organism that produces a disease. c. Environmental conditions conducive for the causal agent must occur.	The teacher will illustrate this important concept to emphasize the point that all three components must be present for an "infectious disease" to occur. Disease management attempts to affect one or all of these three factors.
4. What steps are involved in diagnosing plant disease?	Using the plant disease samples collected earlier (on field trip) and the attached extension bulletin <u>A Systematic Approach to Diagnosing Plant Damage</u>, divide the students into

small groups of 3 or 4. Each group will take a plant sample to diagnose. The object is for each group to be able to correctly diagnose the damage as being caused by a living or nonliving factor(s). The students will present their results to the class for discussion. The students should justify their diagnosis by explaining the reasons for their choice.

Summary -- Conclusion to the Problem: (Application is re-emphasized here and drawn as many students in the class as possible).

A plant disease is any abnormal plant growth. Plant diseases may be caused by living or nonliving factors. In this lesson we have learned to recognize the difference between infectious and noninfectious diseases. The ability to distinguish between biotic and abiotic factors is an important skill in plant disease diagnosis.

Evaluation: (Questions and/or activities which reflect the objectives of the lesson).

1. Define/explain the following terms:

plant disease: any abnormal plant growth.

plant pathology: the study of plant diseases.

infectious plant disease: a disease caused by biotic factors.

noninfectious plant disease: a disease caused by abiotic factors.

causal agent: an organism that produces a disease.

2. Explain the difference between a symptom and a sign.

   sign: evidence of the damaging factor (insect, mite, pathogen life stages, secretions, etc. or toxic chemical residue, mechanical damage, etc.)

   symptom: any change in the growth or appearance of the plant in response to living or nonliving damaging factors.

Assignments: (Designed to meet lesson objectives).

Each student should collect a diseased plant sample and bring it to class. The sample can be collected during the sampling field trip in lesson two or outside of class from their farm, orchard, garden, lawn, etc. The following guide lines should be emphasized:

1. Obtain good fresh samples of diseased plants. It is difficult, and often impossible to diagnosis a plant disease with a poor sample. Try to collect the entire plant if feasible. For some diseases, such as leaf spots or fruit rots, those parts of the plant may be sufficient.

2. Collect several healthy plants along with the diseased plant for comparison when examining.

3. Try to obtain as much background information as possible about the area in which the sample was taken. Ask questions and gather information. Try to identify the diseased plant.

4. Plant samples should be protected from deterioration due to excessive heat, cold, drying, or moisture. To avoid problems, put the plant sample in a sealed plastic bag and place in a cooler during transportation and transfer to a refrigerator until time for examination. Be sure to record the location, date, and your name on the sample bag.

Plant Diseases.

Plant pathology is the study of plant diseases. A **plant disease** is any abnormal plant growth. The occurrence and severity of plant disease is based on three factors:

1. A susceptible plant or host must be present.

2. The disease organism or **causal agent** is an organism that produces a disease.

3. Environmental conditions conducive for the causal agent must occur.

The relationship of these three factors is known as the disease **triangle**.

Disease control programs are designed to affect each or all of these three factors. For example, if crop irrigation is decreased, a less favorable environment will exist for the disease organism. Plant breeding programs have introduced disease resistance into new plant lines for many different crops. Pesticides may also be used to suppress and control the disease organism.

Causal Agents for Plant Disease.

Diseases may be incited by either abiotic (nonliving) factors or biotic (living) agents. **Noninfectious plant diseases** are caused by abiotic factors such as environmental or manmade stress. Examples of noninfectious diseases include nutrient deficiencies, chemical injury from pesticides, salt damage, air pollution, temperature and moisture extremes, etc. **Infectious plant diseases** are caused by living organisms. Examples of causal agents or organisms include: **fungi, bacteria, viruses**, and **nematodes**. Each of these causal agents are briefly described below.

Fungi: Fungi (plural for fungus) are the principal causes of plant disease. Fungi are plants that lack chlorophyll. Their bodies consist of threadlike vegetative structures called **hyphae**. When hyphae are grouped together, they are called **mycelium**. Fungi can reproduce and cause disease by producing spores or mycelia. Spores can be produced asexually or sexually by the fungus. For example, a mushroom produces millions of sexual spores under its cap. These spores can be dispersed by wind, water, insects, and humans.

Bacteria: Bacteria are one-celled or unicellular microscopic plants. Relatively few bacteria are considered plant **pathogens** (a microorganism that will cause disease). Being unicellular, bacteria are among the smallest living organisms. Bacteria can only enter a plant through wounds or natural openings, such as a stem lenticel. Bacteria can be disseminated in ways similar to fungi, but they do not produce an appressorium. An **appressorium** is the swollen tip of a hypha by which the fungus attaches itself to the plant. Several important bacterial diseases are fire blight of apples and pears and bacterial soft rot of vegetables.

Viruses: Plant viruses are pathogenic entities. Viruses are composed of nucleic acids surrounded by a protein sheath. They are capable of altering a plant's metabolism by affecting protein synthesis. Plant viruses are transmitted by seeds, insects, nematodes, fungi, grafting, and mechanical means, including sap contact. Viral diseases produce several well-known symptoms. A **symptom** is the visible change to the host caused by a disease. These symptoms are ring spots, stunting, malformations, and mosaics. A mosaic symptom is a leaf pattern of light and dark-green color.

Nematodes: Nematodes are roundworms that may live in the soil or water, within insects, or as parasites of plants or animals. Plant parasitic nematodes are quite small, often less than 4 mm, and produce damage to plants by feeding on stem or leaf tissue. The main symptom of nematode damage is poor plant growth, which results from nematodes feeding on the roots. The major plant parasitic nematodes are included in one of the following three groups: root-knot, stunt, or root-lesion.

Diagnosis of Plant Diseases.

Investigating and diagnosing problems in the field is both an art and a science. As an individual's experience increases, ability to diagnose problems should also increase. Often it does not. Why? Because this person may forget two things: (1) keep an open mind, and (2) ask the right questions.

The importance of asking "one more question" or making an additional observation cannot be overemphasized. The main point is: **Don't make a conclusion and then gather information to support that conclusion. Gather the information, and then let the information point to the conclusion.**

Plant disease diagnosis can best be made in the field. Some of the useful tools in diagnosing problems include:

- a shovel.
- a soil tube.
- a pocket knife
- a handlens.
- a camera.
- an **open mind.**

Plant disease diagnosis can be divided into three steps:

1. gathering of information.

2. noting overall patterns of affected areas.

3. noting individual plant symptoms.

Two important terms to understand are symptoms and signs. A **symptom** is a visible or otherwise detectable expression of abnormal physiology, development, or behavior in a plant resulting from disease. Symptoms often involve changes in form, color, odor, texture, and structural integrity. Symptoms are changes in the diseased plant. Yellowing is an example. A sign is any observable part or remnant of the causal agent (pathogen) in disease. Common signs include vegetative or reproductive structures of pathogens such as fungal mycelium or spores.

Before entering an affected area, ask questions about the cropping history and method of handling the field. For example:

1. Is this the first time in this crop, or has the same crop been planted in this location many times?

2. Is the problem seasonal or year-round?

3. Have there been unusual weather conditions during this season or the past several seasons?

4. Has anything unusual been done in the field or orchard during the past few years? This is important and should be gone into in great detail.

5. Has there been ammonia, smog, or other toxic gases in the area?

6. What herbicides have been used on this crop this and previous seasons?

7. Have there been unusual soil disturbances such as digging operations, land leveling, or old roadways filled in?

8. Have insecticides or fungicides other than those normally recommended been applied?

9. Have sprays applied in combination always been compatible?

10. What fertilization practices have been used?

LESSON PLAN

Area and/or Course ____________________ Unit ____________________

Lesson Title Weeds No. Periods 01 Date __________

Upon completion of this lesson, the student will be able to:

Objectives:

1. Define\explain the following terms: weed, annual weed, biennial weed, perennial weed, allelopathy, noxious weed, rhizome, stolon.
2. Discuss why weeds are able to thrive and spread where most cultivated plants would not.
3. Describe three problems caused by weeds.
4. List three resources for which weeds and crops compete.

Student Activity.

5. Make a collection of five correctly identified weeds common to your area.

Materials, Equipment, Audio-visual aids:

1. Weed samples pressed, dried, and ready to identify (collected in lesson 2).
2. Weed identification handbook: Weeds of the West. Published by the Western Society of Weed Science. Available from the OSU bookstore or your county extension service. Price is $16.50. This is an excellent reference book with color pictures and good descriptions.
3. Herbarium paper (at least 5 sheets/student) available from the OSU bookstore.
4. Adhesive for securing plants to paper (Elmer's glue works well).
5. *Problem Thistles of Oregon EC 1288
   *Horsetail PNW 105
   *Field Bindweed PNW 115

   *available free from: Publications Orders
   Agricultural Communications
   Oregon State University
   Administrative Services A422
   Corvallis, OR 97331-2119
   (503) 737-2513

References:

Cooper, Elmer L. 1990. AgriScience Fundamentals and Applications. Delmar Publications Inc. pp 168-169.

Ross, Merrill A. and Lembi, Carole A. 1985. Applied Weed Science. Burgess Publishing Co. Minneapolis, Minnesota. pp 1-45.

Introduction -- Motivation -- Interest Approach:
(Application is laced in at this point).

Weeds differ from other plants: they are competitive, persistent, and pernicious. They interfere with human activities and as a result are undesirable. Of 250,000 plant species, only 3% or 8000 can be documented as weeds somewhere in the world. Only 250 or 0.1% are major problems in world agriculture.

Problem Stated, Solutions to Problem, Steps Sequenced, Subject Matter Points, Student Learning Activities, Artful Questions: (Application is laced in at this point, lessons designed to meet the objectives set forth)	Strategy - How are you going to proceed through the lesson: (What objectives are you meeting here?)
1. What are weeds?	The students will read the attached background material before coming to class.
2. What resources do weeds compete for?	The teacher will review the material briefly with the students in class.
3. What are weeds so competitive?	(see attached material)
4. Make a collection of five correctly identified weeds common to your area.	Working in pairs the students will try to identify and neatly mount their weed specimens. The teacher will provide pictures and drawings of common weeds in the area. Each weed should be mounted on a sheet of herbarium paper

and labeled with the proper information. Refer to the information sheet: Collecting Plants for Identification. When completed the weed specimens can be displayed around the classroom for reference.

Summary -- Conclusion to the Problem: (Application is re-emphasized here and drawn as many students in the class as possible).

Weeds are an important pest because they compete with desirable plants for light, nutrients, water, and space. In addition some weeds such as yellow nutsedge and bermudagrass secrete toxins into the soil which act like herbicides to damage desirable plants. The proper identification of weeds is necessary for determining the best combination of control tactics.

Evaluation: (Questions and/or activities which reflect the objectives of the lesson).

1. Define/explain the following terms:

   weed: plants that are competitive, persistent, and pernicious (harmful).

   annual weed: a plant that completes its life cycle within one year.

   biennial weed: is a plant that will live for two years.

   perennial weed: can live for more than two years and may reproduce by seed and/or vegetative growth.

   allelopathy: the inhibition of germination, growth, or metabolism of one plant due to the release of organic chemicals by another.

   rhizomes: a stem that runs underground and gives rise to new plants at each joint or node.

stolons: a stem that runs on the surface and gives rise to new plants at each node.

noxious weeds: a weed specified by law as being especially undesirable, troublesome, and difficult to control.

2. Explain why weeds are able to thrive and spread where most cultivated plants would not.

abundant seed production.

rapid population establishment.

seed dormancy.

long term survival of buried seeds.

adaptations for spreading.

presence of vegetative reproductive structures.

the capacity to occupy sites disturbed by human activities.

3. Describe three problems caused by weeds.

Weeds decrease crop quality.

Weeds reduce aesthetic value.

Weeds interfere with maintenance along rights-of-way.

Weeds harbor insects and disease pathogens (organisms that cause disease).

4. List three resources for which weeds and crops compete.

water, mineral nutrients, light, and space.

Assignments: (Designed to meet lesson objectives).

