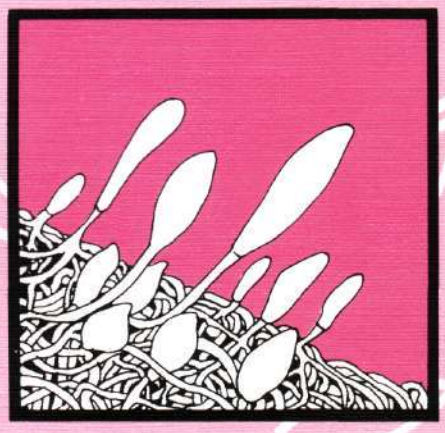
Commercial and Private Pesticide Applicator Core Manual Initial Certification
Michigan State University Extension Service
Joy Neumann Landis, Robin R. Rosenbaum, Andrea Rother
September 1989
90 pages

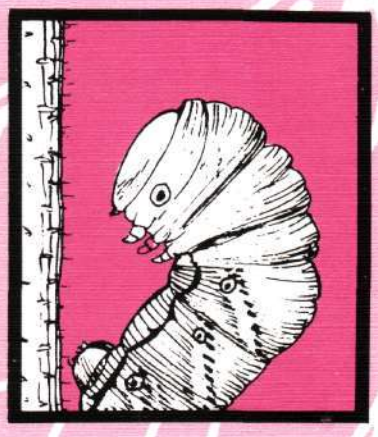
Systemic Pesticide

$3.00

Commercial and Private Applicator Core Manual

Initial Certification





Extension Bulletin E-2195
New, September 1989
Cooperative Extension Service
Michigan State University

Commercial And Private Pesticide Applicator Training Manual

Initial Certification

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Preface

This manual has been developed to replace the initial core certification manuals, E-1824 for commercial pesticide applicators and E-1025 for private pesticide applicators. The introduction describes the procedures for becoming a certified commercial or private pesticide applicator.

Acknowledgements

We would like to express our appreciation to the following Michigan State University Cooperative Extension Service employees for contributing to or reviewing the manuscript prior to publication: Gerard Adams, Department of Botany and Plant Pathology; G.W. Bird, Department of Entomology; Lyman Baker, (former) Kent County; Michael Kamrin, Department of Natural Sciences; James Kells, Department of Crop and Soil Sciences; Roger Mech, Clare County; James Nugent, Northwest District Fruit IPM Agent; Howard Russell, Department of Entomology; Carl Stephens, Missaukee County; Dennis Stein, Bay County; Robert Wilkinson, Department of Agricultural Engineering.

The Pennsylvania State University manual, "Pesticide Education Manual: a guide to safe use and handling," edited by Cynthia L. Brown and Winand K. Hock, was a valuable source of information for this manual. We also thank James McClure and Rae Chambers (Penn State) and Marlene Cameron (Michigan State University) for the illustrations, and Peter Carrington for the cover design.

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Commercial application is located in the **back** of the manual

INTRODUCTION

Why should pesticide applicators be certified?

Pesticides protect our food and non-food crops, ourselves, our homes, pets, and livestock. New highly-sensitive measuring devices are detecting that some of these pesticides are reaching groundwater, remaining in crops as residues, and in other parts of the environment. To better protect the environment and human health by assuring proper, safe use and application of pesticides, the Michigan Department of Agriculture (MDA) requires individuals using *restricted use pesticides* to be certified. This certification gives the applicator the necessary knowledge to purchase and safely use restricted use pesticides.

Procedures for Certification of Commercial Applicators

To become certified as a commercial applicator in Michigan, you are required to successfully complete a minimum of two written examinations: one on the general standards specified in the federal regulations (40 CFR 171.4(b) and 171.6), and the other(s) on the specific requirements of the category or subcategory (40 CFR 171.4(c) and Regulation 636 Rule 4). Anyone who applies pesticides by aircraft or by space fumigation is required to successfully complete an examination for the method of application employed (Regulation 636 Rule 4(b)).

Examination questions are based on information provided in training manuals developed by the Michigan State University Cooperative Extension Service. Each manual is self-teaching and contains a study guide with self-help questions at the end of each chapter. This manual addresses only the general standards required of all commercial applicators. The specific standards required for the category or subcategory, and the additional requirements for aerial application or space fumigation are contained in separate category manuals. Check the category manuals you receive to assure that you have the necessary study materials for each category or subcategory in which you want to be certified.

Procedures for Certification of Private Applicators

The Michigan Pesticide Control Act of 1976 requires that private applicators become certified to purchase, use or supervise the use of pesticides classified as restricted use. A *private applicator* is legally defined as a person who applies or supervises the application of a pesticide during production of an agricultural commodity: (1) on property owned or rented by that person or his or her employer or (2) on the property of another person if applied without compensation other than trading of personal services between producers of agricultural commodities. *Agricultural commodity* means a plant or part thereof, or an animal or animal product produced primarily for sale, consumption, propagation, or other use by man or animals.

Only one person per farm needs to be certified provided that the certified applicator supervises the application of the pesticide. The certified applicator does not have to be physically present unless the labeled instructions for the pesticide require the physical presence of a certified applicator. The certified applicator is responsible for the actions of a noncertified applicator under his or her control and must provide instructions for using the restricted pesticide and for contacting the certified applicator if needed.

To be certified as a private applicator, you must pass an examination demonstrating your knowledge of the safe, effective use of restricted pesticides. This manual is a study guide to prepare you for the examination. A person who is unable to read or is unable to pass a written examination may request an oral interview to demonstrate competency.

Recertification

Similar to a Michigan drivers license, you are required to be recertified every three years. You can be recertified by one of two methods. First, you can request from the MDA to take another exam which shows an increased level of knowledge in proper pesticide use. Study manuals are available from Michigan State University. Second, you can attend approved seminars or workshops and accumulate a specific

number of credits over the three year period. For specific information on recertification contact the MDA.

Suggestions For Studying This Manual

This manual is designed to assist prospective commercial and private applicators to meet the certification requirements under the federal guidelines. You may already know some of the material from your experience with pesticides. The manual has nine chapters. A list of self-help questions are included at the end of each chapter. These questions help you study and are not necessarily the questions on the certification examination. If you have problems using the manual, please consult your county extension agricultural agent or a representative of the MDA for help.

Some suggestions for studying the manual are:

1. Find a place and time for study where you will not be disturbed.

2. Read the entire manual through once to understand the scope and the manner in which the material is presented. *A glossary at the back of the manual defines some of the terms used in the chapters.*

3. Then study one chapter of the manual at a time. Consider underlining important points in the manual or take written notes as you study the chapter.

4. Answer, in writing, the self-help questions at the end of each chapter. These questions are intended to help you study and evaluate your knowledge of the subject. They are an important part of your study.

5. Reread the entire manual once again when you have finished studying all of its sections. Review with care any sections that you feel you do not fully understand.

This manual is intended to help you use pesticides effectively and safely when they are needed. We hope that you will review it occasionally to keep the material fresh in your mind.

Use pesticides safely, effectively and only when necessary!

PI-145 (Rev. 9/89)
APPLICATION FEE
$10.00

MICHIGAN DEPARTMENT OF AGRICULTURE
PESTICIDE AND PLANT PEST MANAGEMENT DIVISION
Lansing, Michigan 48909

Dept. Use Only	
File Number	Co. Code

(In accordance with Act 171, Public Acts of 1976 as amended)

APPLICATION FOR PRIVATE PESTICIDE APPLICATOR CERTIFICATION

Note: If you are not a farmer and/or you apply pesticides for hire, you must apply for commercial certification

Please Print or Type

NAME OF PERSON APPLYING			**TELEPHONE NUMBER**
Last:	**First:**	**M.I.:**	**( )**

ADDRESS (NO. AND STREET OR RFD)

CITY	**COUNTY**	**STATE**	**ZIP CODE**	**BIRTHDATE**
				mo: day: year:

ARE YOU CERTIFIED BY ANOTHER STATE?	**STATE ISSUING CERTIFICATE**	**EXPIRATION DATE**
☐ **Yes** (If yes, complete the next two items) ☐ **No**		

HAVE YOU EVER BEEN FOUND GUILTY IN A COURT OF LAW FOR MISUSE OF PESTICIDES?

☐ **Yes** (If yes, give particulars on another sheet of paper.)
☐ **No**

DO YOU PERSONALLY APPLY PESTICIDES BY AIRCRAFT?

☐ **Yes**
☐ **No**

Fumigation: Regulation No. 636 establishes additional standards for applicators who use fumigant pesticides. Fumigants are pesticides that exert their toxic actions as gases and additional knowledge is required to use these materials safely and effectively. **Please check the appropriate box if you perform fumigation:**

☐ **Space fumigation** - Fumigation of soil, equipment or commodities in enclosed structures such as glass or poly-houses

☐ **Soil fumigation** - Fumigation of soil in fields, tree sites, seed beds, and small quantities of top soil or compost which are out-of-doors and not enclosed in a glass or poly-house.

☐ **Grain fumigation** - Fumigation of grains in bins, temporary bulk storage areas or bagged grains stored on the farm.

This is to certify that the foregoing is true and accurate to the best of my knowledge and belief and that I will comply with the provisions of Act 171, Public Acts of 1976 as amended, and all regulations promulgated thereunder. I understand that falsifying information on this application is grounds for denying or revoking certification.

Date: **Applicant Signature:**

Make remittance by check or money order and make payable to STATE OF MICHIGAN. Mail to the following:

Michigan Department of Agriculture
4th Floor, Ottawa Building N.
P.O. Box 30017
Lansing, MI 48909

** The application must be sent in at least 3 weeks prior to the date you wish to take the exam.*
** The application fee is nonrefundable* ** The fee must accompany this application*

CHAPTER 1

PESTS AND PEST MANAGEMENT

People have been combating diseases, insects and weeds throughout history. Records contain many examples of how pests have had major effects on humans and how they have even altered history. One classic example is the Irish potato famine of the 19th century which directly influenced the population of the United States. A fungus disease called late blight essentially eliminated potatoes, the staple food crop. Potatoes that were not destroyed in the field rotted in storage during the winter. As a result, thousands of Irish starved and more than a million immigrated to the United States. Late blight continues to be a major problem of potatoes, but today pest management techniques of resistant cultivars, proper sanitation practices, and chemical pesticides have assisted in controlling this problem.

Pests are plants, animals or viruses that are detrimental to humans. The main categories of pests for pest management are weeds, insects, diseases, nematodes, and vertebrates which are discussed in detail in Chapter 2.

This chapter explains integrated pest management and the techniques that should be considered to control pests. The primary goal of a pest control program is to reduce pest damage to an acceptable level. In most cases, our objective should not be total eradication of the pest. Eradication is usually an unrealistic goal and our efforts may, in the end, create more problems than they solve (e.g., pest resistance, secondary pest outbreaks, resurgence or environmental contamination.)

Integrated Pest Management

To better understand the complex biological system in which we use pesticides and to use pesticides more effectively, a system was developed known as Integrated Pest Management (IPM). IPM is the use of all available tactics or strategies to manage pests so that an acceptable yield and quality can be achieved economically with the least disruption to the environment. Sole reliance on pesticides has proven to be detrimental to the environment. Pests have developed resistance to chemicals and applicators have spent more money then is necessary for pest management. IPM provides the applicator with a diverse pest control program that avoids sole reliance on one technique and its potential shortcomings. Many successful IPM programs have reduced energy and pesticide use saving applicators money and causing less harm to the environment.

Pest identification, life cycles, pest density, and the pest's relationship to the plant's and animal's stage are essential information for an IPM program. Proper identification is necessary to determine the proper pest management strategy. Knowledge of pest, plant, and animal life cycles can help to time control practices at the pest's susceptible stage without damage to the plant or animal. IPM includes biological monitoring (scouting), sampling and trapping, and environmental monitoring (weather). Lastly, pest densities help determine the economics of the proposed control practice.

By using an IPM program you can limit reliance on pesticides which can reduce *beneficial organisms*. Beneficial organisms help manage or reduce the pest organism population. For example, bees pollinate fruit trees, ladybird beetles feed on aphids, and wasps parasitize many insects.

IPM systems vary with each situation. Changes in pests, available control techniques (natural and applied), weather, and economic circumstances all contribute to variability. Consider the following five steps when developing any IPM program.

1. Identify the Pest

An organism should not be classified or treated as a pest until it is proven to be one. A

species may be a pest in some situations and not in others.

The more that is known about a pest and factors that influence its behavior, the easier and more successful pest management becomes. When you *identify* a pest, you gain important biological information that influences control. You can determine if a control program is necessary, and, if it is necessary, what the elements of the management program should be. Knowing a pest's life cycle is essential. For example, in insect control, an insecticide should be applied to coincide with the presence of a susceptible life stage. In some cases the susceptible stage is only the adult, or larval. In most cases chemicals do not affect the eggs.

2. Define the Management System

The management system is the specific site where pests must be kept at acceptable levels. The limits of the management system, whether it is a greenhouse, a thousand-acre field, or a lawn, are determined by the characteristics of the plant or animal production system and the movement patterns of the key pests.

3. Develop the Pest Management Strategy

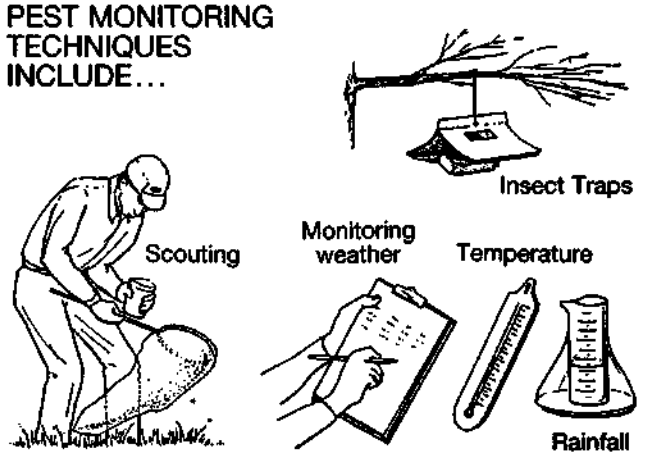
The strategy coordinates the use of multiple tactics into a single integrated system. Select the appropriate control method or combination of methods which achieve effective, economical and environmentally-sound control. The goal is to maintain pest numbers and the resultant damage at economically acceptable levels. IPM is a management approach rather than an eradication program.

Pest management programs require extensive planning and preparation as well as effective evaluation to assess the program results. Evaluation can be done in several ways such as counts of pests or infections before and after treatment, comparative damage ratings, yield data, etc. In most cases, it is difficult, if not impossible, to do an adequate evaluation without leaving untreated checks for comparison. Record results for future reference.

4. Develop Reliable Monitoring Techniques

Pest control decisions are often complex when the many environmental factors are considered. Monitoring information is used in making decisions about immediate pest suppression activities and in determining future activities.

Pesticide applicators can enhance their control effectiveness by monitoring, which involves measuring pest populations (e.g., insects, weeds, nematodes) and the resulting damage or loss. Scouting and trapping systems are commonly used to monitor insects and their activity. By frequently checking and knowing the common pests of the plant or animal, you may detect pest infestations before they become a problem. Weather conditions can also be monitored to predict how long it will take a certain insect to develop. Models, such as BLITECAST for late blight of potato, use weather data to predict the need for pesticides.



5. Use An Economic Decision-Making Process

Pest species in low numbers may cause little injury to a plants' or animals' final yield or quality. Greater populations may cause slight yield or quality loss but not enough to offset the cost of a control measure. Even larger populations can cause significant damage and their control becomes essential. Therefore, economics must be a primary consideration in pest control. Two factors that affect the economic decision-making process are:

1. **Economic injury level:** the level of pest density at which the cost to control the pest is equal to the losses that the pest causes.
2. **Economic threshold or action threshold:** the level or density of a pest population where control measures (action) are needed to prevent the pest from exceeding the economic injury level.

Management of the pest should only be considered if economic damage will occur and the population is at or above the economic threshold.

Different species in each class of pests (weeds, insects, disease, vertebrates) differ in size, reproductive capacity, and rate of growth. Therefore, the economic injury level is different for each pest species and may vary at different times throughout the year.

The economic injury level and economic or action threshold must be modified by plant or animal variety, weather patterns, expected plant or animal value, environmental stresses, and cost of treatment. For example, an economic or action threshold for European corn borer is different for seed corn as compared to grain corn. Likewise, the threshold would be different on juice apples as compared to fresh market apples.

Remember, when making a control decision, consider the market price of the plant or animal, the cost of application, and the effect on the environment.

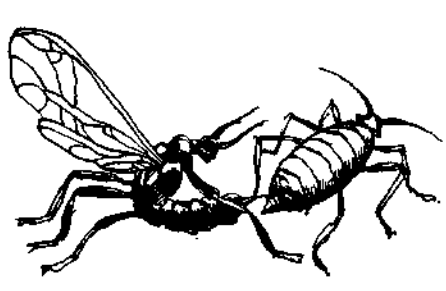
Techniques Used in Pest Management

Natural and applied techniques are used to manage pests. Proper identification, knowing the pest's life cycle, the pest's density and its relationship to the plant's or animal's stage of development allows applicators to choose the right control method or any combination to manage the pest in the most economic manner.

Natural Controls

Natural controls are the measures that check or destroy pests without dependence upon humans for their continuance or success. In fact, humans cannot greatly influence these measures. Natural controls include:

- climatic factors such as wind, temperature, sunshine, and rain
- topographic features such as rivers, lakes and hills
- naturally-occurring predators, parasites, and pathogens.



Wasp parasitizing an aphid

Applied Controls

Applied controls are under the control of humans. Their use is necessary when natural controls have not held harmful pests in check. Under applied control we employ methods of biological control, cultural control, legal control, mechanical and physical control, resistant varieties, sanitation control, and chemical control.

Biological controls introduce, encourage, and artificially increase plants and animals that are parasites or predators of a pest. Biological controls are most commonly used to control insects, mites and some weeds. Examples include wasp parasites of alfalfa weevil; ladybird beetles to suppress scale insects; a seed fly to help combat tansy ragwort; and *Bacillus thuringiensis* (Bt), a bacterium, to control various insect pests on vegetables and ornamentals.

Cultural controls are routine management practices that prevent pests from developing. These include rotating crops, tilling the soil, varying the planting time, destroying crop residues, and pruning, thinning, and fertilizing plants. These practices tend to disrupt the normal association between a pest and its host, making the environment less favorable for pest survival, growth, or reproduction. These methods give the pest control specialist many tools to work with, an important advantage since many of the practices are part of the normal plant or animal production operations.

Examples of cultural control include changing watering and ventilation patterns to prevent moss and algae from growing in greenhouses; frequent watering and fertilizing of birch trees to help them withstand bronze birch borer attack; late planting of winter wheat to avoid Hessian fly; early cutting of alfalfa to eliminate the need for a spray for alfalfa weevil; growing narrow row soybeans to increase shading between rows to reduce weed interference; rotating soybeans with corn to avoid corn rootworm larva; and using a rotary hoe to kill weeds before their emergence in crusted, dry soil.