Each student will collect, dry, press, mount, and correctly identify at least five common weeds in the area.

Weeds.

Weeds are plants that are competitive, persistent, and pernicious (harmful). They interfere with human activities and as a result are undesirable.

Weeds can be divided into three categories based on their life spans and their periods of vegetative and reproductive growth.

Annual Weeds.

An **annual weed** is a plant that completes its life cycle within one year. Two types of annual weeds occur, depending upon the time of year in which they germinate. A **winter annual** germinates in the fall and will actively grow until late spring. It will then produce seed and die during periods of heat and drought stress. Examples of winter annuals are chickweed, henbit, and yellow rocket.

A **summer annual** germinates in the late spring, with vigorous growth during the summer months. Seed are produced by late summer and the plant will die during periods of low temperatures and frost. Examples of summer annuals are crabgrass, spotted spurge, and fall panicum.

Biennial Weeds.

A **biennial weed** is a plant that will live for two years. In the first year the plant produces only vegetative growth, such as leaf, stem, and root tissue. By the end of the second year, the plant will produce flowers and seeds. This is referred to as reproductive growth. After the seed is produced, the plant will die. There are only a few plants that are considered biennials. Some examples are bull thistle, burdock, and wild carrot.

Perennial Weeds.

A **perennial weed** can live for more than two years and may reproduce by seed and/or vegetative growth. The production of rhizomes, stolons, and extensive rootstock are ways in which perennial plants reproduce vegetatively. A **rhizome** is a stem that runs underground and gives rise to new plants at each joint or **node**. A **stolon** is a stem that runs on the surface and gives rise to new plants at each node. These plant parts have **meristematic tissue** (tissue capable of starting new plant growth). Examples of perennial weeds are dandelion, Bermuda grass, Canada thistle, and nutsedge.

Characteristics of Weeds.

Weeds possess certain characteristics which enable them to thrive and spread where most cultivated plants would not. These characteristics include:

1. abundant seed production.

2. rapid population establishment.

3. seed dormancy.

4. long term survival of buried seeds.

5. adaptations for spreading.

6. presence of vegetative reproductive structures.

7. the capacity to occupy sites disturbed by human activities.

Weeds can be considered undesirable for any of the following reasons:

1. Weeds compete for **water, mineral nutrients, light, and space,** resulting in reduced crop yields.

2. Weeds decrease crop quality.

3. Weeds reduce aesthetic value.

4. Weeds interfere with maintenance along rights-of-way.

5. Weeds harbor insects and disease pathogens (organisms that cause disease).

In addition, some weeds actively eliminate competition by a phenomenon known as allelopathy. **Allelopathy** is the inhibition of germination, growth, or metabolism of one plant due to the release of organic chemicals by another. Allelopathy reduces crop development more than is normally expected from competition for water, light, and nutrients alone.

Farmers in the northern states of the Midwest have long recognized the difficulty of establishing crops in land previously infested with quackgrass. Quackgrass rhizomes and residues clearly alter the growth of small grains and corn. Other examples of weeds with the potential to express allelopathic effects on crops and thus improve conditions for their own growth and spread include giant foxtail, large crabgrass, johnsongrass, and common sunflower.

Weed Laws.

Weed laws are enacted to compel local officials and property owners to carry out weed sanitation measures on lands under their jurisdiction. Such lands include farms, roadsides, railroad tracks, waste areas, utility rights-of way and ditch banks. The enabling legislation for a weed law rests with the state legislature.

Although some states impose fines on landowners who allow certain weeds (such as johnsongrass) to set seed, weed laws have been relatively ineffective in stopping the spread of noxious weeds. A **noxious weed** is a weed specified by law as being especially undesirable, troublesome, and difficult to control.

Collecting Plants for Identification.

Plants that are protected by law should not be collected. Be sure permission is obtained from the landowner if collecting is done on property other than your own. The equipment for collecting plants is simple:

* plastic bag in which to put plants.
* scissors or knife for cutting specimen.
* pencil and paper for taking notes.

Plants can be identified (1) immediately, (2) within 2 or 3 days after collection, or (3) after permanent preservation. The best time to identify a plant is immediately upon collection. Always try to collect mature plants in good condition which show as many descriptive features as possible. Remove excess dirt from the roots. Record on a sheet of paper the name of the plant, where it was obtained, the township or nearest town, the county and state and the date. Information on where the plant was growing, habitat such as woods, marsh, or roadside, is also interesting. Place the whole plant in a plastic bag, seal it, and store it in a cool place until ready to press.

The Plant Press.

A plant press is a simple device consisting of two sheets of hard board or masonite 14 x 18 inches (see diagram). Newspapers, blotters, and corrugated cardboard are used as dryers between hard board covers of the plant press. These dryers take up the moisture from the plant.

Pressing Plants.

As soon as you return from a field trip, put the plants in the plant press. To do this, place one piece of hard board on a table. On top of it, place a corrugated cardboard and several sheets of newspaper or blotter papers. Then take a single sheet of newspaper and fold it in half. This should just fit the dryer. The paper should be unfolded and the plant placed between layers. Arrange the plant so that blossom, stem and leaves are in the position desired when the plant is dry. Place plant notes in the press with the plant. Fold the newspaper over the specimen and place another newspaper or blotter on top and then the cardboard. Alternate blotters, newspapers, and cardboard separators. If separators are not plentiful, use them after every four or five plants. The process is repeated until all plants are in the press. The hard board cover is put on the top dryer and the press is either tied, strapped tightly or weighted, so there is pressure on the specimens.

After 24 hours, the plant press should be opened. Each specimen should be examined and the leaves rearranged to properly illustrate what you would like to show. At least one of the leaves should be so the bottom side is visible. If the stem crosses over the leaves, the leaves should arranged so they are beneath the stem. The damp newspapers or blotters should be laid aside to dry and new, crisp, fresh ones inserted in their place. This process should be repeated daily until the plants are perfectly dry. You can tell when a specimen plant is dry by holding it to your cheek. If it feels cool, it is probably still moist. The plants should be kept in their original folded newspaper throughout the drying process. Note: If it is not possible to construct a plant press, it is possible to press plants in newspaper on a table using heavy books to keep them flat while drying. It is important to dry the plants quickly to avoid mold. The damp blotters or newspapers must be changed daily. Place the presses in a place where it is dry and warm and, if possible, where the air circulates.

Mounting Plants.

Once the plant has dried, you can remove it from the newspaper and mount it on herbarium paper (or any stiff paper) using an adhesive. Elmer's glue works well. If the mounted specimens are to be handled often or moved frequently, cover them after they are completely dry. You can sandwich the mounted specimen between a stiff backing and a sheet of clear plastic. Attach a label to each specimen with the following information:

Common name of plant	Johnsongrass
Scientific name of plant	_Sorghum halepense_ L.
Habitat from which collected	Alfalfa field
Geographical location where collected	Benton Co., OR
Life span of plant	Creeping perennial
Name of person collecting plant	John B. Smith
Date collected	September 12, 1991

LESSON PLAN

Area and/or Course ______________________________ Unit ______________________

Lesson Title Cultural and Regulatory Control No. Periods 01 Date ________

Upon completion of this lesson, the student will be able to:

Objectives:

1. Define\explain the following terms: cultural control, crop rotation, intercropping, trap crop, crop-free period, host plant resistance, exotic pest, USDA-APHIS, quarantine.

2. Discuss three advantages of cultural control.

3. Discuss three limitations of cultural control.

4. Explain how some cultural management techniques may actually increase disease and pest problems.

Student Activity.

5. Describe a cultural control method which could be used to manage the following types of pests:

   a. insects.
   b. diseases.
   c. weeds.

   Divide the class into three groups to brainstorm methods of cultural control for these three types of pests; then each group will make a presentation to the class on the results. (Note: The teacher should select a local cropping system for this exercise.)

Materials, Equipment, Audio-visual aids:

1. "IPM in Agriculture" video cassette.

2. Flipchart paper or any large white paper big enough for students to write down their ideas.

3. Marking pens (magic markers).

References:

Bishop, G.W., Davis, D.W. and T.F. Watson 1979. Biological Control and Insect Pest Management: Cultural Practices in Pest Management. Agricultural

Experiment Station University of California Division of Agriculture and Natural Resources. Bulletin No. 1911. pp 61-71.

Bottrell, Dale R. 1979. Integrated Pest Management. Council on Environmental Quality. U.S. Govt. Printing Office Washington D.C. pp 35-37.
Chaube, Hriday S. and Uma S. Singh 1991. Plant Disease Management: Principles and Practices. CRC Press Boston. pp 199-213.

Cooper, Elmer L. 1990. AgriScience Fundamentals and Applications. Delmar Publishers Inc. p. 175.

Texas Agriculture Science and Technology Curriculum.

Introduction -- Motivation -- Interest Approach:
(Application is laced in at this point).

Cultural control methods have an important place in IPM. These methods are economical, easy to apply, environmentally safe, and readily integrated with other types of control methods. The importance of cultural control is often overlooked because effects are usually indirect and subtle, and they often do not provide adequate control independently. In this lesson we will gain a better understanding of what cultural control means and the role it should play in an IPM program. The key point in this lesson is that cultural control methods reduce pest populations and provide the foundation for other control methods in an IPM program.

Problem Stated, Solutions to Problem, Steps Sequenced, Subject Matter Points, Student Learning Activities, Artful Questions: (Application is laced in at this point, lessons designed to meet the objectives set forth)	Strategy - How are you going to proceed through the lesson: (What objectives are you meeting here?)
What does cultural control mean?	The students will study the attached reading material before coming to class. The teacher will briefly explain the meaning and role cultural control in IPM.
What are some commonly used cultural control methods in pest management?	Show the video "IPM in Agriculture."
What are some of the advantages of cultural control?	
What are some of the limitations of cultural control?	

Describe a cultural control method which might be used for each of the following (insects, pathogens, and weeds)	Divide the class into 3 groups. Ask each group to think of as many cultural control methods as they can for each type of pest. (allow about 10 minutes) Have someone from each group stand up and report to the class the results.

Summary -- Conclusion to the Problem: (Application is re-emphasized here and drawn as many students in the class as possible).

In this lesson we have learned that cultural control is the deliberate manipulation of the environment to make it less favorable for pests by disrupting their reproductive cycles, eliminating their food supply, or making it more favorable for their natural enemies. Cultural and regulatory controls are largely preventive. They reduce pest populations and therefore play an important role as the foundation for any IPM program.

Evaluation: (Questions and/or activities which reflect the objectives of the lesson).

1. Define/explain the following terms:

cultural control: the deliberate manipulation of the environment to make it less favorable for pests.

crop rotation: a planting scheme which alternates susceptible and nonsusceptible crops.

trap crop: a susceptible crop planted to attract a pest into a localized area. The trap crop is then either destroyed or treated with a pesticide.

exotic pest: a pest which has been introduced into an area in which it is not native.

USDA-APHIS: the federal pest prevention agency in the U.S. (United States Dept. of Agriculture-Animal Plant Health Inspection Service)

quarantine: the isolation of animals or plants to prevent disease, arthropod, nematode, or weed introduction into an area.

2. Describe three advantages of cultural control.

   -inexpensive.

   -does not require a high degree of technical expertise.

   -requires no additional resources, very low energy inputs are required.

   -highly compatible with IPM practices.

3. Describe three limitations of cultural control.

   -may not be effective when used alone.

   -preventive methods require long term planning.

   -difficult to evaluate.

   -may conflict with other farming practices already established.

Assignments: (Designed to meet lesson objectives).

Students will study the background material for this lesson before class.

Cultural Control.

Cultural control is the deliberate manipulation of the environment to make it less favorable for pests. Most cultural control practices evolved with agriculture, and until the advent of modern pesticides such practices were often the only practical means of suppressing pests on crops. The popularity of these methods can be attributed to their economy and relative ease of implementation, as they were essentially a manipulation or variation of farm practices.

After having received relatively little attention since the discovery of organic pesticides there is a renewed interest in cultural practices for integrated pest management. These methods are largely preventive, and achieve control by disrupting the life cycle of the pest or by providing a more favorable habitat for parasites and predators.