Legal controls limit the development of pest populations by restricting human activities. This is done by a series of federal, state and local laws and regulations. Quarantines, inspections, embargoes, compulsory plant or animal destruction, and similar actions, are legal control measures. Examples include mandatory destruction of abandoned cherry orchards, mandatory treatment or inspection of Christmas trees being shipped out of Michigan to control and prevent the spread of gypsy moth and cereal leafbeetle,

and inspection of produce at U.S. ports of entry to prevent the introduction of new pests.

Mechanical and physical controls prevent the spread or reduce the infestation of pests, primarily insects, pathogens, and vertebrate animals. Mechanical and physical controls include the use of traps, barriers, light, sound, heat, cold, nuclear radiation and electrocution. These methods have very limited potential for crop production; however, nets and fences are used to keep birds and mammals such as deer from destroying crops. Other examples include screens to exclude mosquitoes; rodent-proofing barriers; termite-exclusion barriers; mousetraps; flyswatters; and yellow sticky cards used in greenhouses to trap insects.

Resistant varieties are plants and animals bred for resistance to pests. These varieties possess genetic defenses such as protective physiological or physical characteristics which reduce their susceptibility to pests. Selecting resistant varieties makes the environment less favorable for pests and easier to keep pests below harmful levels. Frequently, pest problems can be avoided or minimized simply by using resistant varieties. Examples include soybean varieties resistant to Phytophthora root rot strains; brussel sprouts resistant to cabbage aphid; and crabapple varieties resistant to fireblight or apple scab.

Sanitation controls are cleanup measures to remove and prevent breeding sites and food supplies for pests. Some sanitation controls are removing food, water, debris and trash or shelter for the pest or making the site inaccessible. In fact, for some pests, effective control cannot be maintained without good sanitation practices. Examples of sanitation are removal of food, garbage, or filth to prevent roaches, rats, and flies; removal of cull potato piles to prevent late blight; and thorough cleaning of storage bins prior to grain filling.

In particular there are several good sanitation practices that can discourage pathogens.

- **Pathogen-Free Seed Stock**: Production of clean seed stock is important in reducing plant disease spread. Often, seeds are grown in arid areas where the amount of moisture is controlled by an irrigation system eliminating infection by diseases which require high moisture and humidity levels.

- **Pathogen-Free Propagation**: Plant disease pathogens are frequently carried in or on vegetative propagation materials. Production of clean planting stock is especially important in the culture of certain high-value agricultural and ornamental plants. These plants must be grown in pathogen-free greenhouses or in sites isolated from growing areas for these plants. When planning for isolation, consider how far the pathogen may spread, how the pathogen is spread, and the distance between potential growing sites.

- **Clean Planting Sites**: In some plants, certain plant disease pathogens can be controlled or reduced by eliminating other nearby plants (weeds around field borders, ditch banks, etc.) which are hosts for the same disease organisms.

- **Removing Infected Plants**: Diseases often can be controlled by systematically removing infected plants (roguing) or plant parts before the disease can spread to healthy plants.

Chemical controls use naturally derived or synthetic chemicals called *pesticides* which kill, repel, attract, sterilize, or otherwise interfere with the normal behavior of pests. Limited use is made of sterilants, repellents, and attractants at present. Examples of chemical control include pentachlorophenol to protect telephone poles from wood damaging pests; chlorine in drinking water to control bacteria; mothballs to repel clothes moths; sex pheromones of gypsy moth to reduce mating incidence; herbicides to kill weeds; insecticides to control insects; and fungicides to control fungal diseases.

REVIEW QUESTIONS – INTRODUCTION AND CHAPTER 1

Write the answers to the following questions. When you are satisfied with your answers, see if they are correct by checking them with the chapter text.

1. Why do you have to be certified?
   a. to protect you and the environment
   b. it's the law
   c. to buy restricted use pesticides
   d. to show you have a baseline knowledge of safe use
   e. all of the above
2. All insects are pests. (True or False)
3. What is Integrated Pest Management?

_____

_____

_____

4. _____organisms, such as wasps and lady beetles, help manage or reduce pest populations.
5. List five steps to consider in planning and implementing an effective Integrated Pest Management plan.
   1) _____
   2) _____
   3) _____
   4) _____
   5) _____
6. What are some techniques for detection of pests?

_____

_____

_____

7. When the pest reaches the _____, pest management procedures need to be applied to prevent the pest from reaching economically damaging populations, or the _____.
8. How are "natural controls" different from "applied controls" as pest management methods?

_____

_____

_____

9. List four methods of applied pest control and give an example of each.
   1) _____
   2) _____
   3) _____
   4) _____
   5) _____
10. Give an example of a sanitation control that will discourage pathogens.

CHAPTER 2

PEST IDENTIFICATION

Accurately identifying pests is extremely important because different species of pests respond to different types of control. Failure to properly identify the pest may result in wasted time, money, chemicals and effort. Each species of plant and animal can be identified by its scientific name. Although most plants and animals also have common names, the scientific naming system is universal, assigning an organism one name to be used regardless of where it is found. This naming system categorizes animals based on their similarities: animals with common characteristics are placed into large groups, then subdivided into smaller groups, and finally given a name.

In this chapter you will learn to identify common pests from seven main groups: weeds; insects; mites, spiders and ticks; plant diseases; nematodes; snails and slugs; and vertebrates. We will discuss the types of damage caused by pests, and the many methods that are available to manage them.

Weed Pests

A weed can be any plant that grows where it is not wanted. Dandelion is a weed in a Kentucky bluegrass lawn. Quackgrass is a weed in a corn field. Weeds cause losses to producers by reducing plant yield and quality, decreasing harvest efficiency, and by harboring insects and diseases. They also can destroy the beauty of turf and ornamentals and obstruct right-of-ways. Weed control accounts for 70% of the total pesticide use in the United States.

As with all pests, the weed species must be accurately identified for successful management. Many times "common names" are used to distinguish weeds, but this can cause confusion as a species may have several "common names" or the same "common name" may refer to several species. Only standardized "common names" should be used. These are included on herbicide labels.

To identify a weed, examine all parts of the plant including root, stem, leaves, flowers, and seeds. Observe the following characteristics:

- Look for underground reproductive structures such as rhizomes, stolons, or tubers.
- Consider the stem shape: round, flat, square, or triangular.
- Consider the leaf size, shape, arrangement on the stem, and hairyness.
- Consider the size, shape, and color of the flower.
- Examine the seeds and seed capsules.
- Smell the plant for any characteristic odor.
- Consider the location where the plant is growing (soil type, drainage, etc.).
- Consider the maturity of the plant in relation to the season to determine the life cycle of the weed.

Several reference publications are available to help identify weeds. One excellent reference is "Weeds of the North Central States," NCR-281. This bulletin is available from your county extension office. In addition, the Plant Diagnostic Clinic at Michigan State University can assist you in identifying weed species.

Weed Biology

Weeds can be divided into three categories according to their life cycle. Knowing the life cycle of a weed helps select the most appropriate control strategy.

1. **Annuals.** These plants live one year or less. They germinate from seed, develop foliage, flower, form seed, and die. *Winter annuals* such as chickweed and penny cress, geminate in the fall, overwinter as nonflowering plants and then flower, set seed and die in spring or early summer. *Summer annuals* (pigweed, lambsquarters, large crabgrass and others) germinate in the spring and complete their life cycle in the summer or fall.

2. **Biennials.** These plants have a two-year life cycle. They generally grow from seed that germinates in the spring. During the first year of growth, they develop a heavy root and a rosette (a compact cluster of leaves). The plants over-

winter as a rosette and, in the second summer, mature, produce seed, and die. Examples: Queen Anne's lace, bull thistle.

3. **Perennials.** These plants live for three or more years and may live indefinitely. Perennial weeds may reproduce by seed or by vegetative reproduction. The above-ground portions of these plants may die back each winter, so they develop new above-ground parts each spring. Examples: poison ivy, Canada thistle.

One characteristic that makes perennial weeds difficult to control is their ability to reproduce by vegetative means through plant structures such as rhizomes, stolons, bulbs, tubers and creeping roots.

Rhizomes are botanically classified as underground stems. They grow horizontal to the soil surface and can be distinguished by the presence of nodes. These nodes are capable of generating new shoots. Examples: quackgrass, johnsongrass.

Stolons are above ground horizontal stems or runners. Examples: ground ivy, bermudagrass.

Bulbs are underground modified buds capable of storing food and producing new shoots. Examples: wild garlic, wild onion.

Tubers are enlarged sections of rhizomes. Examples: yellow nutsedge, jerusalem artichoke.

Creeping or spreading roots can produce new shoots in some species. Examples: Canada thistle, perennial sowthistle, field bindweed.

Insect Pests

All insects and related animals such as mites and ticks belong to a large group (phylum) called Arthropoda. Members of this group are called arthropods and have segmented bodies; segmented appendages, some of which are modified for feeding; and a hard exoskeleton (exterior). On the basis of common characteristics, anthropods are separated into smaller groups called classes. The common classes of arthropods are Insecta, Arachnida, Crustacea, chilopoda, and Diplopoda. Most arthropod pests are insects or arachnids (mites or ticks from the class Arachnida).

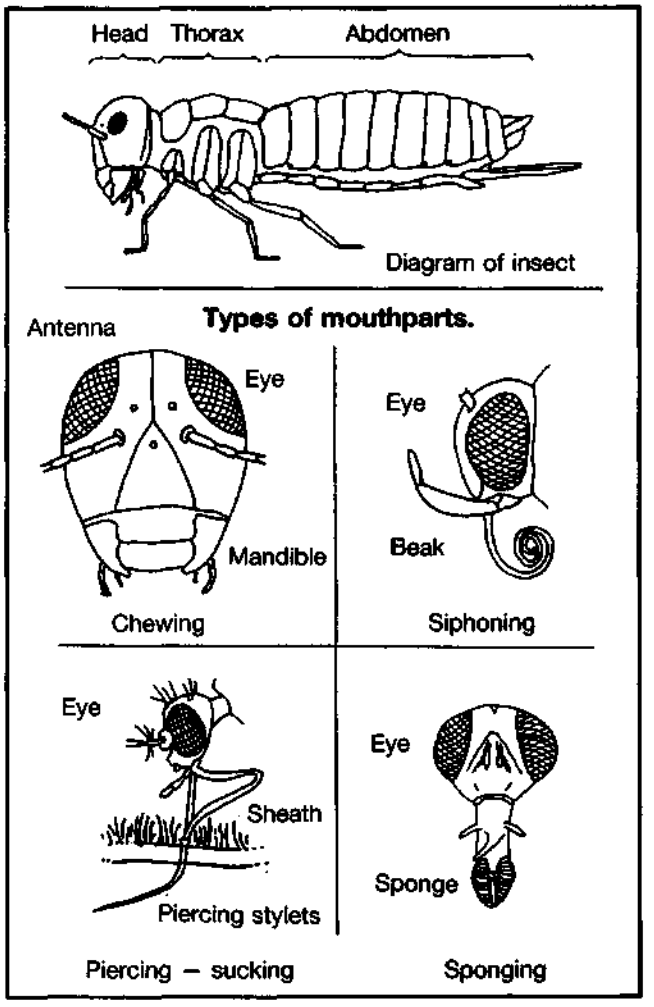
Insects bear unique external features and undergo developmental processes unlike other organisms in the animal kingdom. Understanding these characteristics helps you identify pest insects and plan pest control programs.

Physical Characteristics

The external characteristics of insect adults that set them apart from other animals are a body that has three regions (head, thorax, and abdomen) and three pairs of jointed legs.

(1) Head. The head contains one pair of antennae, eyes, and mouth parts. Antenna contain many sensory receptors for smell, wind, and temperature. The four general types of mouthparts are chewing, piercing-sucking, sponging, and siphoning. **Chewing mouthparts** have toothed mandibles that bite and tear food. Cockroaches, grasshoppers, ants, and beetles have chewing mouthparts. **Piercing-sucking mouthparts** have a long slender tube which penetrates the plant or animal tissue to suck out fluids or blood. True bugs, aphids, mosquitoes, and sucking lice have this mouth type. **Sponging mouthparts** have a tubular tongue-like structure with a sponge tip to suck up liquids. This type of mouthpart is found on flies. **Siphoning mouth-**

parts are formed into a long tube for sucking nectar. Butterflies and moths have this type of mouth.



(2) Thorax. The thorax consists of three segments with one pair of jointed legs. If one pair of wings is present, they will be on the second segment. If two pairs of wings are present, they will be on segments two and three and are called forewings and hindwings. The forewings are modified in different insect groups. Beetles have forewings that are shell-like; grasshoppers have forewings that are leathery. Forewings of true bugs are part membranous while forewings of moths and butterflies are membranous but covered with scales. Most hind wings of insects are membranous.

(3) Abdomen. The abdomen has as many as 11 segments, although eight or fewer visible segments are common.

Development and Metamorphosis

The series of events from egg to adult are called the insect's **life cycle**. The life cycle varies in species, but knowledge of the life cycle is absolutely essential to apply correct control procedures.

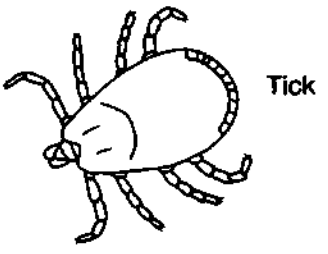
Most insect reproduction is sexual, that is a female's egg cell develops only after union with the male's sperm cell. The females of many insect species lay eggs. Some insects have special modes of reproduction such as those that develop from an unfertilized egg. The number of eggs produced by females varies from one egg to many thousands for some social insects.

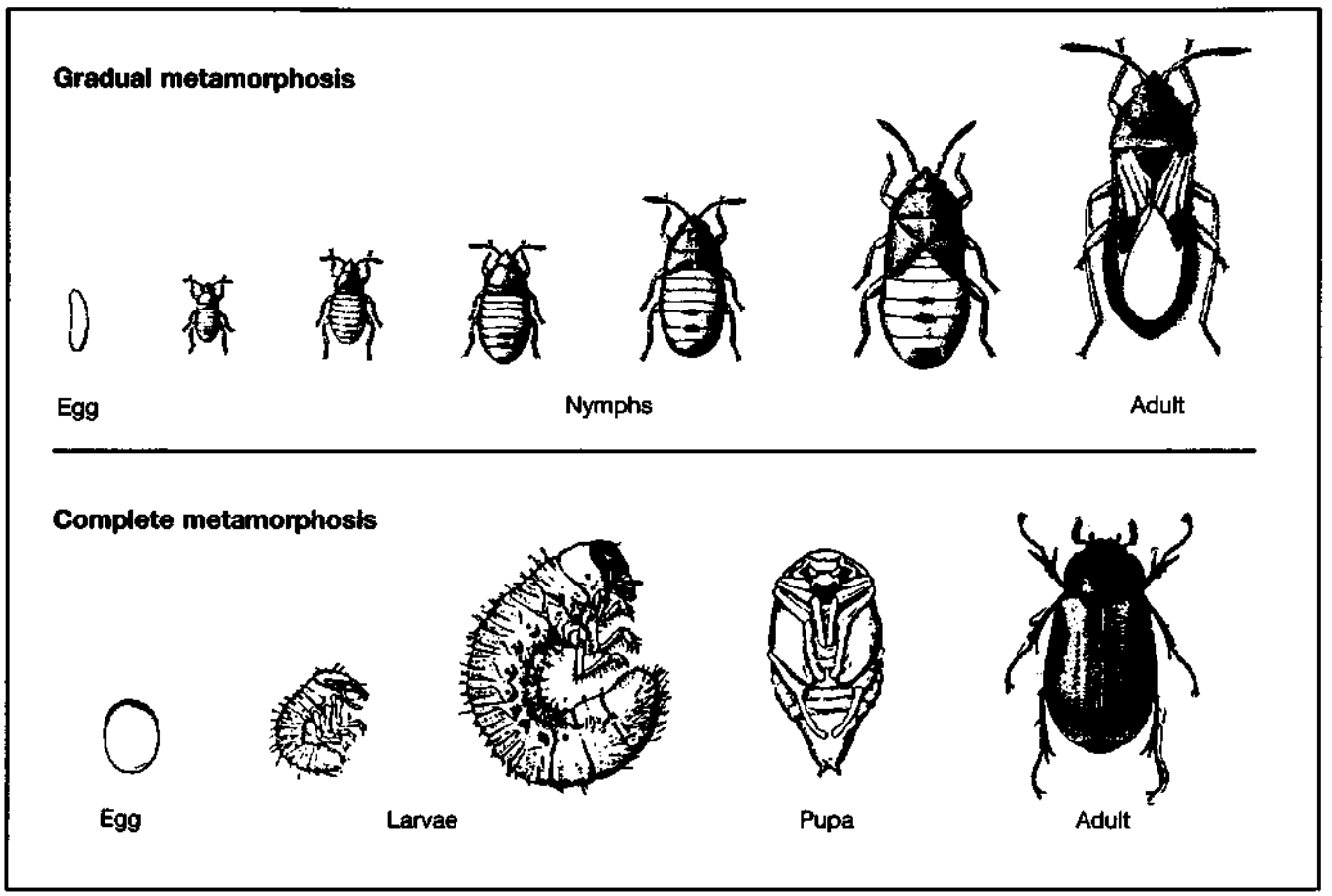
A newly hatched insect differs in size and often in form from the parents. The change that takes place before the young insect assumes the adult form is called **metamorphosis**. The degree of change varies widely in different insects. In some, it is slight and gradual; in others, it is abrupt and complete. These variations identify the insect's classification of metamorphosis:

- No metamorphosis. Body proportions and internal organs of these primitive insects remain similar after each molt (ecdysis). Examples: Callembola (springtails) and Thysanura (silverfish).
- Gradual metamorphosis. Changes are slight and gradual. The young or nymphs resemble the adults and feed in the same habitat and wing development is external. Example: grasshoppers.
- Complete metamorphosis. Drastic alterations including egg, larval, pupal (an inactive, resting stage) and adult stages. This classification includes the majority of insects such as the European corn borer.

Damage Caused by Insects and Insect-Like Pests

Insects, ticks, and mites damage plants, animals, and structures in different ways. The damage often provides clues as to the identity of the pest, as well as the fate of the host. For example, defoliation by insects in the spring is usually more detrimental to a plant than defoliation in late summer because the plant is preparing to drop its leaves anyway. Different types of pest damage can be classified as described in the next section.





Insect Pests of Plants

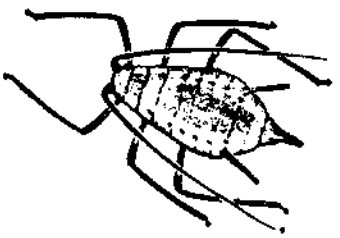
Defoliators. Insects that feed on plants are called herbivores. One of the more obvious types of damage done by herbivores is defoliation caused by the eating of leaf tissue. The most economically important group of defoliators is the caterpillars of the order Lepidoptera (butterflies and moths). Examples of this group include the gypsy moth that feeds on trees and the imported cabbage worm that feeds on cabbage leaves. Defoliators in other orders include the Colorado potato beetle and the Mexican bean beetle.

Beetle

Internal feeders. Internal feeders are larvae that feed and develop (even pupate) inside fruit, grain, or other plant parts. Some examples of internal feeders are the boll weevil, birch leaf miner, and codling moth. Internal feeding insects often cause losses that are not easily detected until the damage is extensive.

Stalk or stem borers. Many larval stages of insects bore into stalks or stems. This destroys tissues weakening the stalk and preventing adequate translocation of water and nutrients within the plant. Weakened plants may blow over or wilt from the damage. Examples of insects that cause this type of damage are the European corn borer, squash vine borer, and dogwood borer.

Plant sucking pests. Many arthropods have mouthparts adapted to sucking juices from plants. Examples are plant bugs, squash bugs, aphids, leafhoppers, whiteflies and scales. Symptoms of plant damage caused by sucking pests include curled and stunted leaves and stems, wilt caused by blocked water-conducting tissues, and dead areas caused by toxins injected by the pest during feeding.



Aphid

In addition to the feeding damage, an important economic effect of plant sucking pests is the vectoring (transfer) of plant pathogens (disease causing organisms). Aphids also excrete honeydew that drips onto the lower parts of the plant. This sticky material makes an excellent environment for a fungus which produces a black sooty mold that can be harmful to the plant if the insect is not controlled.

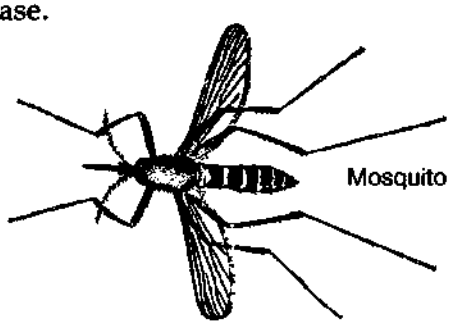
Cut-off at ground level. As the name suggests, cutworms sever plants at ground level. Cutworms are difficult to see and control because they feed at night and remain underground during the day.

Subterranean feeders. Numerous insects cause damage by feeding on plant roots. These insects usually are difficult to identify because they cannot be seen without uprooting the plants. Root feeding can cause dead spots in lawns, goose-necking in corn, or plants that have poor color and reduced vigor. Some examples of subterranean feeders are white grubs, corn rootworms, black vine weevils, and many fly maggots.

Insect Pests of Animals

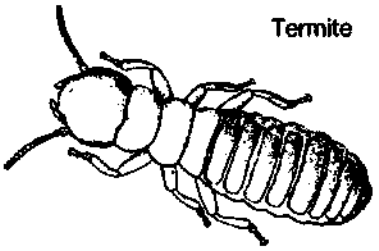
The insects, ticks, and mites that attack humans and animals have mouthparts similar to those of the plant feeders, but use blood and vertebrate tissue rather than plant tissue.

Mosquitoes, lice, and ticks are blood-sucking pests. Cattle grubs, the ox warble of cows, and the bot fly of horses are internal-feeding insects. Face flies, houseflies, and gnats annoy and cause discomfort. Some pests are vectors of disease-causing organisms; the pests introduce bacteria, viruses, or other parasites into animals as they feed. Mosquitoes carry encephalitis, and ticks carry Rocky Mountain spotted fever and Lyme disease.



Structural Insect Pests

Many insects attack and destroy wood structures. The most significant in this group is the subterranean termite. This insect can digest cellulose (a major component of wood) with the aid of a microorganism that lives in its gut. Termite mouthparts are very strong and can rapidly destroy wood.



Many other structural pests such as powder post beetles and old house borers are internal feeders. The larvae of these pests cause the damage. The carpenter ant is a social insect that damages structures through feeding and the introduction of decay organisms.

Plant Diseases

Plant diseases can reduce the quantity and quality of food, fiber, and ornamental products from the time of planting through harvest, sale, and usage. More than a century after late blight caused the Irish potato famine, plant diseases continue to influence the costs of crop production, and ultimately the costs of plants and plant products to the consumer. In the 1970's, Southern corn leaf blight moved through corn fields in the "Corn Belt" states at an alarming rate. Corn yields were significantly reduced, with more than a billion dollars worth of corn destroyed in just one year.

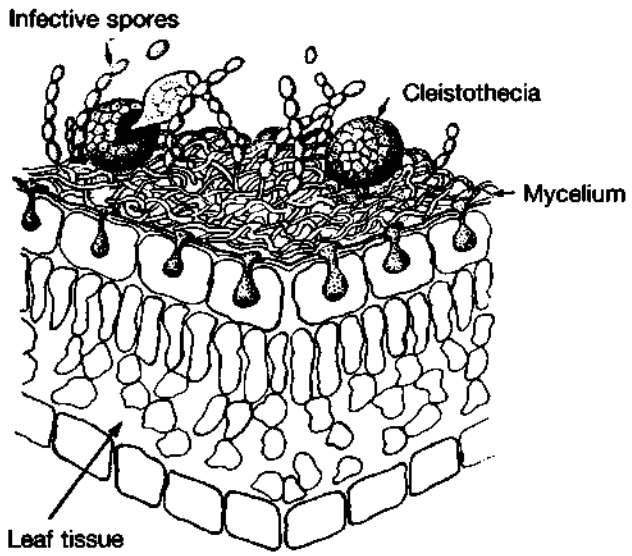
Controlling plant diseases is a complex problem. Curing plant diseases is nearly impossible, so control measures focus on preventing diseases from occurring or minimizing their effect. Control is achieved by understanding the casual organisms, the conditions for culture of the crop, and the tactics available for disease control. With some plant diseases, the acceptable level of disease is determined by consumer preferences.

Pathogens

Certain fungi, bacteria, viruses, and nematodes cause plant diseases. They are called *pathogens* and can be spread from diseased to healthy plants. A plant invaded by a pathogen is called a *host*. Spotted leaves, wilting, stem cankers, and rots are examples of symptoms that may appear on a host as a result of disease.

Fungi

Fungi are the most common plant pathogens. Fungi lack chlorophyll and, therefore, cannot manufacture their own food through photosynthesis. Fungal diseases cause a variety of symptoms. Any part of a plant's roots, stems, leaves, flowers, furits, or seeds may be infected. Fungi also attack harvested products, such as grain, bulbs, and wood, while they are in transit or in storage. Fungi (spores or mycelium) can be spread from healthy to diseased plants by wind, rain or irrigation water, soil, machinery, humans, and animals. Some fungi can penetrate healthy tissues directly. In other instances they enter through wounds. For example, the fungus causing Dutch elm disease may enter the tree through a wound created by European elm bark beetles.

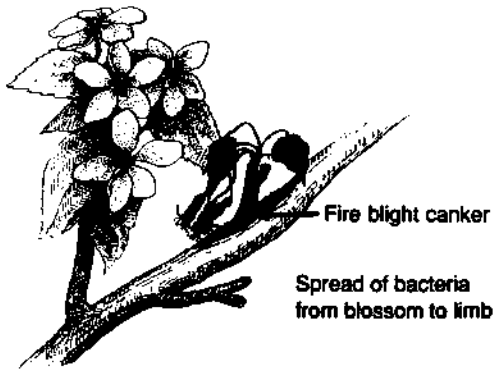


Cross section of a leaf with powdery mildew

Bacteria

Bacteria are microscopic organisms that quickly increase in number, especially in wet, humid weather. Bacterial diseases such as fire blight of pear and apple, and citrus canker can cause significant damage. Bacteria are most important in post-harvest decays and spoilage of fresh fruits and vegetables while en route to or at the market, or at home in the refrigerator. Bacteria enter through natural openings and wounds of the plant. The bacterium that causes fire blight can be spread on pruning tools. Foliar diseases caused by bacteria are often spread by wind-driven rain or splashing rain. Insects also introduce certain bacteria into their feeding wounds.

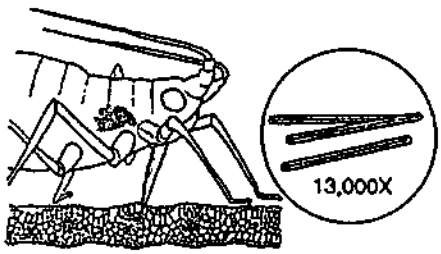
Bacteria: fire blight



Viruses

Viruses are smaller than bacteria and reproduce only when associated with living tissues. Viruses cause a variety of diseases and symptoms (commonly mosiacs or stunts) that most frequently cause reduced yields and poor quality products rather than killing the host. Practically all plants can be infected by one or more viruses. Viruses enter healthy plants only thorough wounds or during pollination. Sucking and chewing insects can transport virus-laden sap from one plant to the next. Some viruses are spread by nematodes and fungi. Viruses can also be carried in cuttings, tubers, and other parts (i.e., graft rootstocks or scions and buds) that are from a virus-infected plant.

A very small group of plant diseases formerly thought to be caused by viruses are now attributed to infection by mycoplasma-like organisms. These extremely small organisms cannot be seen with an ordinary microscope. They induce yellowing in many plants. Their most common disease is Aster yellows, a disease present almost everywhere asters are grown outdoors.

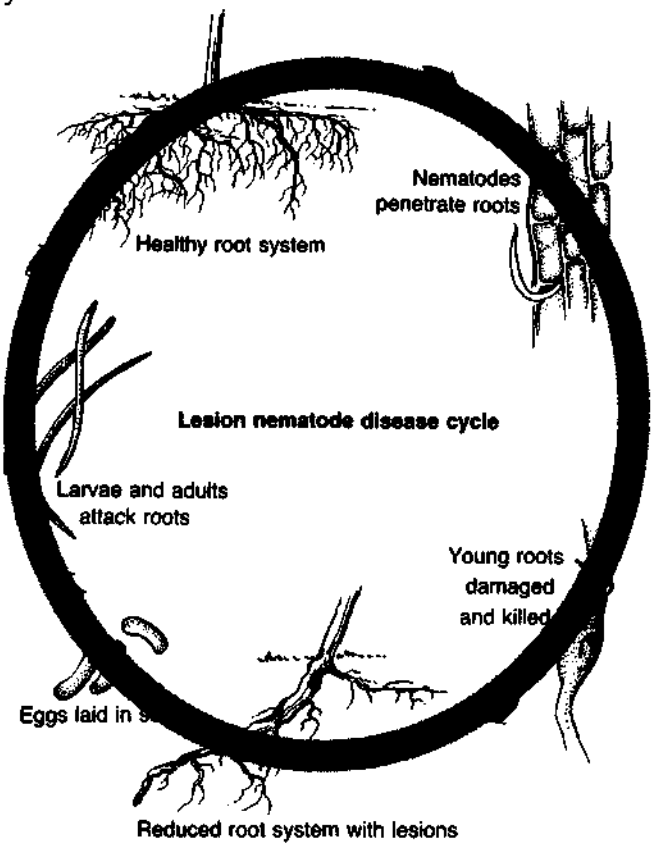


Aphid transmitting virus particles

Nematodes

Nematodes are microscopic, unsegmented, worm-like animals. Root-feeding nematodes are the most common, destroying root systems which reduces the uptake of water and minerals by plants. The symptoms of most nematode diseases are wilting, stunting, and lack of plant

vigor. Diagnosing a disease caused by nematodes is often difficult and requires both root examination and a soil analysis to detect the pathogenic nematodes. Not all nematodes feed on roots. The foliar nematode of chrysanthemum feeds on the foliage and causes triangles of brown, dried tissue to develop on the leaves late in the season. A nematode species that infects cereal grains reproduces and turns what was once a seed into a mass of weather resistant nematodes capable of remaining dormant for 20 years or more.



The Disease Cycle

Plant diseases are caused by many unique pathogens, and plant disease can be influenced by the varieties grown, the cultural practices, and the weather. One view of plant disease which integrates some of these factors is called the disease cycle. Once the disease cycle is understood, the hows and whys of plant disease management become clearer.

The disease cycle is circular without beginning nor an end. Inoculum of a pathogen is needed for the first phase of the cycle. Inoculum is any part of the pathogen that can cause infection. When moisture and temperature conditions are favorable for development of the pathogen, infection occurs as the pathogen enters the host. You can not see a plant being infected; the activity is microscopic.

Infection is followed by colonization, a period during which the pathogen grows within the host. Disease symptoms usually develop during or following this period. Once the pathogen is established in the host, reproduction usually occurs. For example, fungi produce spores and nematodes produce eggs. Reproduction produces enormous amounts of inoculum. The inoculum may reinfect the host; be spread by wind, rain, or equipment to other host plants; or in some cases remain in the soil to infect a plant at a later date. Disease causing organisms vary in reproduction rates, as well as when they can infect a host. For some pathogens the inoculum is produced only once for a short period during the season. Others, can produce new inoculum many times during the season.

Signs are visual evidence of the presence of disease. For example, a sign of powdery mildew on lilac or turfgrass is the white, fuzzy mycelium on the infected leaves. Some signs are inside the plant. An example is sweet corn afflicted by a disease called Stewart's Wilt. When the stem of a diseased corn plant is cut, the knife edge often has a stringy, sticky thread stuck to the blade. The long thread is the sticky bacterial pathogen, the sign of this disease. Sometimes signs do not develop on a diseased host.

The characteristics of a disease cycle depend on the life cycle of the pathogen. Understanding the life cycle and the factors that affect development, reproduction, spread, and survivability of a pathogen are often essential for successful disease pest management. For example, extended periods of cool, wet weather enhance early spring infection of young apple leaves by the apple scab fungus. This fact about the pathogen's life cycle means that disease control chemicals are particularly important when such conditions exist.

Disease Diagnosis

A successful disease control program begins with an accurate diagnosis. Diseased plants are recognized by disease symptoms and signs of the pathogen, and by comparing plants suspected of being diseased with healthy plants. Abiotic diseases are caused by nonliving agents such as frost, mechanical injury, or improper applications of fertilizers or pesticides. Abiotic- and pathogen-caused diseases frequently have similar symptoms. In many instances, the only way to identify the cause of disease is to find the signs of the causal agent. Certain plants can be plagued by a number of problems at the same

time (insects, diseases, and abiotic). Also, the part of the plant showing symptoms may or may not be the primary site of the problem. Disease symptoms usually are easy to see, but the significant questions are often whether the disease can cause a loss and if it warrants a chemical control.

If necessary, seek assistance in diagnosing disease problems from your county cooperative extension office and other knowledgeable sources. Positive identification through clinical analysis is required to diagnose many diseases.

At present, plant disease control measures are mainly preventive. Once a plant or plant product is infected and symptoms appear, few control methods (including pesticides) are effective.

Snails and Slugs

Snails and slugs are members of a large group of animals called mollusks. Snails have a hard shell; slugs have no shell. Both feed on plant foliage. They are pests in lawns, landscape plantings, greenhouses, and crops. Slugs feed at night and hide during the day under plant residues. Their feeding leaves large, irregular holes in leaves and usually a slime trail where the slugs have traveled. To confirm that the damage is from slugs, set out a saucer of stale beer overnight. The slugs will be attracted to the odor and drown in the liquid. In greenhouses, keeping flats off soil and eliminating hiding places helps reduce slug populations.

Vertebrate Pests

One of the primary considerations in vertebrate pest control is determining the need for control. Individuals may differ in their attitudes toward vertebrate pests; some people are willing to accept animal damage which would be considered intolerable by others. However, control would be justified if wildlife pests were endangering human health and safety or destroying agricultural crops or facilities. Because vertebrate control differs significantly from weed, insect, and disease control, the options for vertebrate control are described here.

Environmental. Damage from vertebrates can often be solved by environmental methods. These include relocating susceptible crops away from the depredating species, such as removal of a crop from the forest edge where deer feed. Sound management practices for stored grains and feeds can reduce the attractiveness of these areas to birds and mammals.

Mechanical. Mechanical controls are alternatives to chemical toxicants. Examples of this type of control are placing wire guards around trees and shrubs to prevent rodent gnawing; setting mechanical traps to capture the offending species; or covering ripening fruits with netting to exclude birds.

Chemical. Chemical repellents can make treated crops or stored products unacceptable or change the odor or taste and thus deter feeding. The animal pest is forced to find a new food source in a different location. Toxic chemicals can sometimes reduce the numbers of the offending species. For example, rodenticides reduce orchard mouse populations.

Very few pesticides are registered for use in vertebrate pest control programs, and it is unlikely that the number will increase significantly in the near future. Those that are registered must have labels which name the offending or target species, the details of application, and precautions to be taken. Ideally, a control chemical should affect only the target species and not other species or the environment. While certain pest control chemicals now in use are more toxic to some species than to others, very few materials are toxic to only the intended species.

Careful use of chemicals minimizes the hazard to nontarget species. Factors to consider are:

- the bait on which a toxicant is used
- the time of year the control is undertaken
- the method of chemical placement
- the area of placement

It is possible to use a broad-spectrum pesticide (affecting several species) selectively; however, knowledge of the chemical and the target vertebrate species is critical. The program must also be carefully supervised. Pigeons may be controlled during the winter months in the northern parts of the country when most beneficial birds have migrated south. Pigeon bait placed on the tops of flat roofs is less likely to be found by other bird species. Toxicants for pigeon control may be used on bait particles too large to be eaten by most other birds. These precautions make it possible to use a chemical for selective purposes that is generally toxic to many species. Labor costs increase when these special precautions are taken; however, unless and until selective materials are developed, existing ones must be carefully used to guard against accidental kills of nontarget species. If society continues to permit the use of existing toxic materials, it must be willing to ab-

sorb the added costs of careful pest control methods that protect the environment and beneficial species.

Reproductive inhibitors (birth control) that control vertebrate populations show promise with some species. Research is continuing and may develop birth control for pest species as an acceptable means of combating pest problems. Certain problems in the field use of reproductive inhibitors must be overcome before the method can be widely used.

REVIEW QUESTIONS – CHAPTER 2

Write the answers to the following questions. When you are satisfied with your answers, see if they are correct by checking them with the chapter text.