Development of cultural controls is best achieved after an intimate knowledge of the life cycle and development of the pest as related to all components of the agroecosystem. These methods are founded on ecological principles and are, therefore, compatible with the philosophy of IPM. They lower the equilibrium levels of pest populations with a minimum disruption of natural control factors.

Characteristics of Cultural Control.

The following characteristics help describe cultural control methods for pest management:

* evolved with agriculture.
* are dependable but the results are not fantastic.
* requires long term planning for success.
* requires regional programs to involve neighbors with adjoining fields in a manner of cooperation.
* are preventative in nature not curative (like pesticides).
* usually need to be put into practice 1-5 pest generations ahead of time, this may take 4-5 years.
* are difficult to evaluate.
* are one of the least expensive methods of pest management.
* may not provide complete population reduction of a pest.

Advantages of Cultural Control.

1. Inexpensive.
2. Does not require a high degree of technical expertise.
3. Requires no additional resources, very low energy inputs are required.
4. Highly compatible with IPM practices.

Limitations of Cultural Control.

1. May not be effective when used alone.
2. Preventive methods require long term planning.
3. Difficult to evaluate.
4. May conflict with other farming practices already established.

Some Common Cultural Control Practices Used.

The following are just a few examples of the diverse ways in which cultural control can be used to manage pests.

Sanitation.

Sanitation involves the removal or destruction of breeding refuges or overwintering sites of pests. Prompt disposal of garbage, bread crumbs, pet wastes, and uneaten pet food; enclosure of cereals, bread, cookies, and other food in tight containers; and regular sweeping or vacuuming are basic in preventing infestations of cockroaches and other household pests.

Removal of pieces of wood from under houses and other buildings reduces the chance of infestation by subterranean termites. Frequent removal of livestock waste from barns and other quarters is a proven method for reducing house flies, stable flies, and other insects that breed in this material.

Storage of garbage in tight enclosures, covering of sewer holes, and frequent removal of garbage, pet feces, and other organic wastes are proven management techniques for the Norway rat and house fly when applied on a community wide basis in urban areas.

Removal of fallen fruit from orchards and destruction of tree prunings are useful in reducing insect and disease pests which overwinter in these materials. Removing diseased plants (rouging), pruning infested parts, and removing or effectively treating plant material containing disease organisms (i.e. treating potato tuber piles with chemicals, burning stubble) have been successful in plant disease management.

Crop Rotation.

Crop rotation is the oldest and most widely practiced cultural control method. **Crop rotation** consists of a planting scheme alternating susceptible and nonsusceptible crops. Since ancient times farmers have been aware of the value of rotating crops. A concentration of one crop (monoculture)tends to permit a buildup of the pest population due to the regular presence of a susceptible host. The necessary interval between susceptible crops depends upon the length of life cycle, reproductive potential, degree of specificity, and dispersal characteristics of the target pest.

Trap Crops.

Trap crops are susceptible crops planted to attract a pest into a localized area. The trap crop is then either destroyed or treated with a pesticide. The trap crop must either be more attractive than the crop to be protected or located in a position to interrupt movement of the pest into the crop.

In Hawaii, squash and melon fields are often surrounded by a few rows of corn which attract large numbers of melon flies, key pests of melons and squash. Treatment of the corn "trap crop" generally controls the flies, leaves no residues on the melon or squash crop, and is harmless to natural enemies of the crop plants.

Host Plant Resistance.

Host plant resistance is the use of plant varieties tolerant of or resistant to pest attack. This is a proven, effective, economical, and safe method of pest suppression ideally suited to IPM. Its development and use involve only renewable natural resources, and it is compatible with most other pest management techniques such as biological control. An estimated 75% of the U.S. cropland is currently planted to crop varieties that resist one or more plant disease organisms.

Adjusting Planting and Harvesting Dates.

Planting and harvesting dates of some crops may be altered to reduce or avoid damage from pests. Disease problems can be greatly reduced when the period of time that a pathogen is in contact with a susceptible host is reduced. For example, Cercosporella foot rot can be an important disease of winter wheat planted in the state of Washington before September 15, but almost no disease is present if planting is delayed by one month. This is an example of a **safe planting date.**

In the case of cotton, damage by the boll weevil is commonly reduced by early planting to get bolls past the highly susceptible stage before weevils become abundant; early harvesting then reduces the number of overwintering weevils.

Alteration of Crop Canopy.

The microclimate in a crop with an open canopy is usually drier than the microclimate of a crop with a dense canopy. Dense canopies tend to favor pathogens such as soil-borne fungi which require high levels of moisture. The soil-borne fungi can easily invade the roots of plants maintained in this environment. Damping-off, late blight of potato, downy mildews, etc. are some of the diseases which spread quickly in close space plantings. Canopy density can be adjusted by altering crop spacing, growing smaller plants, and pruning.

Water Management.

Soil moisture is related to many diseases. Careful control of irrigation water is one of the most effective ways for controlling soil pathogens. In some cases, reduced irrigation or rainfall prevents root knot nematode eggs from hatching, thereby reducing larval invasion of the crop roots. Management of irrigation water can also reduce certain weed problems.

Water management procedures (i.e. timing of irrigation and proper drainage) based on a sound understanding of pest biology provides economical and effective control of some pests. Drainage of irrigated pastures, regulation of water levels in rice paddies, and avoidance of stagnant water buildup in old tires, tree crotches, and other breeding habitats are particularly important mosquito management practices.

Fertility Management.

The macronutrients, nitrogen (N), phosphorus (P), and potassium (K), are required in large amounts by crop plants and are frequently limiting to plant growth. The micronutrients are required in smaller quantities. Maintenance of optimum plant health with sufficient, but not excessive, levels of fertility can be beneficial in crop resistance to stress from pathogen and insect attack, also to adequately compete with weeds.

Soil Tillage.

Tillage affects a variety of pests that have at least part of their development in the soil. Pests are reduced by mechanical injury, starvation through debris destruction, desiccation, and exposure. Deep and thorough plowing buries insects and pathogens destroying them. Tillage can control weeds by burying small annual weeds or cutting the weeds below the soil surface. Serious side effects of tillage include: loss of organic matter, especially in warm soils, and accelerated loss of soil to wind and water erosion if the soil is left bare for an extended period of time.

The cultural practice of **conservation tillage**, which includes minimum tillage, no till, stubble-mulch, and chisel plant, reduces erosion and increases soil organic matter content. However this practice may actually increase pest problems because of the high amounts of residues which remain on the soil surface. This residue provides a place for insects to hide, lay eggs, or pupate. Plant disease outbreaks are more likely to occur because the residues provide an excellent habitat for the survival, growth, and multiplication of both soilborne and foliar pathogens. Fungus and bacterial diseases are the principal diseases associated with conservation or reduced-tillage operations.

Another example of a cultural control method that may increase pest problems is the removal of weeds and other plants from an area. This practice removes the habitats of beneficial insects or animals which prey on insects which attack crops. This is an example of a cultural control method which actually increases pest problems. This example illustrates how trade-offs are commonly made when choosing the best pest management strategy. It is important to remember that some cultural control practices may actually increase pest problems.

Regulatory Control.

The movement of plants and plant products within and between countries has resulted in worldwide distribution of many pests. With the development of modern technology, transportation systems can make even remote sectors of the world accessible. The danger of this is that many species may be inadvertently transferred from their native locations to new territories. Even species that are not considered pests in their original locations may become so when introduced to new areas. This is because natural enemies that exist in native areas may not be present in the new surroundings and therefore the new exotic pest populations can grow unchecked. **Exotic pests** are pests which have been introduced into an area in which they aren't native.

Species may be transferred unintentionally in a multitude of ways: on freight carriers, in postal deliveries, on clothing, or along with other goods or products. Some species are intentionally smuggled in or introduced without full realization of the potential implications of such an act. Some of our most serious pests are ones that have been introduced into the U.S. from some other country.

The gypsy moth is an example of an exotic pest that has managed to find it way here and spread across the country. The gypsy moth is a serious pest of trees and shrubs. Populations of gypsy moth can increase rapidly causing widespread defoliation, weakening, and death to trees. A naturalist first brought the gypsy moth into Massachusetts from Europe in 1869 to develop a disease-resistant silkworm. During his experiments some of the gypsy moths escaped. Dispersing mostly by air currents, the young caterpillars can travel long distances and now infest the northeastern U.S. and some areas in the midwest and northwest.

The gypsy moth is a notorious hitchhiker. The female moth lays her eggs on any solid surface such as trees, outdoor furniture, recreational vehicles, firewood, toys, etc. When objects on which eggs have been laid are later moved, gypsy moths are transported for long distances. Infested items brought from the northeastern U.S. are the main source of gypsy moth infestations in Oregon.

The Japanese Beetle is another introduced pest that has caused considerable crop damage in the northeastern U.S. and has recently been found in Oregon. Mediterranean fruit flies were the subject of considerable alarm when they were discovered in California in the early 1980's. These exotic pests possess the capacity to seriously damage fruit crops. Obviously, the best way to deal with such destructive pests is to prevent their introductions whenever possible.

Federal or state governments have created laws that prevent the entry or spread of known pests into uninfested areas. Regulatory agencies also attempt to contain or eradicate certain types of pest infestations. The **Animal and Plant Health Inspection Service (APHIS) of the U.S.D.A. (USDA-APHIS)** is the federal pest prevention agency in the U.S. It acts by inspecting materials (particularly plant and animal related) brought into the U.S. in an attempt to prevent potentially harmful species from being imported. Aircraft and other transport vehicles are thoroughly disinfected where transfer risks exist. Private citizens can do their part by abiding by official guidelines when importing materials.

The Plant Quarantine Act of 1912 provides for inspection at ports of entry. Plant or animal quarantines are implemented if shipments are infested with targeted pests. A **quarantine** is the isolation of plant material to prevent introduction of diseases, arthropods, nematodes, and weeds into an area. A **targeted pest** is a pest which, if introduced, poses a major economic threat. If a targeted pest becomes established, an eradication program will be started. **Eradication** means total removal or destruction of a pest. This type of pest control is extremely difficult and expensive to administer. In California, the Mediterranean fruit fly was eradicated at a cost of $100 million in 1982. This program relied on chemical spraying, sanitation, sterile male releases, and pheromone traps to ensure complete eradication.

On a smaller scale, individual growers can avoid pest problems by refusing contaminated supplies such as impure crop seed that is mixed with weed seed. Producers should thoroughly clean equipment before use and in between use on separate fields. Fruit producers ideally should clean equipment after use on each tree. Such simple measures can go far in pest prevention.

The problem of pest management is ages old. While modern technology has introduced new means of pest control through chemical pesticides, it is a double edged sword with the danger of environmental harm. Additionally, technology heightens the possibility of transfer of deleterious pest species. The best means of control include prevention and the use of integrated pest management systems.

LESSON PLAN

Area and/or Course ______________________ Unit ______________

Lesson Title Biological Control No. Periods 01 Date ________

Upon completion of this lesson, the student will be able to:

Objectives:

1. Define\explain the following terms: biological control, natural enemy, predator, parasite, pathogen.
2. List three advantages of biological control.
3. List two limitations of biological control.
4. Describe an example of successful biological control of a pest in Oregon.
5. Describe the three basic approaches to biological control.
6. Explain why biological control is a sustainable method of pest management.

Materials, Equipment, Audio-visual aids:

1. Greenhouse IPM video.
2. Beneficial Organisms Associated With Pacific Northwest Crops. A Pacific Northwest Publication PNW 343, January 1990. Available from: Publications Orders, Ag. Communications, Oregon State Univ. cost $1.00 each.
3. Poster: Natural Enemies Are Your Allies!.
4. Biological Control Agents And Where To Find Them. Oregon State University Extension Service. EC 1328/September 1989.

References:

Bottrell, Dale R. 1979. Integrated Pest Management: Council on Environmental Quality. Washington D.C. pp 27-32.

Cooper, Elmer L. 1990. AgriScience Fundamentals and Applications. Delmar Publications Inc. pg. 176.

Pasture Management for Control of Tansy Ragwort. Pacific Northwest Extension Bulletin No. 210. August 1984.

Ritcher, Paul O. 1966. Biological Control of Insects and Weeds in Oregon. Technical Bulletin No. 90. Agricultural Experiment Station, Oregon State University, Corvallis, Oregon.

Introduction -- Motivation -- Interest Approach:
(Application is laced in at this point).

Biological control is the use or encouragement of parasites, predators, and pathogens for the reduction of pests. It is one of the most effective components of IPM programs for insects and mites and has been successful against some weeds and plant disease organisms. Successful utilization of biological control requires an understanding of the biology and ecology of both the pest and the beneficial organism operating on it. In this lesson we will learn what biological control is and how it is used.

Problem Stated, Solutions to Problem, Steps Sequenced, Subject Matter Points, Student Learning Activities, Artful Questions: (Application is laced in at this point, lessons designed to meet the objectives set forth)	Strategy - How are you going to proceed through the lesson: (What objectives are you meeting here?)
What is biological control?	The students will read the attached material before coming to class. The teacher will briefly review the important terms. Show the Greenhouse IPM video.
What are some advantages and limitations of biological control?	The teacher will cover the attached material with the students to reinforce the advantages and limitations of biological control.
What are the three basic approaches to biological control?	The teacher will explain the three approaches to biological control: classical, conservation and augmentation, and inundative and inoculative releases.
Describe an example of successful biological control of a pest in Oregon.	The teacher will briefly describe one or two examples successful biological control in

	Oregon.
Explain why biological control is a sustainable method of pest management.	The teacher will explain that because biological control is "self-perpetuating", it is a sustainable, environmentally sound method of pest management.

Summary -- Conclusion to the Problem: (Application is re-emphasized here and drawn as many students in the class as possible).

We have seen how biological control has been successful in managing pest populations in Oregon. Biological control whether naturally occurring or applied, has several distinct advantages over many other control methods. It is safe, economical, and permanent. Biological control does not seek to eradicate a pest population, but rather to maintain pest populations at lower levels than if they were absent. We must remember that IPM integrates many tactics to achieve its goals, so biological control by itself need not be a complete success to make a contribution to successful IPM.

Evaluation: (Questions and/or activities which reflect the objectives of the lesson).

1. Define\explain the following terms:

   biological control: the use of natural enemies to control pests.

   natural enemy: any parasites, predators, pathogens which attack a pest.

   predator: an animal that feeds on a smaller or weaker organism.

   parasite: an organism that lives in or on another organism.

   pathogen: an organism that produces a disease within their host.

2. Describe three advantages of biological control.
   safe, economical, permanent.

3. Describe two limitations of biological control.
   availability, narrow range of control.

4. Describe the three basic approaches to biological control.

classical biological control: deliberate introduction and establishment of natural enemies in areas where they did not previously occur; this approach is used largely against pests of foreign origin.

conservation and augmentation of natural enemies: deliberate actions to protect and maintain natural enemy populations or to increase their beneficial effects.

inundative and inoculative releases: the colonization of large numbers of a natural enemy to control the pest population immediately (inundative) or repeated colonization of relatively small numbers of a natural enemy to build up the beneficial organisms over several generations (inoculative).

5. Describe an example of successful biological control of a pest in Oregon.
   cinnabar moth: controls the toxic weed tansy ragwort.
   St. Johnswort beetle: controls the weed St. Johnswort (Kalamath weed).

Assignments: (Designed to meet lesson objectives).

The students will try to identify five important predators or parasites from the insects they have collected and pinned in an earlier lesson (lesson #2). Using the publication Beneficial Organisms Associated With Pacific Northwest Crops, or any other publication with good photographs, try to identify as many beneficial insects as possible.

Biological Control.

Biological control is the use of natural enemies to control pests. **Natural enemies** (also called beneficials or biocontrol agents) include predators, parasites, and pathogens which attack a pest.

A **predator** is an animal that feeds on a smaller or weaker organism. Some common insect predators include: ground beetles, tiger beetles, lady beetles, lacewings, and preying mantids.

Parasites are organisms that live in or on another organism. Insect parasites are usually much smaller than their insect host. All stages of an insect host (egg, larva, pupa, and adult) are susceptible to parasite attack, however insect parasites usually attack their hosts while in the larval stage, and each species usually attacks only one stage of a given host. Insect parasites may be external on their hosts, or internal in their hosts. There are a number of important insect parasites in the orders Hymenoptera (wasps) and Diptera (flies). Braconid and Ichneumonid wasps are parasitic on the caterpillars of many moths and butterflies.

Pathogens are organisms that produce a disease within their host. Bacteria, fungi, and viruses attack the larvae of Coleoptera and Lepidoptera. For example, the bacteria *Bacillus popilliae* attacks Japanese beetle grubs and *Bacillus thuringiensis* attacks the caterpillars of Lepidoptera. Pathogens are a very effective means of biological control. They are a preferred method of control because they are **host specific**. There is no danger to humans, wildlife, or danger of contamination to water supplies.

Successful biological control programs reduce pest populations below economic thresholds and keep the pests in check. Such programs require a thorough understanding of the biology and ecology of the beneficial organism, as well as of the pest.

Advantages of Biological Control.

1. **Safe.**

   The safety of biological control is outstanding, since many natural enemies are host-specific or restricted to a few closely related species. Therefore it is unlikely that nontarget species will be affected, provided, of course, that the proper taxonomic, biological, and ecological research is carried out to avoid the establishment of undesirable organisms.

2. **Economical.**

   Biological control is relatively economical, since once efficient natural enemies are present (either native or imported), little may need to be done other than to avoid disruptive practices.

3. **Self-perpetuating.**

   Biological control is relatively permanent, since it is almost impossible to eradicate any species. Efficient natural enemies often continue to have an effect year after year, with little or no assistance from farmers, provided that they are not interfered with in some way such as the misuse of pesticides. However, since it is nearly impossible to eradicate a species once it is established, it is of the utmost importance that only desirable natural enemies be released.

Limitations of Biological Control.

1. **Availability.**

   There is not a biological control agent immediately available for every pest.

2. **Narrow Spectrum of Control.**

   Most biological control agents especially parasites, predators and pathogens are very host specific. They may provide a narrow range of control.

Types of Biological Control.

1. **Classical Biological Control.**

Classical biological control involves deliberate introduction of natural enemies in areas where they did not previously occur; the approach is used largely against pests of foreign origin.

Classical biological control is highly effective. In January 1975, there were 213 cases reported worldwide of partial to complete success involving the introduction of natural enemies of important pest insects and arthropod relatives, snails, and weeds where they had not previously occurred.

The value of classical biological control against pests of foreign origin can be illustrated by the example of tansy ragwort Senecio jacobaea. Tansy ragwort is a serious weed problem in western Oregon and Washington. This weed is toxic to cattle and horses and crowds out more desirable plants. It was introduced into the U.S. from Europe. The first reported observation in Oregon was in 1922. It is found in the drier regions of Europe and Asia and in Siberia; therefore, it is believed that it can complete its lifecycle successfully throughout most of the Northwest. In Europe, one of the insect pests of tansy ragwort is the cinnabar moth, a beautiful red and black moth, whose yellow and black banded larvae feed only on tansy ragwort. The cinnabar moth was introduced into the Pacific Northwest in 1960 and is now widespread throughout the ragwort-infested areas west of the Cascade mountains where it provides excellent control of this pest. The tansy flea beetle also feeds on tansy and has provided good control.

Another example of successful biological control of a weed is with St. Johnswort. This is a perennial plant that had claimed about 2 million acres of rangeland in California and Oregon. Introduction of the St. Johnswort beetle Chrysolina quadrigemina in 1944 has reduced that infestation to about 1% of its original level.

2. **Conservation and Augmentation of Natural Enemies.**

Conservation and augmentation of natural enemies are deliberate actions to protect and maintain natural enemy populations or to increase their beneficial effects. Examples include:

* Applications of supplementary foods to retain, arrest, attract, and sustain natural enemies when nonprey food, such as plant pollen, is inadequate to sustain the natural enemies.

* Provision or management of shelter utilized by natural enemies in such places as the edges of crop fields or in trees for use by insect-feeding birds.

* Selective use of attractive food (honey, pollen) to increase the effectiveness of natural enemies.

* Selective use of pesticides at the lowest possible dose for control of target pests. Restricting application of pesticides to part of the crop fields or trees, and timing the treatments to minimize damage to the natural enemy populations.

3. **Inundative and Inoculative Releases.**

Inundative and inoculative releases are the colonization of large numbers of a natural enemy to control the pest population immediately (inundative) or repeated colonization of relatively small numbers of a natural enemy to build up the beneficial organisms over several generations (inoculative releases).

The release of parasites and predators to control insect pests biologically has been used extensively in greenhouse IPM programs. More recently this practice is being used under field conditions. There are a number of commercial firms in the U.S. which sell biological control agents.

LESSON PLAN

Area and/or Course ______________ Unit ______________

Lesson Title Pesticides ______________ No. Periods 01 Date ______________

Upon completion of this lesson, the student will be able to:

Objectives:

1. Define\explain the following terms: pesticides, active ingredient, selective pesticide, contact poison, stomach poison, systemic pesticide, dormant oil spray.

2. List the four categories in which pesticides are classified.

3. Describe two advantages of using pesticides.

4. Describe two disadvantages of using pesticides.

5. List and describe six factors which should always be considered before using pesticides.

Student Activity.

7. Demonstrate the ability to correctly interpret a pesticide label. Each student will bring a pesticide label to class for a class discussion of interpretation of labels.

Materials, Equipment, Audio-visual aids:

1. Handout on "How to Interpret a Pesticide Label."

2. Two or three pesticide labels to interpret.

3. Applying Pesticides Correctly: A Guide for Private and Public Applicators. EM 8392. Available free from:

 Publications Orders
 Agricultural Communications
 Oregon State University
 Administrative Services A422
 Corvallis, OR 97331-2119
 Telephone: (503) 737-2513

References:

Bohmont, Bert L. 1990. The Standard Pesticide User's Guide. Prentice Hall, Inc., Englewood Cliffs, New Jersey. 498 p.

Cooper, Elmer L. 1990. AgriScience Fundamentals and Applications. Delmar Publications Inc. p. 177.

Gilrein, Daniel O. Understanding Pesticides. International Institute of Rural Reconstruction, Silang, Cavite, Philippines.

Introduction -- Motivation -- Interest Approach:
(Application is laced in at this point).

Despite their potential hazards, pesticides are an essential component of many IPM programs. Pesticides are the only tool for pest management that is reliable for emergency action when pests populations approach or exceed the economic threshold. When their use is approached from sound ecological principles, chemical pesticides provide dependable and valuable tools for IPM.

Problem Stated, Solutions to Problem, Steps Sequenced, Subject Matter Points, Student Learning Activities, Artful Questions: (Application is laced in at this point, lessons designed to meet the objectives set forth)	Strategy - How are you going to proceed through the lesson: (What objectives are you meeting here?)
What are pesticides?	The students will read the attached material before coming to class.
What are the four categories in which pesticides are classified?	The teacher will cover the attached material in class with the students.
Describe the advantages and disadvantages with using pesticides.	Divide the class into two groups. One group will discuss the advantages and the other will discuss the disadvantages of using pesticides. Each group will take turns discussing the advantages or disadvantages.
What seven factors should always be considered before using pesticides.	The teacher will explain the importance of each of these factors. (see attached material)
Demonstrate the ability to correctly interpret a pesticide label.	Each student will bring a pesticide label to class. Labels can be obtained from local agricultural chemical

dealers, farm supply stores, or any place where agricultural pesticides are sold. Using the handout on how to interpret a pesticide label, the teacher will ask questions about the label. Students will respond with information specific to their label. The most important point is that the students gain hands-on experience reading and interpreting a pesticide label because someday they may have to apply a pesticide as part of their job.

Summary -- Conclusion to the Problem: (Application is re-emphasized here and drawn as many students in the class as possible).