1. Underground stems with nodes capable of generating new shoots are called:
   a. bulbs
   b. perennials
   c. rhizomes
   d. nematodes

2. List some of the plant characteristics to observe when identifying a weed.

_____

_____

_____

3. Name the three weed categories grouped by life cycle.

1) _____

2) _____

3) _____

4. The body of an adult insect has three regions — the head, thorax, and abdomen. (True or False)

5. Describe no metamorphosis, gradual metamorphosis, and complete metamorphosis.

_____

_____

_____

6. Why is it important for an applicator to know an insect's life cycle?

7. An aphid is an example of a:
   a. defoliator
   b. subterranean feeder
   c. structural pest
   d. plant sucking pest
   e. stem borer

8. A termite is an example of a:
   a. defoliator
   b. structural pest
   c. plant sucking pest
   d. stem borer

9. Fungi are the most common plant pathogen. (True or False)

10. How are bacterial diseases spread?

_____

_____

_____

11. Viruses can be spread by:
   a. insects
   b. fungi
   c. nematodes
   d. all of the above

12. _____ are microscopic, unsegmented, worm-like animals.
   a. nematodes
   b. rhizomes
   c. spores
   d. borers
   e. thorax

13. How does understanding the life cycle of a disease help an applicator control that disease?

_____

_____

_____

14. Plant disease control should not be attempted until the plants are infected and symptoms appear. (True or False)

15. How can you distinguish a snail from a slug?

16. An animal that is considered a pest by one person may be considered desirable by another. (True or False)

17. Environmental controls are ineffective for wildlife vertebrate control. (True or False)

18. List some environmental, mechanical, and chemical controls for wildlife vertebrates management.

CHAPTER 3

PESTICIDES

Pesticides are a substance or mixture of substances intended for preventing, destroying, repelling, or mitigating pests, or intended for use as a plant regulator, defoliant, or desiccant. Pesticides are a mixed blessing. For example, they contribute significantly to agricultural productivity and to improved public health through the control of disease-carrying pests, but they can adversely affect people, nontarget organisms such as fish and wildlife, and the environment.

A **pesticide** more specifically may be defined as any chemical used to directly control pest populations or to prevent or reduce pest damage. Although the ending "cide" is derived from the Latin word *cida*, meaning "to kill," not all pesticides actually kill the target organism. For example, some fungicides may simply inhibit the growth of a fungus without killing it; attractants and repellents lure a pest to or divert it from a particular site.

The Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) has extended the legal definition of a pesticide to include compounds intended for use as plant growth regulators, defoliants, or desiccants, even though they are not normally used as pest control agents, nor are they usually effective as such.

In this chapter you will learn how pesticides are classified, the types of formulations, compatibility complications, and potential problems with insecticide use. This knowledge will help you to use pesticides safely and effectively.

Classifications

Pesticides are classified using a number of different methods. Each method serves specific purposes. The four most common methods of classifying pesticides are based on (1) the group of pests controlled by the pesticide, (2) how the pesticide works, (3) the chemical nature of the pesticide, and (4) the pesticide formulation. The following discusses these four methods.

Method 1: Types of Pests Controlled

This pesticide grouping system is as follows:

Pesticide Classification	Pests Controlled
Insecticide	Insects & other related animals
Acaricide	Mites, ticks & spiders
Miticide	Mites
Nematicide	Nematodes
Fungicide	Fungi
Bactericide	Bacteria
Herbicide	Weeds
Rodenticide	Rodents
Avicide	Birds
Piscicide	Fish
Molluscicide	Slugs & snails
Ovicide	Eggs of organisms
Predacide	Vertebrates

Other Pesticides	Function
Plant Growth Regulators	Modify normal plant processes
Defoliant	Remove unwanted plant growth
Desiccant	Kill plant foliage prior to harvest
Repellant	Divert a pest
Attractant	Lure a pest
Microbial	Cause a disease in a pest

Method 2: How Pesticides Work

These common terms classify pesticides based on how they work:

Protectants - Pesticides applied to plants, animals, structures and products to prevent pest establishment.

Sterilants - Pesticides that control pests by rendering them incapable of normal reproduction.,

Broad-spectrums - Pesticides that control two or more pests of a particular crop. They are sometimes labeled as *multipurpose chemicals*. A material capable of controlling scab, powdery mildew and mites on apples, for example, is broad-spectrum. This category of pesticides is

somewhat more general than the others since a broad-spectrum pesticide may be a protectant, eradicant or systemic in its action.

Contacts - Pesticides that kill pests simply by contacting the pest.

Systemics - Pesticides that are moved within the animal or plant to kill the pest without harming the host animal or plant. For example, a systemic herbicide is absorbed by roots or foliage and carried throughout the plant.

Fumigant - Pesticides which kill the pests by giving off a gaseous vapor.

Many synthetic organic pesticides work in one or more of the above listed ways. Read the pesticide label to find out how the pesticide you are using works.

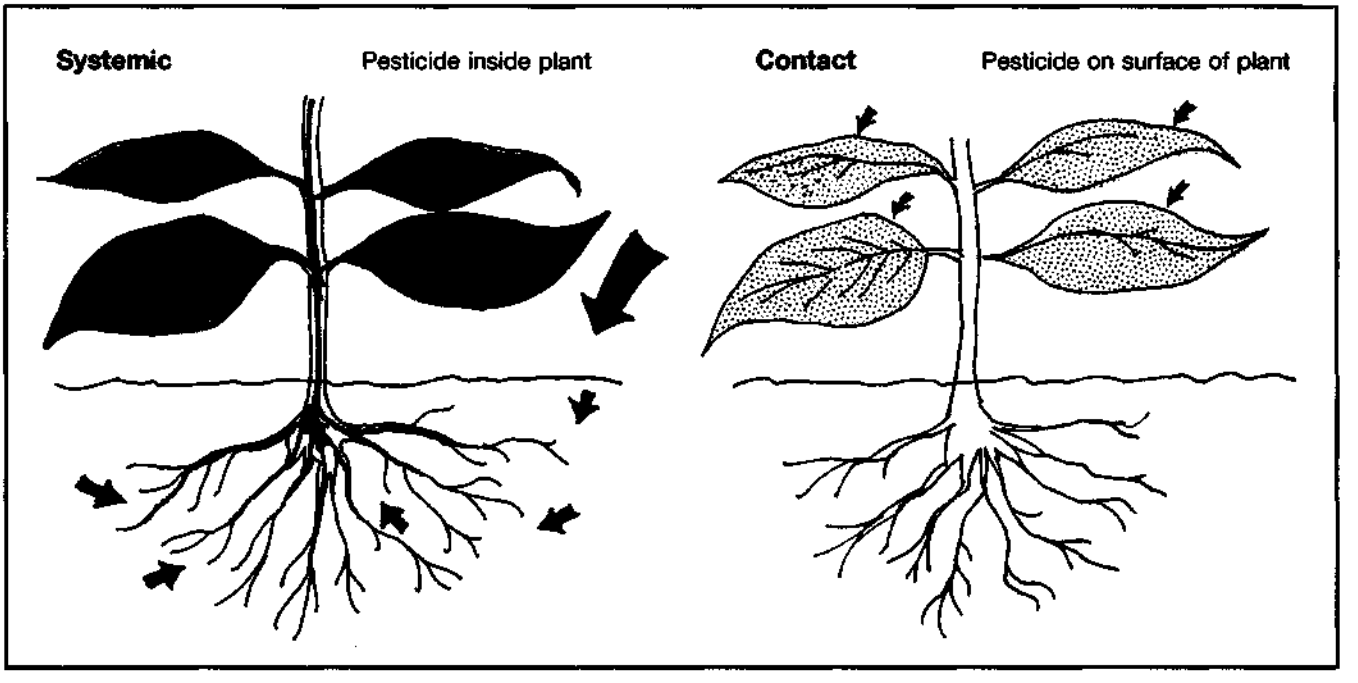
Method 3: Pesticide Chemistry

Pesticides can be divided into two chemical groups: the inorganic and organic compounds. **Inorganic pesticides** are of mineral origin and therefore do not contain carbon. They commonly contain either arsenic, copper, boron, mercury, sulfur, tin or zinc. Examples are sulfur dust, Bordeaux mix, and Paris green. Inorganic pesticides are widely used today, primarily to control plant diseases. They are not, however, very specific in their activity and may be toxic to a wide range of organisms, a characteristic which is often not desirable. They are generally less effective than many of the organic compounds. Some do offer the advantage of relatively low acute toxicity to humans, although compounds containing lead, mercury and arsenic have generated widespread health-related and environmental concerns and their use has been either totally banned or severely curtailed.

Organic pesticides contain carbon. They also contain hydrogen and often oxygen, nitrogen, phosphorus, sulfur or other elements. Most pesticides in use today are organic compounds. A small number of organic pesticides are either derived or extracted directly from plants (**botanicals**, e.g., rotenone, nicotine, pyrethrums, and strychnine). Most, however, are synthetic or man-made compounds. It is these that have been primarily responsible for the rapidly expanding use of pesticides since the 1940's. They are often extremely effective and easy to use, have been relatively inexpensive, and some are quite specific in their activity. They have, however, been the principal focus of health and environmental concerns and have been primarily responsible for problems associated with pesticide use and misuse.

The **synthetic organic pesticides** (i.e., man-made, carbon containing chemicals) include the chlorinated hydrocarbons, organophosphates, carbamates, synthetic pyrethroids, phenoxy herbicides, and a number of other chemical classes.

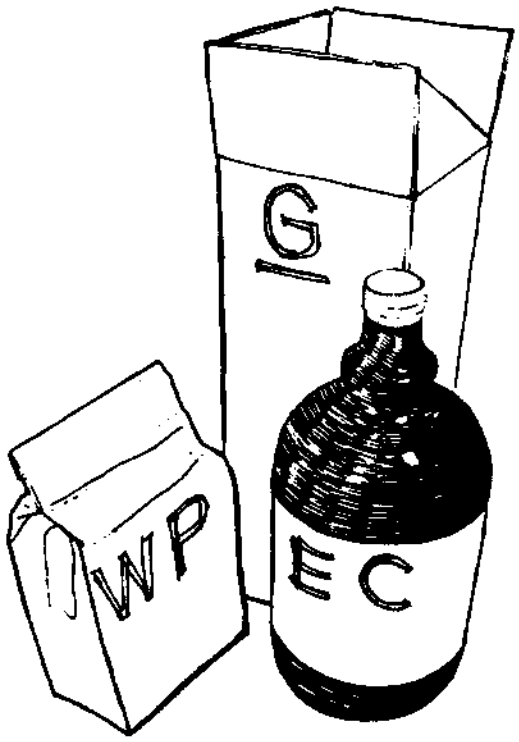
A distinct group of pest control agents are the so-called **microbial pesticides**. These are simply bacteria, viruses, and fungi which cause disease in given pest species. Although they may occur naturally in certain areas, they are intentionally introduced by humans in sufficient quantities so that a relatively high level of control becomes



possible. There is some question as to whether they should legitimately be considered pesticides, although their methods of application are usually similar to those used for more traditional pesticides. Their activity tends to be highly specific and often virtually harmless to nontarget species. There are, however, only a few microbial pesticides registered for use at this time and their success has been limited. Perhaps the best known example is the bacterium, *Bacillus thuringiensis* (Bt), which has been used effectively against some species of caterpillars.

Method 4: Pesticide Formulations

The component of a pesticide that controls the target pest is called the **active ingredient** (a.i.). Before a pesticide product is sold, active ingredients are mixed with liquid or dry **inert ingredients** (nonpesticidal). These mixtures of active and inert ingredients are called **pesticide formulations**. Formulations make an active ingredient more convenient to handle; safer, easier, and more accurate to apply; and in some cases more attractive to the pest. The wide variety of formulations is described in the next section.



Formulations

It is important to choose the formulation that is best for a particular job based on its effectiveness, cost, practicality, and relative safety to you, your neighbor, and the environment. The following are some of the considerations which are important in choosing a formulation:

- Some formulations require constant spray tank agitation; others do not.
- Dusts and granules do not require water for application, but accurate calibration of equipment and uniform distribution are often difficult.
- The potential hazard to the applicator, the potential for drift, and environmental contamination vary substantially among formulations.
- Formulations sold as liquids are easier to measure in the field than dry ones.
- Dry formulations are generally less affected by subfreezing temperatures during storage than liquid formulations.
- Some crops may be treated with any formulation of a particular pesticide; others require a specific formulation.
- The price per pound of active ingredient varies for different formulations.

Liquid Formulations

Emulsifiable concentrates (EC or E): An emulsion is one liquid dispersed, usually as very small drops, throughout another liquid. An emulsifiable concentrate (EC), is a liquid formulation of a pesticide which can be mixed with another liquid to form an emulsion. EC's usually contain two to six pounds per gallon of active ingredient. Water is the usual liquid EC's are mixed with, but some EC formulations are made to be added to oil or other petroleum carriers. Many pesticide active ingredients are not soluble in water, but are soluble in some oils or other solvents. In EC's the active ingredient is dissolved in an oil or solvent, and emulsifying agents and other adjuvants are added to the formulation so that the EC can be mixed with water to form a "milky" emulsion. This emulsion can then be conveniently sprayed. Little agitation in the spray tank is normally required when using EC's.

When EC's are combined with other products, particularly liquid fertilizers, compatibility can be a problem. Therefore, special mixing, agitation, or compatibility agents may be needed to prevent separation.

Some crops are sensitive to the solvents and additives used in EC's and phytotoxicity (plant damage) may result. This is sometimes the

reason why an EC formulation of an active ingredient is not registered for use on a particular crop, while wettable powders and dust formulations of the same active ingredient can be used.

Because of their high concentrations and liquid form, emulsifiable concentrates may be hazardous to the applicator. They readily soak through cotton and polyester clothing and are readily absorbed through the skin. They must be handled with particular caution. They can be used with many types of application equipment, including dilute hydraulic sprayers, low-volume ground sprayers, mist blowers, and low-volume aerial sprayers.

High concentrate liquids, spray concentrates: These formulations may be thought of as special EC formulations. They usually contain a high concentration of the active ingredient, often eight or more pounds per gallon. Most are designed to be mixed with water and oil. They contain chemicals that allow the formulation to wet, spread, and stick well. Ultra-low-volume (ULV) concentrate materials are designed to be used directly without further dilution and they may contain only the pesticide itself.

Low concentrate liquids: These formulations contain low amounts of the active ingredient and are usually solutions prepared to be used as purchased, with no need for further dilution. This type of formulation is most often used for controlling household pests, mothproofing, or as a livestock spray or a space spray in barns.

Flowables (F or L): Some active ingredients can be manufactured only as a solid, or at best, a semisolid material. They usually have relatively low solubility in water or other organic solvents. These pesticides are often formulated as flowable liquids. The active ingredient is very finely ground and suspended in a liquid along with special suspending chemicals and additives. This formulation is mixed with water or liquid fertilizer to form suspensions which require moderate agitation in the spray tank. Flowables seldom clog spray nozzles and usually handle as well as EC formulations. There are fewer phytotoxicity problems with flowables than with EC's.

Solutions (S): Some active ingredients are completely soluble in water or organic solvents and in their original state, are liquids. The pesticide is formulated in an appropriate solvent or water and exists as a true solution or in a molecular state. Solutions, if properly prepared for special uses, do not leave unsightly residues and will not clog spray equipment. Some formulations of this type can damage plants, in which case, other formulations must be used.

Water-soluble concentrates (WS): The active ingredient in water-soluble concentrates is soluble in water and is formulated either with water or with a solvent such as alcohol which mixes readily with water. When the formulations are added to water in the spray tank, they form a true solution and require no further agitation after they are mixed. Water-soluble concentrates are often salt or amine solutions such as paraquat or 2,4-D amine.

Aerosols: The active ingredient of aerosols is in a liquid formulation, in a can, under pressure. One or more pesticides may be in the same formulation. The propellant drives the formulation out through a fine spray opening. The percentage of active ingredient is usually very low in aerosols. Convenience of use is the major advantage. Aerosols are mainly used in the garden and home, occasionally in greenhouses and barns, and seldom in commercial agriculture. In addition to pressurized aerosols, there are thermal and mechanical aerosols which are used in special situations.

Micro-encapsulated pesticides: This is a relatively new method of formulating pesticides. The active ingredient is encased in extremely small capsules made of inert synthetic substances; the capsules are then suspended in a liquid. Application is made with conventional sprayers after diluting the formulation with water. The pesticide is released gradually over a period of time. The principle is similar to that used for slow-release cold medicines. Encapsulated materials can be handled with relative ease and safety and are effective for a longer time than other formulations of the same active ingredient. They may, however, pose a significant hazard to bees since capsules may be taken back to the hive with pollen.

Dry Formulations

Dusts (D): A dust formulation usually consists of the active ingredient mixed with an inert material such as a talc, clay, powdered nut hulls or volcanic ash in concentrations ranging from 1-10 percent. All the ingredients are finely ground to a fairly uniform particle size range. Adjuvants (discussed on page 26) are often added so that the formulation will store well and handle properly.

Some active ingredients are prepared as dusts because they are safer for crops in this form than

if they were EC's. Dusts are always used dry and should *never be mixed with water.* The very small particles in dusts make them subject to drift into nontarget areas during application. Always apply them carefully and never apply them under windy conditions. It is frequently difficult to achieve accurate and adequate coverage with dust formulations when applied to plant foliage. They are best applied to wet foliage since dusts are easily washed or blown off treated surfaces by wind or rain.

Dust formulations are available for use on seeds, plants, and animals. For vertebrate animal control, dusts can be applied in small patches or burrows so the animals come in contact with them. The animals are killed as they swallow the pesticide while cleaning their feet and fur.

Dusts can present a significant hazard to the applicator because of the potential for inhalation of the dust particles even though the concentration of the active ingredient is low. Proper protective equipment should be used.

Granules (G): Granular formulations are dry formulations, usually produced by applying a liquid formulation of the active ingredient to particles of clay or other porous materials such as corn cobs or walnut shells. The granule carrier is prepared in advance to a standard size and then the liquid formulation is added. The liquid active ingredient is absorbed into the granules, or coats the outside of the granules, or both. Other materials may be added to make the formulation handle well. The percentage of active ingredient in a granular formulation ranges from 2-40 percent. Granular formulations are safer to apply than EC's or dusts. Accurate calibration of granular spreaders and uniform distribution, however, is often difficult.

Granular formulations are most often used as soil treatments. They may be applied either directly to the soil or over plants. They do not cling to plant foliage, but may be trapped in the whorls of some plants.

Wettable powders (WP or W): These are dry, powdered pesticide formulations that look like dusts. But, unlike dusts, they contain wetting and dispersing agents. Wettable powders are usually much more concentrated than dusts, containing 15-95 percent active ingredient. They are made to mix with water, and when mixed, form a suspension. Good agitation is needed in the spray tank to keep the formulation in suspension since it does not form a true solution. Some pesticide products can be prepared as wettable powders but not as EC's because of the nature of the active ingredient. Properly prepared wettable powder formulations spray well and do not clog nozzles. Most wettable powder formulations are less likely to damage plants than EC formulations. Wettable powders and EC's are the formulations most widely used.

wettable powders are easy to store, transport, and handle but are potentially hazardous to the applicator, particularly in mixing where the concentrated dust may be inhaled. They are usually not absorbed through the skin as readily as emulsifiable concentrates.

Soluble powders (SP): Soluble powders, like wettable powders, are dry formulations. But, when soluble powders are added to water, they will dissolve and form true solutions. Agitation in the spray tank is sometimes required to get them into solution after which no more agitation is needed. Not many SP formulations are available.

Water-dispersible granules (WDG): Water-dispersible granules (also called "dry flowables") are finely-divided powders that are formulated into concentrated, dustless granules. The formulation is a relatively new one and is increasing in popularity. Water-dispersible granules form a suspension in water or liquid fertilizer and require some agitation to maintain a uniform spray mixture. The principal advantage of this formulation is that, although it is sold in the dry form, it is not a dust and can be handled with great ease and safety. Water-dispersible granules are not intended for direct application through a granular applicator. Unlike granules designed for application in the dry form, these formulations contain a high percentage of active ingredients, often as much as 75-90%.