Chemical control is the use of pesticides to reduce pest populations. Chemical control programs have been very cost effective. However, various problems occur if this tool is misused or overused. Problems that can develop are environmental pollution, pesticide resistance, pest resurgence, and secondary pest outbreaks. When used judiciously, pesticides are an important tool in IPM and will likely remain so for some time. The key to safe pesticide use is to always read the label carefully and follow all instructions. The importance of reading the label cannot be stressed too often. The information that appears on the label is put there for your information and protection. If it is read and understood and all the directions are followed, the likelihood of misusing the material or of having an accident with the pesticide is remote.

Evaluation: (Questions and/or activities which reflect the objectives of the lesson).

1. Define\explain the following terms:

pesticides: any substance or mixture of substances intended for preventing, destroying, repelling or mitigating any insects, rodents, nematodes, fungi, weeds or other organisms perceived to be troublesome (pests).

active ingredient: the chemical or chemicals in a pesticide responsible for the desired effects.

selective pesticide: a chemical that is more toxic to some species (plant, insect, animal, microorganisms) than to others.

contact poison: a pesticide that kills when it touches or is touched by a pest.

stomach poison: a pesticide that must be eaten by an insect or other animal in order to kill the animal.

systemic pesticide: a chemical that is absorbed and translocated throughout the plant or animal making it toxic to pests.

2. List the four categories in which pesticides are classified.

   target pest, mode of action, formulation, chemical nature.

3. List two advantages of using pesticides.

   convenient, simple, effective, flexible, and economical.

4. List two disadvantages of using pesticides.

   Pesticide Resistance, Pest Resurgence, Secondary Pest Outbreaks, Adverse Effects On Nontarget Species, Hazardous Pesticide Residues, Direct Hazards From Pesticide Use.

Assignments: (Designed to meet lesson objectives).

Each student will collect at least one pesticide label from a local pesticide store. Either the teacher can assign a specific pesticide for each student or let the students decide on their own. Before coming to class, each student should read the label carefully to become familiar with the product. The students should bring their label(s) to class on the day this lesson is covered for a discussion on how to correctly interpret a pesticide label.

Pesticides.

The term **pesticide** is defined as any substance or mixture of substances intended for preventing, destroying, repelling or mitigating any insects, rodents, nematodes, fungi, bacteria, weeds or other organisms perceived to be troublesome (pests).

Pesticides are used by people as intentional applications to the environment to improve environmental quality for humans, domestic animals, and plants. Despite the fears and real problems they create, pesticides clearly are responsible for part of the physical well-being enjoyed by most people in the United States and the western world. They contribute significantly to the existing standards of living in other nations.

In the U.S., consumers spend less of their income on food production, and pesticides have made an important contribution in this area. In 1850 each U.S. farmer produced enough food and fiber for himself and three other persons; over 100 years later (1960) he was able to produce enough food and fiber for himself and 24 other people; himself and 45 other people in 1970; and in 1990 he is able to produce enough for himself and 78 other people.

World population was estimated at 4.25 billion people in 1980 and is expected to increase to over 5 billion by 1990 and to over 6 billion people by the year 2000. There will be great pressure on the farmers of the world to increase agricultural production to feed and clothe this extra population.

Environmental Concerns.

In the past, pest problems have often been solved without fully appreciating the treatments and effects on other plants and animals or on the environment. Some of these effects have been unfortunate. Today, scientists almost unanimously agree that the first rule in pest control is to recognize the whole problem. The agricultural environment is a complex web of interactions involving (1) many kinds of pests; (2) relationships between pests and their natural enemies; (3) relationships among all these and other factors, such as weather, soil, water, plant varieties, cultural practices, wildlife, and people.

Pesticides are designed simply to destroy pests. They are applied to an environment that includes pests, crops, people, and other living things, as well as air, soil, and water. It is generally accepted that pesticides which are specific to the pest to be controlled are very desirable. These are referred to as **selective pesticides** because they are more toxic to some species (plant, insect, animal, microorganisms) than to others. However, these products can be very expensive because of their limited range of applications.

Unquestionably, pesticides will continue to be of enormous benefit to humans. They have helped to produce food and protect health. Synthetic chemicals have been the front line of defense against destructive insects, weeds, plant diseases, and rodents. Through pest control, we have modified our environment to meet aesthetic and recreational demands. However, in solving some environmental problems, pesticides have created others of undetermined magnitude. The unintended consequences of the long term use of certain pesticides have been injury or death to some life forms. Much of the information on the effects of pesticides comes from the study of birds, fish, and the marine invertebrates, such as shrimp, crabs, and scallops. It is clear that different species respond in different ways to the same concentration of a pesticide. Reproduction is inhibited in some and not in others. Eggs of some birds become thin and break, while others do not.

Residues of some persistent pesticides are "biologically concentrated." This means that they become more concentrated in organisms higher up in the food chain. When this happens in an aquatic environment, animals that are at the top of the food chain, usually fish-eating birds, may consume enough to suffer reproductive failure or other serious damage. Research has shown that some pesticides decompose completely into harmless substances fairly soon after they are exposed to air, water, sunlight, high temperature, or bacteria. Many others also may do so, but scientific confirmation of that fact is not yet available. When residues remain in or on plants or in soil or water, they usually are in very small amounts (a few parts per million or less). However, even such small amounts of some pesticides, or their breakdown products, which also may be harmful, sometimes persist for a long time.

Pesticides, like automobiles, can create environmental problems, but in today's world it is difficult to get along without them. Those concerned about pesticides and pest control face a dilemma. On the one hand, modern techniques of food production and control of disease-carrying insects requires pesticides; on the other hand, many pesticides can be a hazard to living things other than pests, sometimes including people.

Types of Pesticides.

Pesticides are classified according to the following: their target, mode of action, formulation, and chemical nature.

1. **Target**- type of pest.

    * insecticides: insects.
    * herbicides: weeds.
    * fungicides: fungi.
    * nematicides: nematodes.
    * rodenticides: rats and mice.
    * acaricides: mites.
    * molluscicides: (mollusks) slugs and snails.
    * etc.

2. **Mode of Action**- way(s) the pest is affected by the pesticide.

    * **contact poison:** a pesticide that kills when it touches or is touched by a pest.

* **stomach poison:** a pesticide that must be eaten by an insect or other animal in order to kill the animal.

* etc.

3. **Formulation**- the kind of preparation or mixture of active and inert ingredients. The **active ingredient (a.i.)** is the chemical or chemicals in a pesticide responsible for the desired effects. The inert ingredients make the a.i. less toxic to humans and easier to apply. (Nearly all pesticides are sold as some formulation.)

   * EC = Emulsifiable Concentrate.
   * P/WP = Wettable Powder.
   * F = Flowable.
   * SP = Soluble Powder.
   * L = Liquid.
   * D = Dust.
   * G = Granules.
   * Etc.

4. **Chemical Nature** - the chemical group or type.

   * organophosphates.
   * dithiocarbamates.
   * carbamates.
   * pyrethroid.
   * botanical.
   * microbial.
   * etc.

   E.g. "Sevin" is a carbamate insecticide acting mainly as a contact poison, usually formulated as a wettable powder (WP) or dust (D).

   Names - Most pesticides have at least three names. Common and chemical names usually do not vary but one pesticide may have many trade (brand) names.

   E.g. Common Name----------------Carbaryl.
   Chemical Name--------------1-Naphthyl N-Methyl carbamate (a.i.).
   Trade (brand) Names--------Sevin = Vetox= Ravyon.

Advantages of Pesticides.

The widespread use of pesticides for pest control is largely a result of their convenience, simplicity, effectiveness, flexibility, and economy. These properties represent advantages for use in pest-management programs.

1. Convenient: Pesticides offer the only practical control measure for pest populations approaching or at the economic threshold.

2. Simple: Does not require a thorough knowledge of the biology of the pest by the user.

3. Effective: Pesticides have rapid curative action in preventing economic damage.

4. Flexible: Pesticides offer a wide range of properties, uses, and methods of application to pest situations.

5. Economical: Cost/benefit ratios for pesticide use are generally favorable.

Disadvantages of Pesticides.

1. Pesticide Resistance.

2. Pest Resurgence.

3. Secondary Pest Outbreaks.

4. Adverse Effects On Nontarget Species.

5. Hazardous Pesticide Residues.

6. Direct Hazards From Pesticide Use.

Pesticide Use.

Pesticide application should be the last choice among many other possible pest management strategies (cultural control, resistant crop varieties, natural enemies, crop rotation, etc.) Pesticide misuse can lead to crop damage, high production costs, health and environmental hazards as well as more serious pest problems. If pesticides must be used, the following guide lines should be considered:

1. Timing of Applications - Early morning and evening on sunny, calm days are usually the best times to apply because there is less air movement (wind) which causes drift and loss or degradation from heat (best below 32 C/ 90 F) and light are minimized. Pesticides should be applied during the optimum pest or crop stage as recommended. Some kinds are used before crops and /or pests appear.

2. Application Methods - Different pesticides are used in certain ways for particular types and occurrences of pests, e.g. broadcast over the soil, incorporated into the soil, sprayed over the leaves, spot sprayed, etc.

3. Selection and Specificity - Use a pesticide only when needed at the minimum effective rate, and which targets the particular pest(s), leaving beneficial organisms and non-pests least affected. A good example of this is the use of dormant oil sprays. A dormant oil spray is a spray applied when plants are in a dormant condition, it consists of an oil plus an insecticide and/or fungicide. It helps control pests such as mealybugs, aphids, scales, mites, fungal and bacterial pathogens. The oil smothers the eggs of aphids and mites, which reduces their population later in the year. Dormant oil sprays do not affect beneficial organisms because they are not exposed during the dormant season (winter).

4. Persistence - Some pesticides are effective even many days after the application; others deteriorate after only a day or so. The persistence of pesticide residues also affects the amount of pesticides remaining on the harvested crop consumed by people or animals.

5. Environmental Factors:

   a. soil texture - Fine (silty, clay) soils may need higher rates of soil-applied pesticides than coarse (sandy) ones.

   b. soil moisture - Moderate levels give best results for pesticides used in or on the soil.

   c. rain - Rainfall leaches pesticides off leaves and down through the soil strata, but helps incorporate surface-applied pesticides.

   d. organic matter - If levels are high, somewhat higher rates of soil-applied pesticides may be needed.

   e. humidity and temperature - Herbicides are more effective where these conditions favor fast weed growth. Some pesticides evaporate more quickly with higher temperatures; low temperatures may reduce or stop the activity of some pesticides.

   f. light - Exposure to light (ultra violet) causes some pesticides to rapidly break down.

6. Need-based Rather Than Calendar-based Application.

   Use pesticides when the particular pest problem justifies it, and not on a regular calendar-based system. This requires proper identification of actual pests and beneficials, as well as knowledge of pest levels that warrant pesticide treatment (economic threshold level).

INTERPRETING PESTICIDE LABELS.

The purpose of this exercise is to allow you to locate important information that must be contained on all pesticide labels. Read your label carefully and answer the questions below.

1. Who is the manufacturer?
2. What is the brand name?
3. What is the common name?
4. What is the chemical name?
5. What type of formulation is it?
6. What is the symbol for the formulation?
7. What is the percentage of active ingredients?
8. What is the signal word used on the label?
9. For what toxicity category does the signal word stand?
10. How much pesticide does this container hold?
11. What is the EPA registration number?
12. What is the EPA establishment number?
13. Is this a restricted use or general use pesticide?
14. Is this pesticide flammable or corrosive?

LESSON PLAN

Area and/or Course ____________________ Unit ____________________

Lesson Title **Other Biological and Chemical Control Methods.** No. Periods 01

Date __________

Upon completion of this lesson, the student will be able to:

Objectives:

1. Define\explain the following terms: microbial control, autocidal control, mating disruption technique.

2. List five types of microbial agents used in pest management.

3. List two microbial insecticides currently registered for use in the United States.

4. Name an insect pest which has been successfully controlled with the autocidal control method.

5. Describe two advantages of the mating disruption technique.

6. Describe one limitation of the mating disruption technique.

Student Activity.

7. Participate in a class experiment using B.t. for control of Lepidoptera. Write a short lab report describing the experiment.