Baits

A bait formulation is an active ingredient mixed with an edible substance or some other attractant. The pest is killed by consuming a lethal dosage of the bait's poison either in a single feeding or over a period of time. Baits are useful in controlling mice, rats, and other rodents. They also are used to control ants, flies, and other insects. Whole areas or simple spot treatments can be done with baits, however, the placement of the bait in locations where it is likely to be consumed is of obvious importance. Baits can be used in buildings and outdoors. The percentage of active ingredient in bait formulations is quite low, usually below five percent.

Since this method of application limits the amount of pesticide introduced into the environment, environmental contamination can be minimized. It is important to note that baits may **be attractive to nontarget organisms**. If a bait is not adequately selective, extra caution must be used to prevent nontarget organisms from reaching the bait, either through placement or use of screens, boxes, or other types of physical barriers.

Fumigants

Fumigants are pesticides or mixtures of pesticides which produce vapors (gases) that are toxic when absorbed or inhaled. Fumigants are not a type of formulation. The volatile nature of fumigants is a property of the chemicals themselves. It is not the result of a formulation process. Fumigants are formulated and sold as gases, gels, volatile liquids, emulsifiable concentrates, or granules. All fumigants volatilize when applied.

Soil fumigants can be used to control nematodes, soil fungi, weeds, and soil insects. Fumigants are also important for the control of pests of stored grain.

Pressure liquefied gases: Some active ingredients are gases in their natural form. Pressure liquified gases are all fumigants. When placed under pressure in a container some still remain as a gas, but many of them become a liquid. This type of formulation is stored under pressure (high or low depending upon the product). When applied, it usually is injected directly into the soil, released under tarps, or into a vessel such as a grain storage elevator. Some types of nematicide, insecticide, and rodenticide materials are available in this type of formulation. Applicators must be certified in the fumigation standard before they may apply fumigants. These materials must be used with extreme caution!

Other fumigants are not stored under pressure. They are highly volatile, however, and gradually become gases following application. When applied to soil, they are usually injected with chisel applicators to a depth of six to eight inches. When applied to stored grain, they are normally sprayed on the surface of the grain after the bin has been filled.

Vapors of fumigants are highly toxic and must not be inhaled. Most fumigants can also burn the skin. If any fumigant in liquid form contacts the eyes or skin, it must be washed off immediately. Contaminated clothing should be changed at once. When applying fumigants, proper techniques must be followed and all recommended protective clothing and equipment must be worn.

Adjuvants

An adjuvant or additive is a chemical added to a pesticide principally to increase its effectiveness, although some adjuvants are designed to reduce phytotoxicity or drift. Most pesticide formulations already contain a small percentage of adjuvants. **Wetting agents** and **emulsifiers** are often added so that the pesticide will mix with water or coat treated surfaces more effectively. **Spreaders** allow pesticides to spread evenly over treated surfaces. **Stickers** increase the adherence of the chemical to the treated surface thus increasing its persistence, particularly under adverse weather conditions. **Penetrants** aid the absorption of a systemic pesticide by the plant. Adjuvants are used most extensively in products designed for foliar applications.

Formulations as manufactured often contain all necessary adjuvants in appropriate amounts for all or most uses. However, it may sometimes be desirable for the applicator to add specific adjuvants prior to application. Wetting agents and spreader-stickers are probably the adjuvants added most frequently by the applicator. These materials are often referred to as **surfactants**. Surfactants are surface active agents which maximize the interaction of a pesticide with the treated surface. **Compatibility agents** are being added with increasing frequency to allow the effective mixing of two or more pesticides or a pesticide with a fertilizer. **Drift control agents**, such as thickeners, invert emulsifiers, and foaming agents, are also being used more extensively as drift continues to be of increasing concern.

Adjuvants should normally be added only if recommended on the product label, otherwise you are taking a risk. Some labels expressly prohibit the use of adjuvants. Always bear in mind that while you may be increasing the effectiveness of a particular pesticide, you may also be increasing the potential for excess crop residues, phytotoxicity, and perhaps harm to nontarget organisms and the environment.

Compatibility of Pesticides

In some situations, applicators may attempt to control more than one pest with a single application by combining pesticides in the spray tank.

Such a practice is can create problems. Sometimes these problems are serious and more costly than if the chemicals had been applied alone. There is no question that product mixing requires extensive knowledge of pesticide formulations, timing of application and application techniques.

The important issue is to determine the compatibility of the products involved. In simple terms, we are concerned about whether the mixtures can be used in combination without reducing the safety and effectiveness of the compounds. Before combining any pesticides, check labels, product information sheets, company representatives or Cooperative Extension Service personnel for information on compatibility of the products in question.

There are five major areas of incompatibility that should be considered before an applicator should attempt to mix products.

Physical Incompatibility

Physical incompatibility occurs when two or more pesticides are mixed together and the result is an unsprayable mixture such as excessive foaming, curdling, or a gummy deposit on the bottom of the spray tank. Hard water and cold water can also cause some physical incompatibilities. In some cases these can be recognized in the spray tank before the mixture is sprayed.

Problems associated with physical incompatibility can often be tested by mixing small batches of the mixtures in the same proportions and agitating them in a closed container such as a quart jar.

Chemical Incompatibility

This type of incompatibility occurs when the pesticides are mixed and the effectiveness of one or all of the compounds is reduced or destroyed. This happens frequently when materials with a high pH (such as lime) are added to the mixture. Chemical incompatibility is not evident in the spray tank, but becomes apparent when there is a lack of or reduced control.

Phytotoxic Incompatibility

Phytotoxic incompatibility occurs when product mixtures cause injury to plants sprayed with the mixture. This can happen even though each of the pesticides in the mixture, when sprayed separately, do not cause injury.

As with chemical incompatibility, check all information on the pesticides for any warnings about this type of incompatibility. If in doubt, spray a small amount on a few plants and observe the effect, being sure to allow enough time for injury to develop.

Placement Incompatibility

Even though the mixing of two or more chemicals to control different pests may save time in application, the spray operator must be sure that the chemicals are going to be placed where they will be effective. A good example of this type of incompatibility would be the mixture of a turf fungicide with an insecticide to control grubs in turf. The fungicide needs to be deposited on the leaves on the turf, but the soil insecticide needs to be drenched into the soil where the soil grub comes in contact with the chemical.

It is essential that you understand the problems associated with placement of pesticides or the results can be wasted chemicals and ineffective treatments.

Timing Incompatibility

Pesticides must be applied when the stage of development of the pest is vulnerable to control. With many insects, diseases or weeds, this may be a relatively short period. It is of utmost importance when using two or more chemicals to control different pests, that the mixture be applied at the correct time in the life cycles to be effective.

Herbicides that control lawn weeds are most effective when applied in spring when the growth is tender and readily susceptible. Adding an insecticide for the control of lawn moths that appear in July or August would be a worthless addition to the spring-applied herbicide.

This has been a brief summary of the problems of pesticide compatibility. Remember, you should never assume that pesticides can be mixed together or mixed with a fertilizer unless the combination is specifically indicated on a product label. If recommendations for use are not given on the label, the products in the mix must be applied at a rate not to exceed the label directions for use of any component product applied alone for the same purpose; and the mix can only be applied if not prohibited on one or more of the component product labels.

Potential Problems Associated with Insecticide Usage

Insecticides often have a significant role in pest management programs. Their use requires planning and care to avoid problems, particularly the development of resistant pest populations and the injury of nontarget species.

Pest Resistance

Cross and multiple resistance to insecticides are becoming common. Cross resistance is when a pest develops resistance to two or more compounds that are usually chemically-related with a similar mode of action. Multiple resistance occurs when a pest can tolerate insecticides from different classes of compounds with unlike modes of action. The approaches to a resistance problem may involve using new or altered insecticides, changing insecticide-use patterns, and applying ecological tactics.

New or Altered Insecticides. Single compounds or mixtures of compounds that have more than one mode of action are usually more difficult for the pest to develop resistance to than are compounds that attack only one chemical site in the pest. Synergists applied with insecticides may reduce resistance development by interfering with the detoxifying enzymes in the pest that allow it to survive an insecticide treatment.

New compounds with different modes of action will also lessen the likelihood of resistance development. These include compounds that are very selective as to which insects they kill and compounds that modify the pest's mating or feeding behavior.

Insecticide Use Patterns. When insecticide dosages are reduced, fewer pests die so the pressure to develop resistance is decreased. Rotation of compounds with different modes of action may limit resistance. The timing and placement of pesticides also affects resistance. Applying pesticides over limited areas reduces the proportion of the pest population exposed. This tactic limits the development of a resistant population by keeping a greater proportion of susceptible genes in the population. Also, treating alternate generations of pests decreases the selection for resistance.

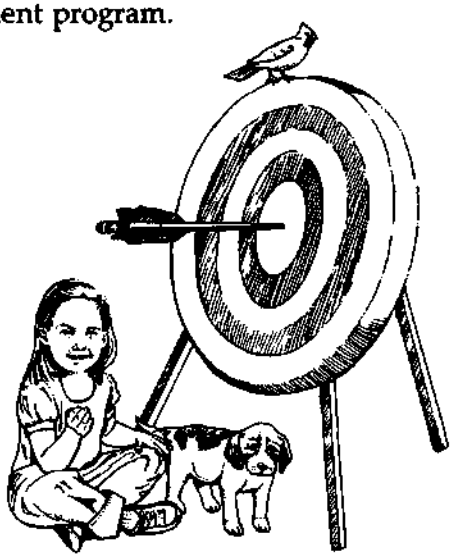
Ecological Tactics. Biological and behavioral factors involving the reproductive characteristics and mobility of pests are related to insecticide resistance. For example, the greater the number of generations per year and offspring per generation, the greater the chances of insecticide resistance appearing in a pest population. Similarly, behavioral factors such as insect mobility and migration influence insecticide management strategies. The frequency of resistant genes in a population is diluted when insecticide-susceptible individuals move into an area and interbreed with the resistant population. This tends to slow the pace of resistance development in the pest population.

Managing resistance is a part of integrated pest management. Resistance must be detected when it is at a very low level, and then controlled by using all of the available techniques to extend the useful life of our current insecticides.

Hazard to Nontarget Organisms

Another problem associated with insecticide usage is potential injury to nontarget organisms. Most pesticide poisonings of humans and animals are caused by insecticides. Great care must be taken in selecting and using insecticides so as to minimize injury to pesticide handlers and others who may come in contact with pesticide residues. This care must also safeguard bees, birds, fish and other wildlife and nontarget plants.

Information on pesticides and their uses is available on the label and by contacting your county cooperative extension office, the manufacturer's technical service representative, or state regulatory agencies. These sources can provide the best information available on pesticides, their potential adverse effects, and how to integrate insecticide usage into a total pest management program.



Use pesticides carefully to protect non-target organisms.

REVIEW QUESTIONS – CHAPTER 3

Write the answers to the following questions. When you are satisfied with your answers, see if they are correct by checking them with the chapter text.

1. A pesticide is a chemical that:
   a. controls only insects and vertebrates
   b. directly controls pest populations
   c. prevents or reduces pest damage
   d. only a certified applicator may apply
   e. b and c

2. List the four classification methods of pesticides and give an example of each.

   1. _____
   2. _____
   3. _____
   4. _____

3. An insecticide is a pesticide which controls _____.

A fungicide is a pesticide which controls _____.

A herbicide is a pesticide which controls _____.

4. Protectants are pesticides applied to control pests by rendering them incapable of normal reproduction. (True or False)

5. A pesticide that controls more than one pest is called
   a. systemic
   b. broad-spectrum
   c. multipurpose
   d. a and c
   e. b and c

6. What is the difference between a contact and systemic pesticide?

_____

_____

_____

7. Pesticides that contain carbon are called
   a. organic pesticides
   b. inorganic pesticides
   c. synthetic pesticides
   d. these don't exist
   e. carbonic pesticides

8. The component of the pesticide that controls the target pest is called the active ingredient. (True or False)

9. An emulsifiable concentrate (EC), is a _____ formulation of a pesticide which can be mixed with another _____ to form an emulsion.
   a. dry, dry formulation
   b. liquid, dry formulation
   c. liquid, liquid
   d. dry, liquid
   e. none of the above

10. What is a "flowable" formulation?

11. How are granular formulations most commonly used?

12. Why are fumigants considered hazardous?

_____

_____

_____

13. What are the advantages of water-dispersible granules?

_____

_____

_____

14. Spreaders and stickers are an example of an

15. What does the term incompatibility mean with reference to mixtures of pesticides?

16. List five types of pesticide incompatibility and give a brief definition of each.

   1. _____
   2. _____
   3. _____
   4. _____
   5. _____

17. Where can you find information on the compatibility of pesticide mixtures?

18. List some of the tactics for dealing with pest resistance to an insecticide.

CHAPTER 4

PESTICIDES AND THE ENVIRONMENT

As our population continues to grow, so do our demands for clean water and air, and an environment that is not threatening to our health and safety. We have become increasingly concerned about the state of our environment. We worry that the earth's natural resources are not only being depleted, but also becoming polluted and unfit for human use. As a result, many of the activities that we have taken for granted are now being carefully examined for potential damage to the environment. Pesticides are but one group of chemicals being blamed for environmental abuse.

This chapter explores the fate of pesticides after application. You will learn about groundwater and how it can be contaminated. We will discuss the effects of pesticides on nontarget organisms and the environment. For our purposes, **environment** means all of our physical, chemical and biological surroundings such as climate, soil, water, and air and all species of plants, animals, and microorganisms.

Pesticide Fate

As soon as a pesticide is released into the environment it is affected by various processes. Sometimes these processes are beneficial and enhance pest control. For example, the leaching of a root-absorbed herbicide into the root zone can enhance weed control. The degradation of pesticides can remove nonessential pesticide residues from the environment. Often, however, these processes are detrimental. Runoff can move a herbicide away from target weeds. As a result, chemical is wasted, weed control is reduced, and there is an increased chance of damage to nontarget plants, hazard to human health, and pollution of nearby soil and water.

In this section we will examine the fate of pesticides and the various processes that affect their stability and persistence following an application, disposal, or spill.

Adsorption

Adsorption is the binding of chemicals to soil particles. The amount and persistence of pesticide adsorption varies with pesticide properties, soil moisture content, soil pH, and soil texture. Soils high in organic matter or clay are the most adsorptive; coarse, sandy soils that lack organic matter or clay are much less adsorptive.

A soil-adsorbed pesticide is less likely to volatilize, leach or be degraded by microorganisms. When pesticides are tightly held by soil particles, they are less available for absorption by plants. For this reason certain pesticides used on highly adsorptive soils often require higher rates or more frequent applications to compensate for the pesticide which binds to the soil particles.

Volatilization

Volatilization occurs when a solid or liquid turns into a gas. Volatilization of pesticides increases with higher air temperature and air movement, higher temperature at the treated surface (soil, plant, etc.), low relative humidity, and when spray droplets are small. Pesticides also volatilize more readily from coarse-textured soils and from medium- to fine-textured soils with high moisture content.

A pesticide in a gaseous state can be carried away from a treated area by air current; the movement of pesticide vapors in the atmosphere is called **vapor drift**. Unlike the drift of sprays and dusts that can sometimes be seen during an application, vapor drift is invisible.

Application of a volatile pesticide should be avoided when conditions favor volatilization. The vapor pressure rating of the pesticide may help indicate the volatility of the material. The higher the vapor pressure, the more volatile the pesticide. Volatilization can be reduced through the use of low volatile formulations and incorporation of the pesticide.

Runoff

Runoff is a process that moves pesticides in water. Runoff occurs as water moves over a sloping surface, carrying pesticides either mixed in the water or bound to eroding soil. The amount of pesticide runoff depends on the grade or slope of an area, the erodibility and texture of

the soil, the soil moisture content, the amount and timing of irrigation or rainfall, and properties of the pesticide. For example, a pesticide application made to a heavy clay soil already saturated with water is highly susceptible to runoff. Established vegetation or plant residues also influence runoff because of their ability to retain soil and moisture.

Pesticide losses from runoff are greatest when heavy rainfall occurs shortly after a pesticide application. If heavy rainfall is expected, delay applying pesticides. Some no-tillage and minimum-tillage cropping systems have been found to reduce pesticide runoff, as do soil incorporation application methods. In addition, adjuvants that promote pesticide retention on treated surfaces can reduce the pesticide content in runoff water. Finally, surface grading, drainage ditches and dikes, and the use of border vegetation can help reduce the amount and control the movement of runoff waters.

Leaching

Leaching is another process that moves pesticides in water. In contrast to runoff which occurs as water moves on the surface of the soil, leaching occurs as water moves through the soil. Several factors influence the leaching of pesticides. These include the water solubility of the pesticide. A pesticide that is dissolved in water can move readily with the water as it seeps through the soil. Soil structure and texture influence soil permeability (how fast the water moves through soil) as well as the amount and persistence of pesticide adsorption to soil particles. Adsorption is probably the most important factor influencing leaching of pesticides. If a pesticide is strongly adsorbed to soil particles, it is less likely to leach, regardless of its solubility, unless the soil particles themselves move with the flow of water.

Groundwater contamination is a major concern associated with the leaching of pesticides from treated fields, mixing and rinsing sites, waste disposal areas, and manufacturing facilities. Refer to the next section in this chapter, "Groundwater Contamination" for information on how to prevent contamination.

Absorption

Absorption is the process by which chemicals are taken up by plants and microorganisms. It is another process that can transfer pesticides in the environment. Once absorbed, most pesticides are degraded within plants. These residues may persist inside the plant or be released back into the environment as the plant tissues decay.

Crop Removal

Crop removal is another pesticide transfer process. When treated crops are harvested, or animals are removed from an area for slaughter, the pesticide residues are removed with them and transferred to a new location. After harvest, many agricultural commodities are washed or processed, which can remove or degrade much of the remaining residue.

Microbial Degradation

Microbial degradation occurs when microorganisms such as fungi and bacteria use a pesticide as food source. Microbial degradation can be rapid and thorough under soil conditions favoring microbial growth. Those conditions include warm temperatures, favorable pH levels, adequate soil moisture, aeration (oxygen), and fertility. The amount of adsorption also influences microbial degradation. Adsorbed pesticides, because they are less available to some microorganisms, are more slowly degraded.

Chemical Degradation

Chemical degradation is the breakdown of a pesticide by processes not involving a living organism. The adsorption of pesticides to the soil, soil pH levels, soil temperature and moisture all influence the rate and type of chemical reactions that occur. Many pesticides, especially the organophosphate insecticides, are susceptible to degradation by hydrolysis in high pH (alkaline) soils or spray mixes. The addition of buffers to the spray mix can help slow hydrolysis reactions.