Materials, Equipment, Audio-visual aids:

1. Two large glass jars (gallon size) with screen or mesh cloth and rubber bands to serve as a lid.

2. B.t. (microbial insecticide).

3. Small hand pump sprayer (quart size).

4. Fresh supply of green plant material to feed the larvae (try to use the same host as they were collected on i.e. alfalfa).

5. Lepidoptera larvae that were collected and treated with B.t. earlier.

6. Data sheet for recording results.

References:

Bottrell, Dale R. 1979. Integrated Pest Management. Council on Environmental Quality. pp 32-39.

Kirsch, Philipp 1988. Pheromones: Their Potential Role in Control of Agricultural Insect Pests. American Journal of Alternative Agriculture. Institute for Alternative Agriculture. Greenbelt Md. Spring/Summer (213) pp 83-97.

Maddox, J.V. 1982. Use of Insect Pathogens in Pest Management. In Introduction to Insect Pest Management. Edited by Metcalf, Robert L. and William H. Luckmann. Second Edition John Wiley and Sons. New York. pp 175-216.

Introduction -- Motivation -- Interest Approach:
(Application is laced in at this point).

In addition to the control methods mentioned in earlier lessons, there are other tools available for use in IPM programs. This lesson will focus on three other control tactics which include: microbial control, autocidal control, and mating disruption. Microbial control has application in controlling insects, pathogens, and weeds, while the other two methods are limited to insect control. The purpose of this lesson is to introduce the students to some of the other techniques available for IPM.

Problem Stated, Solutions to Problem, Steps Sequenced, Subject Matter Points, Student Learning Activities, Artful Questions: (Application is laced in at this point, lessons designed to meet the objectives set forth)	Strategy - How are you going to proceed through the lesson: (What objectives are you meeting here?)
What is microbial control? What types of microbial control agents are used in pest management? (bacteria, viruses, fungi, protozoa,and nematodes.) Can you name two commercially available microbial agents? (B.t. and Nosema.)	The students will study the background material before coming to class. The teacher will review the material on microbial control and then describe the B.t. experiment in progress. The class will examine the larvae in both cages and record the number of larvae alive in each cage. The teacher will record the results on the chalkboard and the students will record the results on their data sheet

to be turned in with a short lab report describing the experiment.

What is autocidal control?

The teacher will describe this method of insect control and an example of how it has been successful (i.e. screwworms).

What is mating disruption?

Describe the advantages and limitations of mating disruption.

The teacher will describe this method of insect control and an example of how it has been successful (i.e. oriental fruit moth).

Summary -- Conclusion to the Problem: (Application is re-emphasized here and drawn as many students in the class as possible).

Microbial control agents include viruses, bacteria, fungi, protozoa, and nematodes. The principal advantages in using microbial control are safety and host specificity. The most popular microbial agent used is *Bacillus thuringiensis* or "B.t." Autocidal control involves rearing and release of insects that are sterile or are altered genetically in order to suppress members of their own species that are causing pest problems.

The most common autocidal control method is the sterile male release method. Mating disruption is a technique in which high concentrations of synthetic formulations of insect sex pheromones are released into an area to disrupt the orientation of male insects to their mates.

When successful, the reduced number of matings within the population leads to suppression of the population over subsequent generations. This method has achieved excellent control for a number of important insect pests including the pink bollworm in cotton, the oriental fruit moth in peaches, and the codling moth in pears.

Evaluation: (Questions and/or activities which reflect the objectives of the lesson).

1. Describe the following pest management techniques:

   microbial control: the suppression of pests by utilizing microorganisms or their by-products.

   autocidal control: involves rearing and release of insects that are sterile or are altered genetically in order to suppress members of their own species that are causing pest problems.

   mating disruption: the use of synthetic formulations of sex pheromones to disrupt the orientation of male insects to their mates.

2. List the five types of microbial agents used in pest management.

   bacteria, viruses, fungi, nematodes, and protozoa.

3. List two microbial agents currently registered for use in the U.S.

   Bacillus thuringiensis (B.t.)

   Bacillus popilliae

   Nosema locustae

4. Name an insect pest which has been successfully controlled with the autocidal method (SIT).

   screwworms, fruit flies, codling moth.

5. Describe two advantages of the mating disruption technique.

   low toxicity, ease of application, few regulatory restrictions, compatible with cultural practices, compatible with natural control agents, resistance unlikely, long-term population suppression.

6. Describe one limitation of the mating disruption technique.

   immigration of mated females, secondary pests, breakdown of control under high pest populations, cost.

Assignments: (Designed to meet lesson objectives).

The students will study the background material for this lesson before coming to class.

A group of students should be responsible for providing fresh food for the insect larvae during the B.t. experiment. The jars should be checked each day to make sure fresh food is provided. Try to provide the same food (host) as the larvae were collected in (i.e. alfalfa, clover, potato leaves, etc.) Avoid store bought produce because it may contain insecticide residue. Each student should prepare his\her own data sheet for reporting the results of the experiment.

Other Biological and Chemical Control Methods.

Microbial Control.

Microbial control is the suppression of pests by utilizing microorganisms or their by-products. This definition includes the use of microorganisms as naturally occurring control agents, introduced control agents, and the application of microorganisms and/or their by-products as microbial insecticides. Although microbial agents exist for control of weeds and plant pathogens, by far the most successful control has been achieved against insect pests. Therefore this discussion will focus on microbial control of insects.

Types of Microbial Agents for Insect Pest Management.

There are five types of microbial agents which attack insects, they are: **viruses, bacteria, fungi, protozoa, and nematodes.** Some of these pathogens are quite common in natural insect populations, while others may occur so infrequently that they are seldom observed. Some of these disease agents may be very pathogenic to their hosts and cause a high rate of mortality, while others may produce only chronic effects. More than 1500 insect pathogens are known, and this is probably only a small fraction of the total number of pathogens infecting insects.

Insect pathogens can be used in pest management in at least three different ways: (1) by the maximum utilization of naturally occurring diseases, (2) by the introduction of insect pathogens into insect pest populations as permanent mortality factors, and (3) by the application of insect pathogens as microbial insecticides for the temporary control of an insect pest.

Some of the more commonly used microbial control agents include:

1. **Bacillus thuringiensis or "B.t."** for short. A bacterial insecticide used mainly against caterpillars (Lepidoptera), although one formulation (B.t. var. israelensis) controls fly larvae (Diptera) of mosquitoes, black flies, fungus gnats, etc. B.t. is harmless to mammals, birds, fish, and biological control agents. The active ingredients are bacterial spores and crystals of a toxin produced by the bacterium. When eaten by the caterpillar, these crystals cause paralysis and disturb the gut. The spores germinate, allowing the bacteria to escape, multiply, and eventually invade the blood. Death of the caterpillar may take several days, but feeding ceases shortly after ingestion of the spray deposit. Good coverage is essential. A recent development involves "transgenic" potato plants. These plants contain genes of Bacillus tenebrio the toxin which controls the Colorado Potato beetle.

2. **Bacillus popilliae** is another bacterial insecticide which has been used extensively since the 1940's against the Japanese beetle, one of the most serious insect pests in this country; it attacks turf, fruits, vegetables, and many ornamental plants. The marketed powder is made from ground inoculated grubs of the pest and is mixed with an inert carrier such as chalk. It is applied to the soil where it is spread by rainwater, insects, and other animals, thereby affecting the grubs (immature feeding stages) of the beetle which live in the soil.

3. Nosema locustae or "Nosema" for short. A microsporidial (protozoan) pathogen which infects only grasshoppers and Morman crickets. Honey bees and beneficial organisms are not affected. The microsporida may be transmitted from one insect to another orally (grasshoppers are cannibalistic) by a resistant spore form, or transovarially from an infected female to her progeny. Nosema is formulated as a wheat bran bait for application in home gardens, lawns, crop and rangelands. It is marketed under several names including: Grasshopper Attack, Hopper-Stopper, and NOLO-Bait.

4. **Nematodes.** Not all nematodes are bad. In fact a beneficial species Steinernema carpocapsae, has earned praise as an effective biological control agent against the larvae of wood borers, black vine weevils, and several Lepidoptera pests. Nematodes are an effective alternative to chemical controls. They will not harm people, mammals, birds, or plants and have no impact on beneficial organisms such as earthworms or honey bees when used according to label directions.

Nematodes by themselves do not kill their host insects. A lethal bacteria inside their bodies, Xenorhabdus spp., is released once the nematode enters the insect hosts. While the Xenorhabdus bacteria kills the insect, it is incapable of entering an insect's body by itself. It needs the nematode to penetrate the insect's body cavity, and the nematode needs the bacteria as a food source. Thus the nematode and bacteria have a symbiotic relationship when it comes to controlling host insects.

The nematodes are easily mass-produced and applied. They can be applied through almost any chemical sprayer. They actively seek out susceptible hosts and possess high virulence and infectivity, killing their hosts within 24 to 48 hours. They have a wide host range, capable of killing more than 250 insect species under laboratory conditions. They are limited to moist situations favorable for their survival in nature. Thus it is important to protect them from environmental stresses, such as high temperatures and low moisture. Predatory nematodes are marketed as biological soil insecticides, under such names as Biovector and BioSafe.

Autocidal Insect Control.

Autocidal control involves rearing and release of insects that are sterile or are altered genetically in order to suppress members of their own species that are causing pest problems.

Sterile-Male Method.

The sterile-male method involves artificially sterilizing large numbers of insects by irradiation or chemical sterilants so that after being released into an area inhabited by a wild population, the sterile males mate with wild females. If the wild population is flooded with large numbers of sterile males and they outcompete the wild fertile males, the wild females produce substantially fewer offspring than they normally would. Repeating this procedure for several consecutive generations may eventually annihilate the wild population. This is one of the most ingenious pest control methods yet developed; it has been widely publicized, primarily because of its successful application against the screwworm fly, Mediterranean fruit fly, pink bollworm, and the codling moth. However, the high costs of rearing, sterilizing, and liberating the sterile insects make this technique feasible for only a few insect pests.

Mating Disruption.

Many female insects release a sex pheromone into the atmosphere to attract the male for the purpose of mating. When males of the same species detect the pheromone, they orient themselves upwind in the direction of the pheromone source. In this manner, male insects are able to locate fertile and sexually mature females. **Mating disruption** explores the concept of using synthetic formulations of sex pheromones to disrupt this orientation of male insects to their mates. If successful, the reduced number of matings within the population should lead to suppression of the population over subsequent generations.

Mating disruption promises to be an alternative pest management technique useful for some key agricultural pests. Commercially acceptable levels of control, using pheromones for mating disruption, have been demonstrated for oriental fruit moth in California, grape berry moth in New York state, second generation European grape berry moth in Germany, tomato pinworm in California, lesser peach tree borer in the Southeastern U.S., codling moth in Switzerland, and the bagworm moth in Maryland.

Advantages of Mating Disruption.

1. **Low toxicity.** The single most important benefit of using pheromones is their low toxicity. Toxicological tests performed on those compounds that have been subject to review by environmental protection agencies indicate that these materials have negligible mammalian toxicity. Further, due to the low amounts used and the method of application, pheromones are not expected to have adverse effects on nontarget species.

2. **Ease of application.** Polyethylene pheromone dispensers are easy to apply, requiring no special equipment. Applicators do not need to have the special training and protective clothing that are required in the use of conventional pesticides.

3. **Fewer regulatory restrictions.** There are fewer regulatory restrictions involved in the use of pheromones compared to insecticides. Treated fields do not need to be posted against entry by unauthorized persons. Re-entry or preharvest intervals do not need to be observed. Due to the very low toxicity of naturally occurring pheromones, the instability of the active ingredient, and the very low levels of material applied in the field, there are no restrictions on the amount of pheromone residue on fruit at harvest.

4. **Compatible with cultural practices.** The use of pheromones for pest management is readily compatible with other cultural and production operations in agriculture. Pheromone applications are predictable on a calendar schedule, and other operations including irrigation, hand and mechanical cultivation, thinning, tree propping, pruning, and harvest can be easily scheduled without fear of interference from in-season insecticide applications. Cultural operations requiring large amounts of hand labor, e.g. thinning and hand cultivation, can be conducted at the proper time without any concern for insecticide residues.