Photodegradation

Photodegradation is the breakdown of pesticides by the action of sunlight. Pesticides applied to foliage, the soil surface, or structures, vary considerably in their stability when exposed to natural light. Similar to other degradation processes, photodegradation reduces the amount of chemical present, which can subsequently reduce the level of pest control. Soil incorporation by mechanical means during or after application, or by irrigation water or rainfall following application, can reduce pesticide exposure to sunlight.

Groundwater Contamination

Groundwater can be defined as the water beneath the earth's surface occupying the saturated zone, that is the area in which all the pore spaces in the rock or soil are filled with water. It is stored in water-bearing geological formulations known as **aquifers**. Groundwater moves through aquifers and can be obtained at points of natural discharge such as springs or streams, or by drilling a well into the aquifer.

The upper level of the water-saturated zone in the ground is called the **water table**. The water table depth below the soil surface fluctuates throughout the year, depending on the amount of water removed from the ground and the amount of water added by recharge and connected surface waters. **Recharge** is water that seeps through the soil from rain, melting snow, or irrigation. Surface waters are visible bodies of water such as lakes, rivers, and oceans.

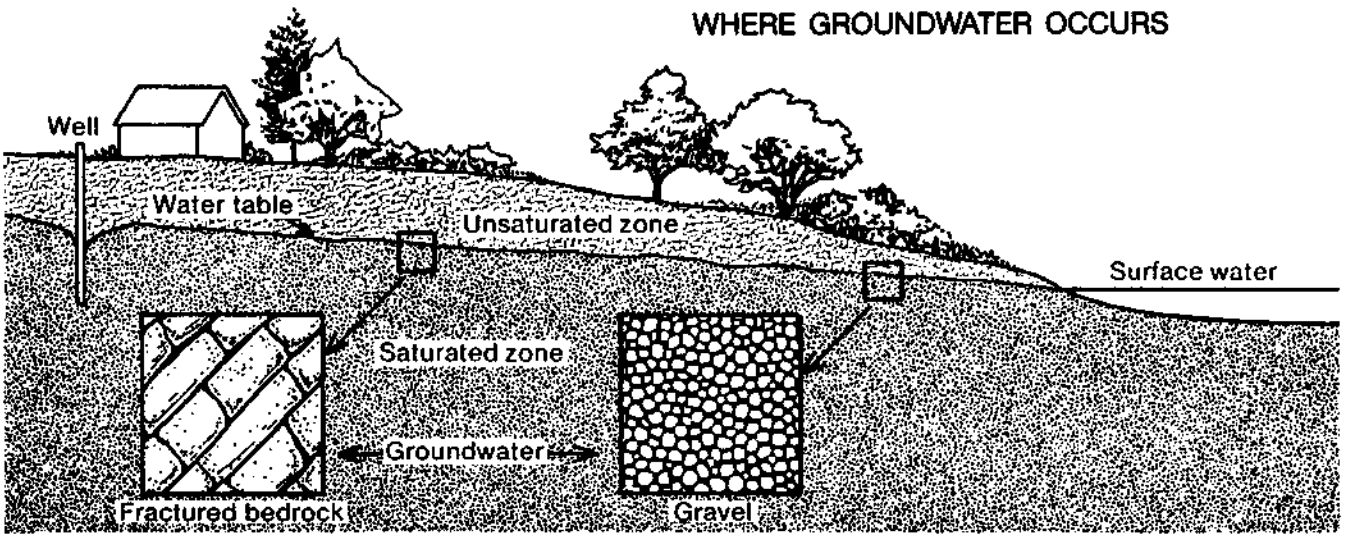
Both surface water and groundwater are subject to contamination by **nonpoint source pollution**. This type of pollution generally results from land runoff, precipitation, acid rain, or percolation rather than from a discharge at a specific, single location (such as a single pipe). Pollution from nonpoint sources occurs when the rate at which pollutant materials entering waterbodies or groundwater exceeds natural levels.

The potential for the pollution of groundwater from improper waste disposal is a major concern. Problems result from domestic waste (i.e., septic systems, landfills, waste treatment plants), industrial waste (i.e., landfills, brine and mine wastes, deep well disposal), and government generated waste (i.e., radioactive wastes). Another concern is improper agricultural practices. Inadequate handling of livestock waste storage facilities and improper application of manures and fertilizers can leave unacceptable levels of nitrates in groundwater. Pesticide residues in particular are receiving considerable national attention. Evidence suggests that in certain areas agriculture's relative contribution to groundwater contamination may be significant.

Pesticides in Groundwater

Earlier in this chapter we discussed pesticide fate and the numerous transfer and breakdown processes that occur in the environment. Those processes help determine whether pesticides reach groundwater, or are degraded prior to reaching these underground waters. Geological characteristics, such as the depth of the water table and the presence of sinkholes are also critical. If the water table is close to the soil surface, there may be few opportunities for adsorption and degradation reactions to occur.

On the soil surface and within the first few inches of soil, pesticides can be volatilized, adsorbed to soil particles, taken up by plants, or they can be broken down by sunlight, soil microorganisms, and chemical reactions. The extent of pesticide leaching is affected by both pesticide and soil properties. Weather conditions and management practices also affect leaching of pesticides through the soil. Too much rain or irrigation water can leach pesticides beyond the treatment area. A pesticide that is not volatilized, absorbed by plants, bound to soil, or broken down can potentially move through the soil to groundwater.



After pesticides reach groundwater they may continue to break down, but at a much slower rate because of less available light, heat, and oxygen. The movement of groundwater is often slow and difficult to predict. Substances that enter the groundwater in one location can turn up years later in other locations. A major difficulty in dealing with groundwater contaminants is that the sources of pollution are not easily recognizable. The problem is occurring underground, out of sight.

Keeping Pesticides Out of Groundwater

It is very difficult to purify or clean groundwater that has become contaminated. Treatment is complicated, time consuming, expensive, and often not feasible. The best solution to groundwater contamination is to prevent the problem in the first place. The following pesticide applicator practices can reduce the potential for surface and groundwater contamination.

• **Use Integrated Pest Management Programs** — Pesticide use can be minimized by combining chemical control with other pest management practices.

• **Consider the Geology of Your Area** — When planning pesticide applications, be aware of the water table depth and the permeability of the geological layers between the surface soil and groundwater. Sinkholes can be especially troublesome because they allow surface water to quickly reach groundwater.

• **Consider Soil Characteristics** — The susceptibility of your soil to leaching should be determined. Soil texture and organic matter content in particular influence chemical movement into groundwater. The leachability of the soil may determine whether a pesticide can be used in that area or not.

• **Select Pesticides Carefully** — Remember, those pesticides which are highly soluble, relatively stable, and not readily adsorbed to soil tend to be the most likely to leach. Choose pesticides with the least potential for leaching into groundwater. Read labels carefully and consult a specialist from a cooperative extension office, or your chemical dealer if necessary.

Follow Label Directions — The label carries crucial information about the proper rate, timing, and placement of the pesticide in that container.

• **Calibrate Accurately** — Equipment should be calibrated carefully and often. During the calibration procedure check the equipment for leaks and malfunctions.

• **Measure Accurately** — Concentrates need to be carefully measured before they are placed into the spray tank. Do not "add a little extra" to ensure the pesticide will do a better job. Such practices only increase the likelihood of injury to the treated crop or animal, the cost of pest control, and the chance of groundwater contamination.

• **Avoid Back-Siphoning** — The end of the fill hose should remain above the water level in the spray tank at all times to prevent back-siphoning of chemical into the water supply. Use an anti-backflow device when siphoning water directly from a well, pond, or stream. These practices also reduce the likelihood of the hose becoming contaminated with pesticides.

• **Consider Weather and Irrigation** — If you suspect heavy or sustained rain, delay applying pesticides. The quantity of irrigation should be controlled to minimize the potential for pesticide leaching and runoff.

• **Clean Up Spills** — Avoid spills. But when they do occur, they should be contained and cleaned up quickly. Chemicals spilled near wells and sinkholes can move directly and rapidly into groundwater.

• **Change the Location of Mixing Areas** — Mix and load pesticides on an impervious pad if possible. If mixing is done in the field, change the location of the mixing area regularly.

• **Dispose of Wastes Properly** — All pesticide wastes must be disposed of in accordance with local, state, and federal laws. Triple rinse containers. Pour the rinsewater into the spray tank for use in treating the site or the crop.

• **Store Pesticides Away from Water Sources** — Pesticide storage facilities should be situated away from wells, cisterns, springs, and other water sources.

Michigan's aquifers currently provide a vast supply of clean water for agriculture, homes, and industry. They can ensure high quality groundwater for future needs only if they are protected now. Be sure to understand how your activities, including pesticide usage, can impact them.

Effects on Nontarget Organisms

Applying pesticides carelessly can harm nontarget organisms that are beneficial to agriculture

and our environment. It is crucial that we protect these species.

Bees and Other Pollinators

Bees and other pollinating insects are essential for successful production of many crops such as deciduous tree fruits, small fruits, most seed crops and certain vegetables. Many pesticides, particularly insecticides, are highly toxic to pollinating honeybees and wild bees. Be aware of how bee poisonings can occur, and how they can be prevented.

The following precautions reduce the chance of bee poisoning.

- Do not apply pesticides that are toxic to bees during bloom. Even shade trees and weeds should not be sprayed during bloom. Mow cover crops and weeds to remove the blooms prior to spraying.
- Select pesticides that are least harmful to bees and select the safest formulation. Dusts are more hazardous to bees than sprays. Wettable powders are usually more hazardous to bees than either emulsifiable concentrates or water soluble formulations. Granular insecticide formulations are generally the least hazardous to bees. The hazard to bees increases, however, when insecticides are microencapsulated. The minute capsules can be carried back to the hive in much the same manner as pollen.
- Reduce drift during application. Aerial applications usually are more hazardous to bees than are ground applications.
- Time pesticide application carefully. Evening applications are less hazardous than early morning; both are safer than midday applications.
- Do not treat near hives. Bees may need to be moved or covered before using insecticides near colonies.

Other Beneficial Insects and Microorganisms

The best way to avoid injury of beneficial insects and microorganisms is to minimize pesticide usage. Selective pesticides should be used whenever possible and applied only when necessary as part of a total pest management program.

Fish and Other Wildlife

Pesticides can be harmful to all kinds of vertebrates. Most recognizable are the direct effects from acute poisoning. Fish kills often are a direct result of water pollution by a pesticide. Pesticides can enter water via drift, surface runoff, soil erosion, leaching and in some cases deliberate or careless release of pesticide directly into the water. Fish kills are most often caused by insecticide contamination of small ponds or streams with low water volume or turnover.

Bird kills from pesticides can occur in a number of ways. Birds can ingest the toxicant in granules, baits, or treated seed; they may be exposed directly to the spray; they may consume a treated crop or drink or use contaminated water; they may feed on pesticide contaminated prey.

Environmental damage can be avoided when pesticides are used carefully, wisely and according to the instructions on the product label.

REVIEW QUESTIONS – CHAPTER 4

Write the answers to the following questions. When you are satisfied with your answers, see if they are correct by checking them with the chapter text.

1. List four processes which effect pesticides as they are released into the environment.

   1. _____
   2. _____
   3. _____
   4. _____

2. Pesticide adsorption is greatest in coarse, sandy soils. (True or False)

4. The airborne movement of a pesticide from the target area occurs only during application and is clearly visible when it occurs. (True or False)

5. The vapor pressure rating of the pesticide may indicate its volatility. The higher the vapor pressure, the _____volatile the pesticide.

6. _____ occurs when water moves on the soil surface. _____ occurs when water moves through the soil.

7. Groundwater is stored in _____.

8. Contamination of groundwater is more likely to occur when:
   a. pesticides are applied on a sunny day
   b. the water table is close to the soil surface
   c. the soil type is clay
   d. a and c
   e. none of the above

9. What is the best solution to groundwater contamination?

10. List ten or more practices that reduce the potential for groundwater and surface water contamination.

_____

_____

_____

_____

_____

11. What precautions can you take to reduce the chances of bee poisoning from pesticides?

_____

_____

_____

12. Fish kills most commonly result from pollution of water by _____ in small ponds or streams with low water volume or turnover.
   a. herbicides
   b. fungicides
   c. insecticides
   d. rodenticides
   e. avicides

13. List some of the ways nontarget birds may be killed by pesticides.

_____

_____

_____

CHAPTER 5

PESTICIDES AND HUMAN HEALTH

With few exceptions, pesticides must be toxic to living organisms to be effective. They are specifically designed to be toxic to those organisms we considers pests. In many respects, however, living organisms are not all that different; they share many basic features. A substance that is toxic to one species will usually be somewhat harmful to another, including humans. Pesticides are poisonous to pests and they may be poisonous to us too.

This chapter explains how pesticides enter the body, how to protect yourself from contamination, and how to perform first aid if contamination does occur. An explanation of terms will help clarify this information. The words toxicity and hazard often are interchangeably used when describing a pesticide's toxic effects. However, they are not the same. **Toxicity** is a measure of the capacity of the pesticide to cause injury. It is a property of the chemical itself and its concentration. **Hazard**, on the other hand, is the potential for injury. It reflects both the toxicity of the pesticide and the likelihood that significant exposure will occur in a particular situation. Pesticide applicators should be concerned with the hazards associated with exposure to the chemical and not exclusively with the toxicity of the chemical itself.

The best way to avoid or minimize the hazards of pesticide use is to know what you are using and how to use it. This means you must read the label carefully and follow the instructions. The attitude of the applicator is of utmost importance. If applicators mistakenly think they know exactly how to use a pesticide, or do not care about what precautions should be taken, accidents are more likely to occur. By taking adequate precautions and practicing good common sense with safety in mind, there should be few accidents from pesticide usage.

Exposure: How Pesticides Enter the Body

To cause an adverse effect (including death), a pesticide must first enter the body and reach a susceptible site. Three routes through which a pesticide can enter the human body are: the skin (dermal), the lungs (inhalation), and the mouth (oral).

Dermal Exposure

In most exposure situations, the skin is the most important route of pesticide entry into the body. Evidence indicates that about 97 percent of all body exposure to pesticides during a spraying operation is by skin contact. Dermal absorption may occur from a splash, spill, or drift when mixing, loading, applying, or disposing of pesticides. It may also result from exposure to plant residue or when cleaning or repairing contaminated equipment.

Even if only a small amount of chemical is allowed to remain on the skin and be absorbed into the body, a person can be poisoned. Different parts of the body vary in their abilities to absorb pesticides. The statistics in Table 1 were obtained from a study of volunteers and show that you should take special care to protect the scalp, ear canal and forehead. A hat with a wide brim would serve to protect these three areas.

Table 1

Anatomy	Percent Absorption*
Scalp	32.1
Ear Canal	46.5
Forehead	36.3
Forearm	8.6
Palm of Hand	11.8
Abdomen	18.4
Scrotum	100.0
Ball of Feet	13.5

*Parathion was used in this study.

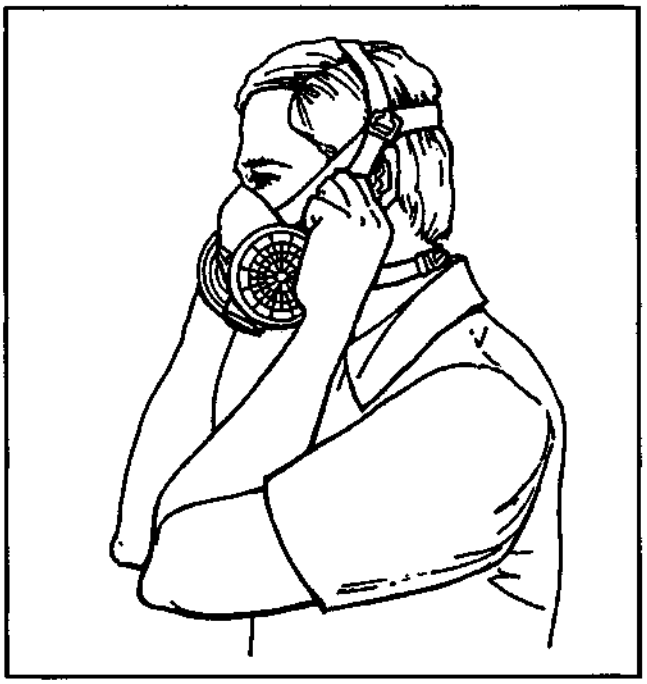
The scrotal area and the head tend to be more absorptive, although cuts, abrasions, and skin rashes can enhance absorption in other parts of the body. Pesticide formulations vary in their absorbency through skin. In general, wettable powders, dusts, and granular pesticides are not as readily absorbed as are oil-based liquid formulations such as emulsifiable concentrates.

Under certain conditions and with certain pesticides, absorption through the eyes can be sig-

nificant and particularly hazardous. Eyes are very sensitive to many pesticides and, considering their size, are able to absorb surprisingly large amounts of chemical. Serious eye exposure can result from a splash or spill, drift, or rubbing the eyes with contaminated hands or clothing. Avoid this type of exposure by wearing protective eye covering, especially when indicated on the label.

Inhalation Exposure

Protecting the lungs is especially important since pesticide powders, dusts, gases, vapors, or very small spray droplets can be inhaled during mixing, loading, or application, or when pesticides are applied in confined areas. Once breathed into the lungs, pesticides can enter the bloodstream rapidly and completely. If inhaled in sufficient amounts, pesticides can cause damage to nose, throat, and lung tissue. The label will indicate whether face masks or respirators are required when using specific pesticides.



The respirator should fit snugly around your face.

Oral Exposure

Accidental oral exposure occurs most frequently when pesticides have been taken from the original labeled container and put into an unlabeled bottle or food container. Unfortunately, children are the most common victims. Children under age ten are the victims of at least half of the accidental pesticide deaths in the United States.

Oral exposure also occurs when liquid concentrates splash into the mouth during mixing or when cleaning equipment. The mouth should never be used to clear a spray line or to begin siphoning a pesticide. Chemicals can also be swallowed when eating, drinking, or smoking, or even licking one's lips. Since many pesticides are rapidly and completely absorbed by the intestinal tract, it is sound advice to wash hands and face thoroughly before eating, drinking, or smoking.

Toxicity and Potential Health Effects of Pesticides

The toxicity of a particular pesticide is determined by subjecting test animals (usually rats, mice, rabbits, and dogs) to different dosages of an active ingredient and to each of its formulated products. From these studies acute and chronic toxicity and effects are determined, signal words are assigned and proper handling procedures are determined to reduce risk.

Acute Toxicity and Acute Effects

Acute toxicity is the capacity of a pesticide to cause injury from a single exposure. This is the most common type of pesticide poisoning problem.

Acute toxicity is determined by at least three methods:

1) dermal toxicity is determined by exposing the skin to the chemical;

2) inhalation toxicity is determined by permitting the test animals to breathe vapors of the chemical; and

3) oral toxicity is determined by feeding the chemical to test animals.

The harmful effects that occur from a single exposure by any route of entry are termed **acute effects**. In addition, the effect of the chemical as an irritant to the eyes and skin is examined under laboratory conditions.

Acute toxicity is usually expressed as LD50 (lethal dose 50) and LC50 (lethal concentration 50). This is the amount or concentration of a toxicant required to kill 50 percent of a test population of animals under a standard set of conditions. LD50 values of pesticides are recorded in milligrams of pesticide per kilogram of body weight of the test animal (mg/kg), or in parts per million (ppm). LC50 values of pesticides are recorded in milligrams of pesticide per volume of

air or water (ppm). To put these units into perspective, 1 ppm can be compared to 1 inch in 16 miles or 1 minute in 2 years.

The LD50 and LC50 values are used to compare the toxicity of different active ingredients as well as different formulations of the same active ingredient. The lower the LD50 value of a pesticide, the less it takes to kill 50 percent of the population, and therefore the greater the acute toxicity of the chemical. Pesticides with high LD50 values are considered the least acutely toxic to humans when used according to the directions on the product label.

Acute toxicities are the basis for selecting the appropriate signal word (toxicity categories) to be used on a product label.

Signal Words

Those pesticides that are classified as "highly toxic," on the basis of either acute oral, dermal, or inhalation toxicity, must have two signal words **DANGER** and **POISON** (in red letters) and a skull and crossbones prominently displayed on the package label. **PELIGRO**, the Spanish word for danger, must also appear on the labels of highly toxic chemicals. Acute oral LD50 values for pesticide products in this group range from a trace to 50mg/kg. As little as a few drops of such a material taken orally could kill a 150-pound person.

Some pesticide products carry the signal word **DANGER** without the skull and crossbones symbol. This occurs when possible skin irritation or eye effects are more severe than suggested by the acute toxicity (LD50) of the product.

Pesticide products considered "moderately toxic" must have the signal words **WARNING** and **AVISO** (Spanish) displayed on the product label. Acute oral LD50 values range from 50 to 500 mg/kg. From 1 teaspoonful to 1 ounce of this material could kill a 150-pound person.

Pesticide products classified as either "slightly toxic or relatively nontoxic" are required to have the signal word **CAUTION** on the pesticide label. Acute oral LD50 values are greater than 500 mg/kg.

Chronic Toxicity and Chronic Effects

Chronic toxicity is the ability of a pesticide to cause injury from repeated, prolonged exposure to small amounts. There are a number of pesticides which cause this type of effect. Chronic toxicity is very dangerous because pesticide applicators do not realize anything is wrong until it is too late. Applicators should remember that the absence of any immediate effect is not necessarily the same as safe use.

The chronic toxicity of a pesticide is determined by subjecting test animals to long term exposure of an active ingredient. The harmful effects that occur from small doses repeated over a period of time are termed **chronic effects**. Some of the suspected chronic effects from exposure to certain pesticides include birth defects (teratogenesis); toxicity to a fetus (fetotoxic effects); production of tumors (oncogenesis), either benign (noncancerous) or malignant (cancerous or carcinogenesis); genetic changes (mutagenesis); blood disorders (hemotoxic effects); nerve disorders (neurotoxic effects); and reproductive effects. Pesticides are required to include chronic toxicity warning statements on the product label if effects may occur. The chronic toxicity of a pesticide is more difficult to determine through laboratory analysis than the acute toxicity.

Because of the variety of effects that pesticides can cause and the amount of time it might take for the effects to appear, it is prudent to reduce exposure as much as possible to all pesticides. When effects do occur, treatments are generally available but prevention is much preferable to treatment, especially since some of the effects are irreversible.

First Aid for Pesticide Poisoning

Most pesticide poisonings result from careless use, improper storage or ignorance. By law, everything you need to know to apply pesticides safely is on the pesticide label. Therefore, the most important rule to follow when using pesticides is: **Read and follow the instructions and precautions on the label.** Read the label before buying the product, opening the container, mixing or applying the solution and before disposing of unused product or empty containers.

Symptoms and Signs of Pesticide Poisoning

Herbicides and Fungicides. Herbicides and fungicides are designed as "plant poisons." Human exposure to toxic levels results in a variety of general symptoms and signs of poisoning. These vary with the herbicide or fungicide, the amount absorbed, and the general health condition of the individual. Some of the most common symptoms and signs are:

• **When a substance is touched:** skin irritation (drying and cracking), skin discoloration (reddening or yellowing) or itching.

• **When the substance is inhaled:** burning sinuses, throat and lungs, accompanied by coughing, hoarseness and upper respiratory congestion.

• **When the substance is ingested:** mouth and throat irritation, chest pains, nausea (stomach ache), diarrhea, muscle twitching, sweating, headache and weakness.

Some of the symptoms begin immediately upon exposure while others are delayed for several hours or even days.

Insecticides. Symptoms differ with various insecticides, but all are dependent on both the amount and timing of exposure. Insecticides of most concern are the organophosphates and carbamates which inhibit **cholinesterase**, a chemical critical for normal functioning of the nervous system. Symptoms might begin almost immediately after exposure to a direct cholinesterase inhibitor such as mevinphos or Furadan. Symptoms may be delayed several hours, however, after an equal exposure to a delayed cholinesterase inhibitor such as parathion, Guthion or phorate (Thimet). Onset of symptoms more than 12 hours after exposure generally excludes organophosphate or carbamate insecticide poisoning, unless it is chronic poisoning from small repeated exposures.

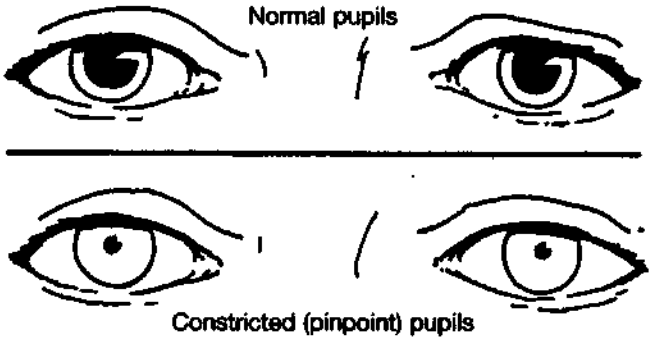
The most commonly reported symptoms, which often appear in progression and depend, in part, on whether the chemical was touched, inhaled or ingested, are:

• headache,

• visual disturbances (blurred vision),

• pupillary abnormalities (primarily pin-point pupils, but on rare occasions, dilated pupils), and

• greatly increased secretions such as sweating, salivation, tearing and respiratory secretions.



More severe poisonings results in nausea and vomiting, pulmonary edema (the air spaces in the lungs begin to fill with fluid), changes in heart rate, muscle weakness, respiratory paralysis, mental confusion, convulsions or coma and death.

Cholinesterase Tests

Cholinesterase tests are used only for cholinesterase-inhibiting insecticides: organophosphates and carbamates. Urine and blood analysis, together with symptoms, are used to diagnose most herbicide, fungicide and non-cholinesterase inhibiting insecticide exposure and poisonings.

If you work with organophosphate or carbamate insecticides for an extended time (farmers, pesticide applicators, pesticide manufactures, formulators) you should establish a regular cholinesterase test program with your doctor. For a farmer, such a program might consist of one (initial) cholinesterase test to determine a "base line level." This test should be made "off season" (January or February). Then, when insecticides are used during the summer, similar tests are conducted and the results are compared with the base line level. Through this testing procedure, you can learn of any changes in cholinesterase levels when you are exposed to pesticides. When cholinesterase levels are low, your doctor may advise you to limit or possibly stop your exposure to these pesticides until the cholinesterase level returns to normal.

For more information, contact your doctor or the state health department.

First Aid Instructions

When you are working with pesticides, it is always best to work with someone. Arranging to have someone with you may sometimes be an inconvenience, and it may seem like an unnecessary precaution — until something happens.

If you are with someone who is exposed to a pesticide, immediately begin first aid treatment yourself or assist the victim in any way you can. Always be careful not to contaminate yourself. If there is any cause to seek medical attention, either call a doctor or take the victim directly to a doctor. **Take the pesticide label or labeled container with you.**

First aid treatment varies according to the type of exposure. You should become thoroughly familiar with **all** of the appropriate procedures. They should be **learned ahead of time**; you prob-

ably won't have the time or the opportunity to look them up if you ever need them.

Dermal Exposure

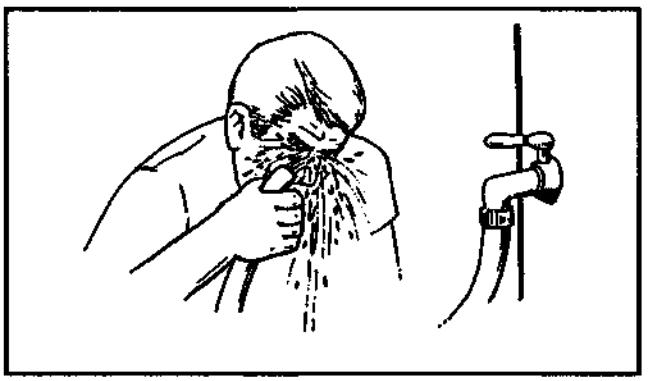
- Remove clothing, if it has been contaminated.
- Drench skin with water.
- Wash thoroughly including hair if necessary; detergents and commercial cleansers are better than soap.
- Rinse thoroughly — use rubbing alcohol if it is readily available rather than water.
- Wash again and rinse.
- Dry and wrap the person in a blanket.
- Where chemical burns of the skin have occurred, cover area loosely with a clean, soft cloth. Avoid the use of ointments, greases, powders, and other medications.

Inhalation Exposure

- Get to fresh air immediately.
- If you are with someone who has been poisoned, carry the victim (do not let him or her walk) to fresh air immediately.
- Do not attempt to rescue someone who has been poisoned in an enclosed area if you do not have the proper respiratory equipment.
- Loosen all tight clothing.
- If breathing has stopped or is irregular, give mouth-to-mouth resuscitation.
- Victim should remain as quiet as possible.
- Prevent chilling (wrap in blankets, but do not overheat).
- If you are with a victim who is having convulsions, watch their breathing and protect them from falling and striking their head. Keep their chin up so their air passages will remain free for breathing.
- Do **not** give alcohol in any form to the victim.

Eye Exposure

- Hold eyelids open and wash eyes with a gentle stream of clean running water. Use large amounts of water. **Do so immediately; delay of even a few seconds greatly increases the possibility of injury.** Continue washing for 15 minutes or more.
- Do **not** use medications in the wash water — use pure water.



Use clean water to gently flush pesticides from the eyes for at least 15 minutes.

Oral Exposure

- If a pesticide has gotten into your mouth, but has not been swallowed, rinse your mouth with large amounts of water.
- If the pesticide has been swallowed, the most important consideration is whether or not to induce vomiting; the decision must be made quickly and correctly. Where specific instructions are given, always follow label directions. Beyond that, never induce vomiting if:
  - the victim is unconscious or is having convulsions.
  - the pesticide is **corrosive**. A corrosive substance is any material, such as a strong acid or alkali (base), which causes chemical destruction of living tissues. Poisoning symptoms include severe pain and a burning sensation in the mouth or throat.

In attempting to induce vomiting, it is important to use safe and effective procedures.

- vomiting should be induced for:

  — an **adult** with two tablespoons (one ounce) of Syrup of Ipecac (this can be obtained from your pharmacist without a prescription) and two glasses of water, or

  — a **child** with one tablespoon (one-half ounce) of Syrup of Ipecac and one glass of water.

  If Syrup of Ipecac is not available, induce vomiting by drinking one or two glasses of water and then touching the back of the throat with your finger. **Salt water should not be used to induce vomiting.**

- Victim should be lying face down or kneeling forward while retching or vomiting, thus preventing vomitus from entering the lungs and causing further damage.

• Collect some of the vomitus for the doctor; he or she may need it for chemical tests.

• **Do not waste a lot of time attempting to induce vomiting; get to a hospital as soon as possible.**

Where the label identifies specific antidotes, this information is intended for use by a doctor. Antidotes should not be administered except under the direction of a physician or other medical personnel. Taken improperly, antidotes can be more harmful than the pesticide itself.

The name, address, and telephone number of the physician, clinic, or hospital emergency room that will provide care in the event of a pesticide poisoning should be clearly posted at all work sites.

Safety: Protect Yourself from Pesticides

The greatest risk to the pesticide applicator occurs during application and mixing and loading of pesticide concentrates. Although application of diluted material is usually less hazardous, the hazard is increased when there is significant drift or when appropriate safety and application procedures are not followed. The danger of exposure also exists when cleaning up pesticide spills, making equipment repairs, and entering treated areas prematurely.

Wearing protective clothing and equipment offers protection against exposure. Remember:

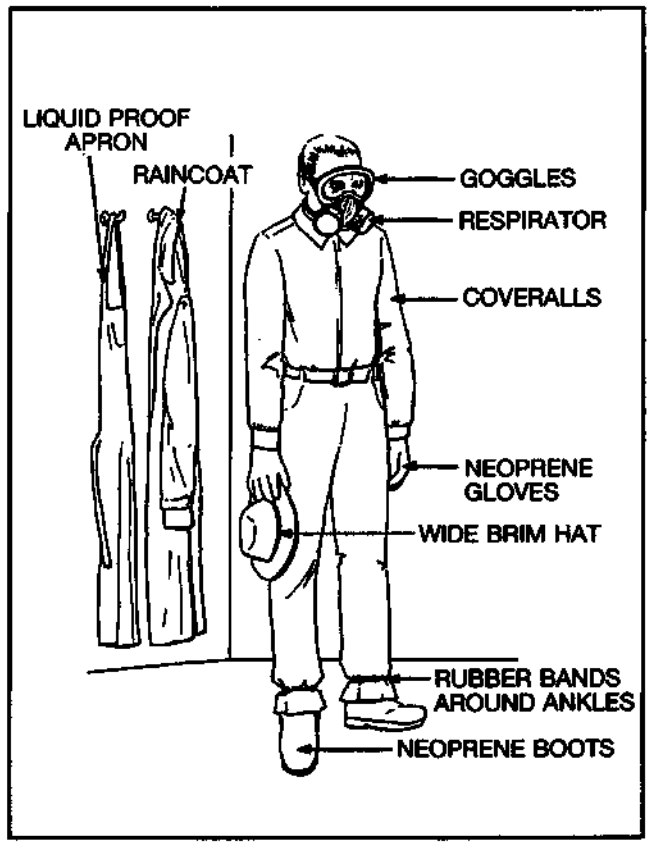
$$\text{RISK} = \text{Toxicity} \times \text{Exposure}$$

To reduce risk, choose pesticides with lower toxicity and reduce exposure.

We will briefly discuss the various types of protective clothing and equipment, and review some important considerations for their selection.

Clothing

Protective clothing should include a long-sleeved shirt and long trousers that are clean and made of a tightly woven fabric or a water repellent material. A cotton T-shirt and shorts are not adequate protection when applying pesticides. Common denim provides good protection. Specific items of protective clothing are described in the following sections. For more information, see Extension Bulletin E-2150, "Choosing Clothing for Pesticide Safety."



Coveralls, Aprons, Raincoats

Coveralls, whether disposable or reusable, vary in their comfort, durability, and the degree of protection provided. They are generally adequate when handling most pesticides. A liquid-proof apron or raincoat (or rainsuit) should be worn when pouring and mixing concentrates and when using highly toxic pesticides since coveralls usually do not provide adequate protection against spills and splashes of these chemicals. A rainsuit should be worn whenever mist or spray drift are likely to substantially wet the work clothes or coveralls. Liquid-proof aprons and rainsuits should be made of rubber or a synthetic material resistant to the solvents in pesticide formulations. The apron should cover the body from the chest to the boots.

Gloves

Unlined, waterproof gloves should be worn when handling or applying pesticides. Gloves should be long enough to cover the wrist and should not have a fabric wristband. Check gloves carefully to be sure there are no holes — fill them with water and squeeze. Be certain gloves are approved for use with chemicals, i.e., for some fumigant products, rubber gloves should not be used. Some rubber products react with certain solvents and become sticky as the

rubber dissolves. If this occurs, dispose of the gloves and use gloves approved for use with the specific pesticide. For most jobs, shirt sleeves should be worn outside of the gloves to keep pesticides from running down the sleeves into the gloves. But, if you will be working with your hands and arms overhead, put the gloves outside of the sleeves and turn up the cuff of the gloves to catch material that might run down your arms. Wash chemicals off the gloves with soap and water before removing them. This avoids contamination of your hands when removing the gloves.

Hats

A head covering should be worn when handling pesticides. It should be liquid- proof and have a wide brim to protect the face, ears and neck. Hats should be either disposable or easy to clean with soap and water; they should not contain any absorbent materials such as leather, straw, or cloth. **Baseball hats do not provide adequate protection.**

Shoes and Boots

Boots should be unlined and made of rubber. Because of their absorbency, boots of leather, canvas, or cloth should never be worn when handling pesticides. Trouser legs should be worn outside the boots to prevent pesticides from running down the leg and into the boot.

Goggles and Face Shields

Tightly fitting, nonfogging goggles, or a full-face shield should be worn when there is any chance of getting pesticide in your eyes. This is especially important when pouring or mixing concentrates or handling dusts or toxic sprays. Those who wear contact lenses may want to consult an eye doctor or physician prior to using pesticides.

Goggles and face shields should be kept clean at all times. Wash them with soap and water, and sanitize by soaking equipment for two minutes in a mixture of 2 tablespoons chlorine bleach in a gallon of water. Rinse thoroughly with a clean cloth and allow to air dry. In particular, pay attention to the goggle headbands. They are often made of absorbent material that requires regular replacement.

Respirators

For many toxic chemicals, the respiratory (breathing) system is the quickest and most direct route of entry into the circulatory system. From the blood capillaries of the lungs, the toxic substances are rapidly transported throughout the body.

Respiratory protective devices vary in design, use, and protective capability. In selecting a respiratory protective device, first consider the degree of hazard associated with breathing the toxic substance, and then understand the specific uses and limitations of the available equipment. Select a respirator that is designed for the intended use, and always follow the manufacturer's instructions concerning the use and maintenance of your respirators for different chemicals or groups of chemicals. Select only equipment approved by the National Institute of Occupational Safety and Health (NIOSH), and the Mine Safety and Health Administration (MSHA). The NIOSH approval numbers begin with the letters TC.

After each use of the respirator, remove all mechanical and chemical filters. Wash and sanitize the facepiece using the same procedure recommended for goggles. Store the respirator facepiece, cartridges, canisters, and mechanical filters in a clean, dry place, preferably in a tightly sealed plastic bag. **Do not store your respirator with pesticides or other agricultural chemicals.**

Laundering Pesticide-Contaminated Clothing

All protective clothing and equipment should be washed at the end of each day of use. Pesticide contaminated clothing should be stored and washed separately from the family laundry. Remember to wear gloves during these handling and laundering steps and be sure to check the label for any specific instructions. **Note:** Clothing that has become saturated with a concentrate should be discarded.

Some residues may be removed by hosing the contaminated clothing with water or presoaking it in an appropriate container. Washing in hot water removes more pesticide from the clothing than washing in lower water temperatures. The hotter the better; cold water might save energy, but it is relatively ineffective in removing pesticides from clothing.