5. **Compatible with natural control agents.** Relative to conventional broadly toxic insecticides, the use of pheromones allows preservation of beneficial biological control agents, as well as insect pollinators. Numbers of beneficial arthropods increase dramatically when toxic pesticides are no longer applied and population levels of predatory insects and mites are generally higher in pheromone-treated areas when compared to those in areas treated with insecticides.

6. **Resistance is unlikely.** It is unlikely that insects will develop resistance as readily to pheromone-based control strategies as they have to all major classes of insecticides. Mating disruption of pink bollworm has been undertaken for over eight years, yet there has been no sign of resistance in populations subject to continuous disruption pressure. Some scientists point out that selection for resistance may be difficult because it would involve changes in both males and females, unless there is close genetic linkage between emission and response.

7. **Long-term population reduction.** Pheromones may ultimately offer an opportunity to reduce target pest populations over the longer term. This effect has been observed in Australia, where growers have used mating disruption over three or more successive seasons for control of oriental fruit moth.

Limitations of Mating Disruption.

1. **Immigration of mated females.** Mating disruption does not prevent damage that may result from immigration or extended host searching of mated female insects from sources external to the field treated with pheromone. As a result, it is essential to try and treat

complete crop units. Single tree evaluations and small plot trials placed within large non-pheromone treated blocks need to be avoided. As a result, the technique probably has little promise for household garden or backyard use.

2. **Secondary pests.** Mating disruption is a very species specific control tactic. This has disadvantages as well as advantages. Nontarget pest species controlled by broad spectrum pesticides in conventional management programs may reach damaging population levels in the absence of these sprays. This has been observed in the implementation of oriental fruit moth mating disruption in California and in preliminary evaluation of codling moth mating disruption in pears. It may be that the greatest likelihood for successful adoption of mating disruption in pest management will be in situations where there is only one important pest species and secondary pest problems arise through pesticide treatments directed at the key pest.
3. **Breakdown of control under high pest populations.** Mating disruption is ineffective as a control technique when used against very high populations of the target pest. The relationship between efficacy of mating disruption and pest density would be the same as for application of insecticides and other methods of control. If disruption of mate finding is largely due to interference with the long range guidance mechanism that insects use, then the density of the pest will influence the effectiveness of the confusion treatment regardless of secondary and shorter range stimuli, such as vision, that may be involved. Where there are high endemic populations of the target insect, it may be necessary to reduce the population pressure with an insecticide application in the initial year of pheromone use.

4. **Cost.** Possibly the major factor limiting the widespread development and implementation of pheromones is still the cost of synthesis of active ingredient. As a result, the commercialization of the technique is currently limited to control of key pests of high-value crops that are presently protected by expensive conventional spray programs or control of pests of large acreage crops such as cotton. Mating disruption will become more competitive with the development of dispensing systems that release pheromone more efficiently. Ultimately, the current regulatory climate and consumer pressure for pesticide-free produce may force the adoption of biologically based pest management techniques regardless of the costs involved.

LESSON PLAN

Area and/or Course ______________________ Unit ______________

Lesson Title **Integrated Pest Management.** No. Periods 02 Date ________

Upon completion of this lesson, the student will be able to:

Objectives:

1. Describe the six key components of an IPM program.

2. Write a brief news article (1 - 2 pages) for the school newspaper, community newspaper, or the Capital Press newspaper on some aspect of IPM.

Student Activity.

3. Participate in the development of an IPM program for a farm in Oregon.

Materials, Equipment, Audio-visual aids:

1. Flipchart paper or chalkboard for recording students ideas.

2. Marking pens (if flipchart is used).

References:

Olkowski, William, Olkowski, Helga, and Sheila Daar 1988. What is IPM? Common Sense Pest Control IV (3) Summer, pp 9-16.

Introduction -- Motivation -- Interest Approach:
(Application is laced in at this point).

IPM is a decision-making process that considers the whole ecosystem in determining the best methods for managing pests. The objective of an IPM program is to suppress the pest population below the level that causes economic, aesthetic, or medical injury. IPM strategies are designed to be the least disruptive of natural pest controls, human health, and the general environment. Horticultural, physical, mechanical, biological, least-toxic chemical, and educational tactics are integrated to solve pest problems with a minimal reliance on pesticides.

In the first nine lessons of this curriculum, the students have learned some of the basic concepts of IPM. In this lesson, the students will try to put what they have learned together and do some creative "thinking". The students will work together in designing an IPM program for a farm in Oregon. The students will also write a short article for a newspaper on some aspect of IPM. These two exercises will provide an excellent opportunity for the students to develop their creative thinking skills.

Problem Stated, Solutions to Problem, Steps Sequenced, Subject Matter Points, Student Learning Activities, Artful Questions: (Application is laced in at this point, lessons designed to meet the objectives set forth)	Strategy - How are you going to proceed through the lesson: (What objectives are you meeting here?)
Describe the six key components of an IPM program. 1. initial information gathering 2. monitoring/sampling 3. establishing injury levels 4. record-keeping 5. least-toxic treatments 6. evaluation	The students should read the lesson material carefully before coming to class. The teacher will discuss the six key components of an IPM program with the class, explaining the importance of each component to a successful IPM program.
Write a brief news article (1 - 2) pages for the school newspaper, community newspaper, or the Capital Press (regional) newspaper, on some aspect of IPM. Some ideas include: What is IPM? The role of cultural control in IPM. Parasites and Predators. Why farmers should monitor their crops for pests. etc.	This can be a valuable learning experience not only for the students, but also for the public. This assignment could be made earlier so that it is ready by lesson 10. It would be great if some of the articles could actually be published in the local paper.
Participate in the development of an IPM program for a farm in Oregon.	The class will visit a local farmer and spend an hour interviewing the farmer on his pest management program. The students will formulate questions in class before the visit so that meaningful information will be gathered. It might be useful for the teacher to contact the county extension agent for a

suitable farmer. After the students finish interviewing the farmer, they will use the information gathered to brainstorm an IPM program for that farmer's operation. This would occur the following day in class. Have the students use the 6 key components of an IPM program as a guide for formulating their questions. Encourage the students to be as creative as possible in developing the IPM program. Record their ideas on the flipchart or chalkboard and spend the last 10 minutes of class summarizing the results.

Summary -- Conclusion to the Problem: (Application is re-emphasized here and drawn as many students in the class as possible).

Integrated Pest Management (IPM) is a decision-making process for determining: IF you need pest suppression treatments, WHEN you need them, WHERE you need them, and WHAT strategy and mix of tactics to use to provide cost-effective, environmentally sound control. Costly experience with the conventional pest control practices of the 1950s and 1960s led to the development of the IPM approach. These practices included:

* Sole reliance on a chemical control strategy.
* Preventive or "calendar" spraying.
* Treatment at the first sign of the pest, without efforts to identify pests or set injury levels.
* Little or no evaluation of treatments.
* No system-wide perspective.

Evaluation: (Questions and/or activities which reflect the objectives of the lesson).

1. Describe the six key components of an IPM program.

   INITIAL INFORMATION GATHERING.

   MONITORING\SAMPLING.

   ESTABLISHING INJURY LEVELS.

RECORD-KEEPING.

LEAST-TOXIC TREATMENTS.

EVALUATION.

Assignments: (Designed to meet lesson objectives).

The students will study the lesson material carefully before coming to class. Due to the time constraint for this lesson, it is necessary for the students to formulate their questions for the farmer before coming to class. The students should use their notes from the interview to begin developing an IPM program as homework. The students will present their ideas during the second day of this lesson.

Integrated Pest Management.

There are at least four ways in which IPM programs must be "integrated". The first meaning of integration is that many treatment strategies may be fitted together or integrated into a total management program. This is the most common understanding of the term, and on this basis alone many programs are claimed to be IPM.

The key here is the word "integrated" itself. IPM is not simply a stew cooked up out of various, miscellaneous tactics, i.e., a little biological, chemical, or cultural methods all mixed up together, with some public relations announcements to season the pot. The methods employed within an IPM program must be organized through the use of a monitoring and evaluation system, and decisions to take action must be based on judgements of the amount of economic, medical, or aesthetic damage the pest problem is likely to cause.

Secondly, in designing IPM programs, the practitioner takes into consideration the many potential interactions between the key pests, their natural enemies, other actual or potential pests, and other living and non-living factors.

One of the first problems the IPM program designer faces is determining the boundaries of the system to be managed. For example: when a fungus is causing damage, the IPM practitioner will consider the effect of fungicides on beneficial fungi which may be holding nematode populations in check; or, when faced with management of a weed problem, the IPM practitioner will consider the effect of weeds on insect pests and natural enemies; or, when advising a homeowner to modify certain structural components of the house to combat pests, the practitioner will advise building out a number of pests at once - not just the pest in question at the specific time.

A third meaning of "integration" is that IPM practitioners view pest management as but one aspect in the management of a total ecosystem or "whole system". Social, economic, political, and ecological factors affect pest management decisions. In agriculture, IPM practitioners have to look at all aspects of production - they are even concerned with the effect of management practices in neighboring fields!

How people feel about pest damage also has to be considered. Cosmetic damage to fruits and vegetables may not affect their quality and taste, but it will effect marketability and hence pest management. Aesthetic damage to landscape plants in the city may not endanger their growth, but it can reduce enjoyment of them.

Another consideration is the federal and state registration process for insuring pest control safety and effectiveness. This process is time-consuming and politically sensitive. It affects pest managers' choices concerning availability and use of products. IPM practitioners can be influential in product development and plant protection research if they make their pest management needs and desires known.

Finally, the fourth level of integration concerns the development of a coherent body of IPM theory that is transdisciplinary (not bound to a particular discipline). IPM programs must incorporate the findings of entomologists, plant pathologists, soil scientists, meteorologists, agronomists, foresters, architects, public health professionals, sociologists, economists, etc. Contributions from many fields must come together to provide what is essentially a site-specific intervention strategy that seeks to harmonize the relationship between human beings and other species regarded as pests.

It is important to remember that, in large measure, pest problems have been designed into our human-managed systems. The most energy- and cost-effective pest management strategy in the long term is to redesign the system to eliminate the life support systems required by the pests. Through appropriate selection and mix of plant species, horticultural and animal husbandry practices, building maintenance, design or remodeling of structures or landscapes, contouring of sites, and design of organic waste and other resource management processes, we can reduce the preferred harborage, food, water, and other essential requirements of pests.

Summary of Treatment Strategies.

A pest management strategy is a series of planned tactics or methods for preventing or suppressing pest populations based on ecological understanding. The IPM approach takes advantage of the fact that combined strategies for pest management are more effective in the long run than a single strategy. Some strategies are superior to others because they build out the pest, or build in its natural enemies, thus giving long-term suppression or elimination of the pest problem. In contrast, short-term strategies respond to an immediate crisis but do little to prevent the problem from recurring repeatedly. The major strategies, in the order in which they should be considered, are:

A. Design or redesign of the landscape or structure.
This includes:

1. Selection of plants, livestock, or structural materials that are:

   * resistant to pests
   * supportive of natural controls
   * enhancing of ecosystem diversity and processes

2. Agricultural, landscape, or structural designs that are:

   * conducive to plant health or sound structural maintenance
   * appropriate to the weather, soil, mineral, water, energy, and human resources of the site and the maintenance system.

B. Habitat modification or changing the biophysical environment for purposes of:

1. Reduction of pest harborage, food, or other life support requirements.

2. Enhancement of the environment required by the pests' predators, parasites, pathogens, antagonists, or competitors.

C. Human behavior changes, including:

1. Horticultural controls and maintenance practices

   * modification of such resource management practices as mowing, cultivating, watering, planting, fertilizing, pruning, mulching, household cleaning, waste management, etc.

2. Education

   * modification of aesthetic judgements regarding "cosmetic damage" to fruits and vegetables, manicuring of landscapes, and the visual presence of certain animal species.

   Who needs to receive education?

   * pest management professionals
   * farmers, foresters, landscape and building maintenance personnel, resource managers of every kind.
   * policymakers and regulatory personnel in public and private institutions and agencies.
   * the general public.

D. Biological controls, including:

1. Conservation of the pests' natural enemies through the proper selection of materials, and the timing and placing of treatments.

2. Augmentation of existing natural enemies by releasing additional numbers of the same species.

3. Inoculation by the repeated reintroduction of effective natural enemies that are available commercially but are unlikely to live from season to season in the natural environment.

4. Importation of the host-specific natural enemies of exotic invaded pests. Note: This is the one strategy not available to private individuals or institutions, and must be carried out by government supervised quarantine facilities.

E. Physical controls such as:

1. Barriers
2. Traps
3. Heat, cold, humidity, desiccation, or light
4. Electric current
5. Mechanical removal
6. Others

F. Chemical controls, including:

1. Pheromones and other attractants to lure and/or confuse the pest.
2. Juvenile hormones that arrest pest development.
3. Repellents
4. Allelopathins
5. Sterilants or contraceptives to reduce breeding or future generations.
6. Contact, stomach, and other poisons.
7. Fumigants
8. Combinations of the above (e.g., baits with attractant and stomach poison)
9. Others

Components Of An IPM Program.

An IPM program contains the following key components:

1. **INITIAL INFORMATION GATHERING.** Obtain an identification of the pests and/or problem. The scientific name of an organism is the key to all that has been written about the pest in the past. Examine the literature on the biology of the pest and its management. Interview local management personnel on the history of pest management at the site as well as other

activities that might influence the pest problem. Information collected on the background of the problem, plus records of ongoing activities once the program begins, provide the basis for intelligent program continuity.

2. **MONITORING\SAMPLING.** Observe the plants, or site, for potential pest problems at regular intervals (see lesson two for more details).

3. **ESTABLISHING INJURY LEVELS.** Determine when the pest problem is likely to become serious enough to require some action (refer to lesson two).

4. **RECORD-KEEPING.** Keep records of what is seen, decisions made, actions taken, and results. Records are the memory of a system. When personnel leave, their experience is lost if there are no records.

5. **LEAST-TOXIC TREATMENTS.** Select pest management approaches and specific methods according to the criteria below.

   Choose strategies that are:

   * least-disruptive of natural controls
   * least-hazardous to human health
   * least-toxic to non-target organisms
   * least-damaging to the general environment
   * most likely to produce a permanent reduction in the environment's ability to support that pest
   * most cost-effective in the short and long term

6. **EVALUATION.** Inspect after treatment action has been taken. Write down what you learn. Has the treatment been worthwhile? How can the whole process be improved to achieve the overall objectives of the program?

Course Title__________________ Name______________________

Instructor____________________ Date______________

Score_______/46

INTEGRATED PEST MANAGEMENT FINAL EXAM.

Multiple Choice.

Circle the best answer.

1. Any organism that may adversely affect human activities

   a. key pest. c. secondary pest.
   b. pest. d. target pest.

2. Temperature, relative humidity, and soil conditions are examples of

   a. biological controls. c. cultural controls.
   b. chemical controls. d. natural controls.

3. The lowest population density that will cause economic damage

   a. economic threshold. c. economic injury level.
   b. population equilibrium level. d. pest damage level.

4. The term instar refers to the development stage of

   a. plants. c. bacteria.
   b. fungi. d. insects.

5. The major causal agent of plant disease is

   a. nematodes. c. viruses.
   b. bacteria. d. fungi.

6. The disease triangle consists of a causal agent, a conducive environment, and

   a. host. c. pathogen.
   b. vector. d. susceptible host.

7. Noninfectious plant diseases are caused by

   a. nematodes. c. air pollution.
   b. fungi. d. viruses.

8. A nematode is a type of

   a. fungus.
   b. roundworm.
   c. annual plant.
   d. insect.

9. Complete metamorphosis consists of

   a. egg, nymph, adult.
   b. egg, naiad, adult.
   c. egg, young, adult.
   d. egg, larva, pupa, adult.

10. A biennial weed will live for

   a. one year.
   b. two years.
   c. three years.
   d. more than three years.

11. A trap crop is an example of a

   a. cultural control.
   b. regulatory control.
   c. biological control.
   d. chemical control.

12. A pest which has been introduced into an area in which it is not native is called a/an

   a. target pest.
   b. exotic pest.
   c. introduced pest.
   d. occasional pest.

13. The control strategy which relies on the introduction of parasites and predators is

   a. cultural.
   b. natural.
   c. biological.
   d. host resistance.

14. A pesticide used to control diseases is a/an

   a. fungicide.
   b. nematicide.
   c. insecticide.
   d. acaricide.

15. A chemical that is more toxic to some species than to others is a/an

   a. systemic pesticide.
   b. stomach poison.
   c. contact poison.
   d. selective pesticide.

Each item has only <u>one</u>(1) correct answer. All answers are used, and used only once. Please place the correct letter in the blank provided.

<u>Matching.</u>

_____ 1. Economic injury level.
_____ 2. Natural control.
_____ 3. Abiotic.
_____ 4. Mating disruption.
_____ 5. Economic threshold.
_____ 6. Autocidal control.
_____ 7. Chewing mouthparts.
_____ 8. Symptom.
_____ 9. Rhizome.
_____ 10. Biotic.
_____ 11. Predator.
_____ 12. Sucking mouthparts.
_____ 13. Stolon.
_____ 14. Parasite.
_____ 15. Sign.
_____ 16. Biological control.

a. A stem that runs underground and gives rise to new plants at each joint or node.
b. Aphids.
c. Evidence of the damaging factor.
d. Control measures which occur without the intervention of humans.
e. Non-living factors.
f. The lowest population density that will cause economic damage.
g. Grasshoppers.
h. A stem that runs on the surface and gives rise to new plants at each node.
i. The density at which control measures should be initiated to prevent economic damage.
j. An animal that feeds on a smaller or weaker organism.
k. Any change in the growth or appearance of the plant in response to living or nonliving damaging factors.
l. Living factors.
m. The use of natural enemies to control pests.
n. An organism that lives in or on another organism.
o. Involves rearing and release of insects that are sterile or are altered genetically in order to suppress members of their own species that are causing problems.
p. The use of synthetic formulations of sex pheromones to disrupt the orientation of male insects to their mates.

True or False?

Answer the following questions by marking a T if you think the statement is true or F if you think the statement is false.

_____ 1. Insects have six pairs of legs.
_____ 2. Monitoring is a key component of an IPM program.
_____ 3. Cultural control is the deliberate manipulation of the environment to make it less favorable for pests.
_____ 4. Inert ingredients are the chemical or chemicals in a pesticide responsible for the desired effects.
_____ 5. Sanitation is a type of regulatory control.
_____ 6. Infectious plant diseases are caused by abiotic factors.
_____ 7. Adult flies have one pair of wings and chewing mouthparts.
_____ 8. Metamorphosis is the period of time from hatching to the adult stage in insects.
_____ 9. Monoculture is the practice of growing the same crop in the same area on a continuing basis.
_____ 10. Pesticide resistance is the genetic ability of some organisms to tolerate normally lethal doses of a pesticide.
_____ 11. The sterile-male release method is an example of mating disruption.
_____ 12. Bacillus thuringiensis or B.t. is an effective microbial agent against all insect pests.
_____ 13. The cinnabar moth has been successfully controlled using biological control in Oregon.
_____ 14. Pesticides cause environmental damage and should not be used in IPM.
_____ 15. Water management is an important cultural control method.

Course Title__________________ Name Key

Instructor__________________ Date__________

Score_____/46

INTEGRATED PEST MANAGEMENT FINAL EXAM.

Multiple Choice.

Circle the best answer.

1. Any organism that may adversely affect human activities

   a. key pest.
   (b) pest.
   c. secondary pest.
   d. target pest.

2. Temperature, relative humidity, and soil conditions are examples of

   a. biological controls.
   b. chemical controls.
   c. cultural controls.
   (d) natural controls.

3. The lowest population density that will cause economic damage

   a. economic threshold.
   b. population equilibrium level.
   (c) economic injury level.
   d. pest damage level.

4. The term instar refers to the development stage of

   a. plants.
   b. fungi.
   c. bacteria.
   (d) insects.

5. The major causal agent of plant disease is

   a. nematodes.
   b. bacteria.
   c. viruses.
   (d) fungi.

6. The disease triangle consists of a causal agent, a conducive environment, and

   a. host.
   b. vector.
   c. pathogen.
   (d) susceptible host.

7. Noninfectious plant diseases are caused by

   a. nematodes.
   b. fungi.
   (c) air pollution.
   d. viruses.

8. A nematode is a type of

a. fungus.
b. roundworm.
c. annual plant.
d. insect.

9. Complete metamorphosis consists of

a. egg, nymph, adult.
b. egg, naiad, adult.
c. egg, young, adult.
d. egg, larva, pupa, adult.

10. A biennial weed will live for

a. one year.
b. two years.
c. three years.
d. more than three years.

11. A trap crop is an example of a

a. cultural control.
b. regulatory control.
c. biological control.
d. chemical control.

12. A pest which has been introduced into an area in which it is not native is called a/an

a. target pest.
b. exotic pest.
c. introduced pest.
d. occasional pest.

13. The control strategy which relies on the introduction of parasites and predators is

a. cultural.
b. natural.
c. biological.
d. host resistance.

14. A pesticide used to control diseases is a/an

a. fungicide.
b. nematicide.
c. insecticide.
d. acaricide.

15. A chemical that is more toxic to some species than to others is a/an

a. systemic pesticide.
b. stomach poison.
c. contact poison.
d. selective pesticide.

Each item has only one(1) correct answer. All answers are used, and used only once. Please place the correct letter in the blank provided.

Matching.

f	1.	Economic injury level.
d	2.	Natural control.
e	3.	Abiotic.
p	4.	Mating disruption.
i	5.	Economic threshold.
o	6.	Autocidal control.
g	7.	Chewing mouthparts.
k	8.	Symptom.
a	9.	Rhizome.
l	10.	Biotic.
j	11.	Predator.
b	12.	Sucking mouthparts.
h	13.	Stolon.
n	14.	Parasite.
c	15.	Sign.
m	16.	Biological control.

a. A stem that runs underground and gives rise to new plants at each joint or node.
b. Aphids.
c. Evidence of the damaging factor.
d. Control measures which occur without the intervention of humans.
e. Non-living factors.
f. The lowest population density that will cause economic damage.
g. Grasshoppers.
h. A stem that runs on the surface and gives rise to new plants at each node.
i. The density at which control measures should be initiated to prevent economic damage.
j. An animal that feeds on a smaller or weaker organism.
k. Any change in the growth or appearance of the plant in response to living or nonliving damaging factors.
l. Living factors.
m. The use of natural enemies to control pests.
n. An organism that lives in or on another organism.
o. Involves rearing and release of insects that are sterile or are altered genetically in order to suppress members of their own species that are causing problems.
p. The use of synthetic formulations of sex pheromones to disrupt the orientation of male insects to their mates.

True or False?

Answer the following questions by marking a T if you think the statement is true or F if you think the statement is false.

F 1. Insects have six pairs of legs.
T 2. Monitoring is a key component of an IPM program.
T 3. Cultural control is the deliberate manipulation of the environment to make it less favorable for pests.
F 4. Inert ingredients are the chemical or chemicals in a pesticide responsible for the desired effects.
F 5. Sanitation is a type of regulatory control.
F 6. Infectious plant diseases are caused by abiotic factors.
F 7. Adult flies have one pair of wings and chewing mouthparts.
F 8. Metamorphosis is the period of time from hatching to the adult stage in insects.
T 9. Monoculture is the practice of growing the same crop in the same area on a continuing basis.
T 10. Pesticide resistance is the genetic ability of some organisms to tolerate normally lethal doses of a pesticide.
F 11. The sterile-male release method is an example of mating disruption.
F 12. Bacillus thuringiensis or B.t. is an effective microbial agent against all insect pests.
F 13. The cinnabar moth has been successfully controlled using biological control in Oregon.
F 14. Pesticides cause environmental damage and should not be used in IPM.
T 15. Water management is an important cultural control method.