Laundry detergents, whether phosphate, carbonate, or heavy-duty liquids are similarly effective in removing most pesticides from fabric. However, heavy-duty liquid detergents typically have better oil removing ability and therefore are more effective than other detergents in remov-

ing emulsifiable concentrates. The ease of pesticide removal through laundering does not depend on toxicity, but on the formulation of the pesticide. Bleach or ammonia may possibly help in the removal or break down of certain pesticides. **Bleach and ammonia should never be mixed because they react to form chlorine gas which can be fatal.**

Washing should be done at the full water level. After washing, it is important to rinse the washing machine with an "empty load," using hot water and the same detergent. Line drying of clothing is recommended for two reasons. First, it eliminates the possibility of residues collecting in the dryer. Second, residues of many pesticides will break down when exposed to sunlight.

Wash hands and arms after the laundering procedure. Keep protective clothing separate from the pesticide storage area. For more laundering information, see Extension Bulletin E-2149, "10 Tips for Laundering Pesticide Soiled Clothing."

Personal Care After Application

After cleaning application equipment and protective clothing equipment, personal clean up is next. In particular, wash your hands and face thoroughly with soap and hot water before eating, drinking, or smoking. Shower and change clothing as soon as possible. Be sure to scrub your scalp, neck, behind your ears, and under your nails.

REVIEW QUESTIONS – CHAPTER 5

Write the answers to the following questions. When you are satisfied with your answers, see if they are correct by checking them with the chapter text.

1. What is the difference between toxicity and hazard?

2. In most pesticide exposure situations, which route of entry into the body is the most important?

3. Pesticide residues are absorbed through the skin at relatively the same rate on different parts of the body. (True or False)

4. _____ are the most common victims of oral exposure.

5. Give an example of inhalation exposure and oral exposure.

6. Toxicity from small, repeated exposures to a pesticide over a period of time is called _____ Toxicity from one exposure is _____.

7. Which LD50 is representative of a highly toxic pesticide?
   a. 640 mg/kg
   b. 5,800 mg/kg
   c. 12,840 mg/kg
   d. 380 mg/kg
   e. 46 mg/kg

8. The signal word on a pesticide label indicates the pesticide's
   a. effectiveness
   b. toxicity
   c. compatibility
   d. formulation
   e. ability to cause tumors

9. Which signal word(s) would indicate the product is least toxic to an applicator?
   a. DANGER
   b. CAUTION
   c. WARNING
   d. DANGER-POISON
   e. Skull and Crossbones

10. Where can the applicator find out everything he or she needs to know to apply pesticides safely?

11. Insecticides of most concern are the _____ _____ and _____ which inhibit cholinesterase.

12. _____ is a chemical critical for normal functioning of the nervous system.

13. Who should receive regular cholinesterase testing?

14. What pesticide-related document should you take with you when you take a pesticide-poisoning victim to the doctor?

15. List three things you should do when someone has been dermally exposed to pesticides.

_____

_____

_____

16. Never induce vomiting in a pesticide-poisoning victim if:
   a. the victim is a child
   b. the victim is unconscious or is having convulsions
   c. the pesticide involved is corrosive
   d. all of the above
   e. b and c only

17. List three things you should do when someone has inhaled a pesticide.

_____

_____

_____

18. To reduce the risk of pesticide use, the applicator should choose pesticides which have lower _____ and reduce _____.

19. A cotton T-shirt, shorts, and baseball hat provide adequate protection when applying pesticides. (True or False)

20. Gloves and boots worn when handling most pesticides should be made of:
   a. canvas
   b. leather
   c. lined rubber
   d. unlined rubber
   e. none of the above

21. How frequently should protective clothing be laundered?

22. Pesticide contaminated clothing should be washed separately from the family laundry in hot water with laundry detergent. (True or False)

23. In the space provided, fill in the name and telephone number of the nearest Poison Control Center. Post it near a telephone as well!

_____

CHAPTER 6

PESTICIDE HANDLING, STORAGE AND DISPOSAL

There is always danger of exposure whenever we handle pesticides. The greatest risk to the applicator is in handling and applying highly toxic materials and in mixing and loading pesticide concentrates. Therefore, the applicator must use safety measures and also be familiar with what to do in the event of a spill or fire. Study the safety precautions described in this chapter and use them when handling, applying, transporting, and storing pesticides. You will find that most precautions are common sense.

Mix and Load Pesticides Safely

Mixing and loading concentrates are some of the most hazardous activities involving pesticides. Here are safety guidelines for mixing and loading procedures.

• Review the label before opening the container so that you are familiar with current mixing and usage directions.

• Always wear adequate protective clothing and equipment. Put them on before handling or opening a pesticide container. Remember that a respirator or appropriate form of eye protection should be worn if there is any chance of pesticide inhalation or eye exposure. Never eat, drink, or smoke while handling pesticides.

• Carefully choose the pesticide mixing and loading area. It should be outside, away from other people, livestock and pets. Pesticides should not be mixed in areas where a spill or overflow could get into a water supply. Handling areas are sometimes near a pond or stream bank. If this is the case, the area should be graded to slope away from the water. If you must work indoors or at night, be sure there is adequate ventilation and light. Have a supply of clean water and soap available. Hydrated lime and bleach can be used to neutralize and cleanup surfaces where spills occur. Clay, kitty litter, activated charcoal, sawdust, or similar material are also helpful to soak up spills or leaks. If possible, do not work alone.

• Do not tear paper containers to open them; use a sharp knife or scissors. When pouring from a container, keep the container at or below eye level and avoid splashing or spilling on your face or protective clothing. Do not use your mouth to siphon a pesticide from a container. Always stand upwind, or so the wind does not blow the pesticide toward your body. If an accident occurs, attend to it immediately. Remove any contaminated clothing and wash yourself thoroughly with soap and water. Spills on the floor or ground should also be attended to.

• Measure accurately; follow label instructions and mix only the amount you plan to immediately use. Newer measuring devices such as "tip and pours" are a great help in handling small amounts of concentrate. All measuring devices (spoons, cups, scales) should be kept in the pesticide storage area and labeled to avoid used for other purposes. Measuring cups should be rinsed and the rinsewater put into the spray tank.

• Pesticide containers should be triple rinsed as soon as they are emptied because residues can become dried and difficult to remove later. Pour the rinsewater into the spray tank to avoid disposal problems and wasting product. Replace container caps and close bags. Return them to the pesticide storage area.

• Equipment should be operational and calibrated prior to filling and using. The spray tank must also be clean. Oil, grease and chemical residues can cause incompatibility problems. The agitation system should be running and the spray tank should be approximately half full of water before any pesticide is added. For your own safety, always keep your head above the fill hole and do not allow the pesticide to spill or splash when putting it into the tank. If two or more pesticides are to be mixed, they must be compatible and mixed in the proper order: wettable powders, flowables, water solubles and emulsifiable concentrates. Small quantities of wettable powders often mix easier if a slurry is made first.

• When adding the additional water to a spray mixture, the waterpipe or hose should remain above the level of the mixture, never contacting it. This prevents contamination of the hose and avoids the possibility of back-siphoning the pesticide into the water source. Keep in mind that water characteristics influence the effectiveness of some pesticides. Alkaline spray water, for example, leads to chemical breakdown of many organophosphates and carbamates. The recommended water pH for mixing most pesticides is between 5.0 and 7.0. Buffers and acidifying agents can be used to adjust the pH of the water.

Never leave a sprayer unattended while it is being filled.

Store Pesticides Safely

Proper pesticide storage helps prolong chemical shelf-life while protecting the health of people, animals, and the environment. A number of conditions are essential for safe pesticide storage. Consult the pesticide product label for specific storage information. Other storage guidelines are presented in the following sections.

Storage Area

All pesticides should be kept out of the reach of children, pets, livestock, and irresponsible people. Pesticides should be stored in a locked, secure place, such as a separate building or storage room. Around the home, the same rule applies — lock them up.

A storage area should be located where water damage is unlikely to occur. Soil and land surface characteristics should be considered when constructing a storage facility to prevent contamination of surface or groundwater by drainage, runoff, or leaching. In certain situations, dikes may be warranted. For pesticide storage outdoors, a fence should be erected to prevent unauthorized entry and reduce the chance of theft and vandalism. In addition:

• Post highly visible warning signs on walls, doors, and windows to indicate to anyone attempting to enter the facility that pesticides are stored there. Also post "No Smoking" signs.

• Store pesticides in an area away from food, feed, potable water supplies, veterinary supplies, seeds and protective equipment. This prevents contamination from fumes, dusts, or spills, and reduces the likelihood of accidental human or animal exposure.

• Ventilate the storage area and keep it relatively free from temperature extremes. Very high or low temperatures can cause pesticide deterioration. Exhaust fans directed to the outside reduce the temperature and dust or fume concentrations. Fireproof construction with a sealed cement floor is the best.

• Keep pesticides cool, dry, and out of direct sunlight.

• Keep plenty of soap and water available in or close to the storage area. A fire extinguisher approved for chemical fires, first aid equipment, and emergency telephone numbers should all be readily available.

Crop seed treated with a pesticide presents a potential hazard if not stored properly. Such seed is usually treated with a brightly colored dye to serve as a warning that the seed has been treated with a pesticide. Unfortunately, the bright colors may be attractive to children. Treated seed should never be used for feed or mixed with untreated seed. It should be handled with the same care as the pesticide itself and stored in a locked storage facility away from feed, veterinary supplies, pesticides, other farm chemicals, farm equipment, pests, and children.

Store volatile herbicides separately to avoid possible cross contamination of other pesticides, fertilizers, and seeds.

Pesticide Containers

Store pesticides in their original containers rather than using soda-pop bottles, fruit jars, or other types of nonpesticide containers. Serious poisonings could result because small children as well as most adults associate the shape of a container with its contents.

Pesticides should never be stored in food or beverage containers. They may be swallowed accidentally.

Keep the original label attached to the container. To keep a label legible, protect it with transparent tape or lacquer. Remember, the label is the most important safety factor in the use of pesticides; do not let it become damaged or destroyed.

Never lend a pesticide in an unmarked or unlabeled container. Those who use the pesticide should not rely on verbal directions.

Close containers securely when not in use. Dry formulations tend to cake when wet or subject to high humidity. Opened bags of wettable and soluble powders, dust, and granules can be placed into sealable plastic bags or other suitable containers. This reduces moisture absorption by the material, and prevents spills should a tear or break occur.

Store liquid formulations and small containers of dry formulations on metal shelving. Metal shelving will not absorb spilled pesticides and is easier to clean than other surfaces.

Store pesticides in the original containers, under cool conditions, on lower shelves. Too much heat can cause the container to break or explode. Containers should not extend beyond shelving where they could be bumped or knocked off. Place larger metal drums and nonmetallic containers on pallets.

Check containers regularly for leaks, breaks, rust, and corrosion. If a leak or break occurs, place the container inside another container, or transfer the contents to an empty container which originally held the same material and has the same label attached.

Shelf Life of Pesticides

Keep an inventory of all pesticides in storage and mark each container with the purchase date. If a product has an effective shelf life recorded on the label, you will know how long the product should remain usable. If there are doubts concerning the shelf life of a pesticide, call the dealer or manufacturer. Pesticide deterioration may be apparent during mixing: excessive clumping, poor suspension, layering, or abnormal coloration. Sometimes, however, pesticide deterioration from age or poor storage conditions is apparent only after application. Poor pest control or damage to the treated crop or surface can occur.

To minimize storage problems, buy only as much as you anticipate needing for the season; recommendations may change by next season. Keep records of previous usage to make good estimates of future needs.

Reporting Requirements

Title III of the federal Superfund Amendments and Reauthorization Act of 1986 (SARA) is also called the Emergency Planning and Community Right-to-Know Act. This Act requires, among other things, the reporting of inventories of certain pesticides if the amount stored is greater than a "threshold planning quantity" (see Chapter 9, Pesticide Regulations). It is good policy to inform your local fire department if you store agricultural chemicals (including fertilizers). Chemical fires cannot usually be extinguished by ordinary means, and the smoke from the fire can be extremely hazardous to fire fighters. The fire department must be properly prepared in the event of a chemical fire. For more information on these requirements see the Michigan State University Extension Bulletin E-2173 or contact the MDNR Title III Office at (517) 373-8481.

Dispose of Pesticides Safely

It is the responsibility of the pesticide user to see that pesticide wastes, such as unused chemicals and empty pesticide containers, are disposed of properly. In recent years there has been growing concern that improper disposal of pesticide wastes can create serious hazards for both humans and the environment. Empty pesticide containers are a hazard to curious children and animals. Improperly disposed of pesticides can result in groundwater contamination and plant damage.

It makes good business sense to deal with pesticide wastes properly and safely. Plan carefully and observe the following guidelines:

- Avoid disposal problems associated with excess pesticide by purchasing only the amount needed for one growing season.
- Always read the label for disposal instructions.
- Clothing and protective equipment to be discarded, and contaminated soil or other materials used to clean up spills, should be considered pesticide waste and handled as such.
- Federal and state laws regulate the disposal of containers and other pesticide wastes. Anyone requiring assistance with pesticide disposal should contact the Michigan Department of Natural Resources (MDNR) Waste Management Division at (517) 373-2730.

Cleaning and Disposing of Containers

Triple rinsing allows glass, metal, plastic, and even some heavy paper containers to be considered nonhazardous waste. It also saves money because each rinse captures pesticide residues from the sides and bottom of the container that are included in the spray mix and not wasted.

To triple rinse following these steps:

1. Allow the concentrate to drain from the empty pesticide container for 30 seconds.

2. Fill approximately 10 percent of the container volume with water, replace the lid, and rotate the container so all the interior surfaces are rinsed.

3. Dump the rinsewater into the spray tank, allowing it to drain for at least 30 seconds.

4. Repeat the procedure two more times.

Triple-rinsed containers that will be held for disposal at a later time should be marked to indicate triple rinsing has been done and the date. Pesticide containers that will not be recycled through a recycling facility or the dealer should be rendered unusable by breaking, puncturing, or crushing. **Never reuse pesticide containers.** All containers should be kept in the locked storage area until disposal, and kept away from all possible contact with children and animals.

Disposal of triple-rinsed containers in a sanitary landfill is permissible, but it is a good policy to check with your local solid waste authority prior to discarding pesticide containers there.

Whenever feasible, triple-rinsed containers should be recycled. For information on recycling facilities contact the MDNR Waste Management Division at (517) 373-2730.

Spray Mixes and Rinsewater

Estimate job needs carefully so you will mix only as much pesticide as needed for a particular application. If you do mix too much, it is best to apply the material in the recommended manner to another crop or site listed on the label.

If possible use the rinsewater from your spray tank in a future spray mix. Be extra careful with herbicide-contaminated rinsewater on sensitive plants. Caution must also be exercised with food or feed crops to avoid illegal residues. Never dispose of pesticide-contaminated rinsewater in a manner that will contaminate public or private water sources or sewage treatment facilities.

Farmers who need to dispose of a surplus spray mixture or contaminated rinsewater should do so only in accordance with the label and with the approval of the landowner. A site at least 500 feet from any source of water should be selected. In addition, the disposal site should not have a high water table or lead to a surface water source.

Pesticide Concentrates

The safest means of disposal for pesticide concentrates is to dispose of the product in a manner consistent with its label. If this is not possible, return it to the dealer or manufacturer or offer it to another qualified applicator. If no disposal option is available, then check with the MDNR Waste Management Division at (517) 373-2730. Certain pesticides may be disposed of through a municipal refuse collection service; others may require more stringent and costly disposal procedures.

Commercial applicators should be aware of the current hazardous waste guidelines established under the Resource Conservation and Recovery Act (RCRA) as well as state (Act 64) hazardous waste statutes prior to disposing of pesticide wastes. Pesticide wastes classified as hazardous require special disposal and record keeping practices. MDNR Waste Management Division (517-373-2730), can provide more information on RCRA and your specific disposal responsibilities under the law.

Follow disposal instructions on the label; seek assistance with disposal problems!

Transport Pesticides Safely

Once a pesticide is in your possession, you are responsible for its safe transport. Accidents can occur even when transporting materials a short distance. Do all you can to prevent a transport problem, but be prepared in case an emergency should arise.

Transport Vehicle

The safest way to carry pesticides is in the back of a truck. Flatbed trucks should have side and tail racks. Steel beds are preferable since they can be more easily decontaminated if a spill should occur.

Pesticides should **never** be carried in the passenger compartment of a vehicle. Hazardous fumes may be released; spills may cause injury and be impossible to remove from seats. If pesticides are transported in a station wagon, windows should be open and no one should be permitted to ride near the pesticides. **Never** carry pesticides in the same compartment as fertilizers, seed, food or feed; the risk of contamination is too high should a spill occur. Herbicides in particular should be separated from fertilizers and other pesticides.

Pesticide Containers

Inspect containers before loading to be sure all caps and plugs are tightly closed and legible labels are attached. Handle containers carefully when loading to avoid rips or punctures. Be sure the outside of the containers are not contaminated with pesticide.

Secure containers to safeguard against spills or leaks which may result if the containers roll or slide. Packing or shipping containers provide extra protection. All containers should be protected from moisture that would saturate paper and cardboard packages or rust metal. Clean the vehicle thoroughly after unloading.

Protect pesticides from temperature extremes during transport. In hot weather, for instance, the temperature inside the trunk of a car is always considerably higher than outside.

Never leave your vehicle unattended when transporting pesticides in an unlocked trunk compartment or open-bed truck. You are legally responsible if curious children or careless adults are accidentally poisoned from pesticides left unattended and exposed in your vehicle. Whenever possible, transport pesticides in a locked compartment.

Never eat, drink, or smoke when handling pesticides, even if containers are intact and tightly sealed; wash your hands thoroughly when you finish.

Pesticide Fire Safety

Pesticide products vary significantly in their flammability and storage hazard. Those requiring extra precautions bear the label statement **"Do not use or store near heat or open flame."** Pesticides containing oils or petroleum solvents are the ones most likely to have these warnings, although certain dry formulations also present fire and explosion hazards.

To reduce fire hazards:

- Locate storage areas as far as possible from where people and animals live.
- Keep storage area locked at all times.
- Post signs that indicate combustible materials are stored in the facility.
- Store combustible materials away from steam lines and other heating systems.
- Do not store glass containers in sunlight where they can concentrate heat rays and possibly explode or ignite.
- Install fire detection systems in large storage areas.
- Keep a fire extinguisher approved for chemical fires in all storage areas.
- Notify the servicing fire company as to the location and contents of the storage area. It may save their lives and the lives of others should there be a fire.

In the Event of a Pesticide Fire:

- Clear all personnel from the area to a safe distance upwind from the smoke and fumes.
- Call the fire department and inform the fire fighters of the nature of the pesticides involved. Material Safety Data Sheets (MSDS) which provide technical and emergency information are available from chemical dealers.
- Fire fighting personnel must bring and wear the proper protective clothing and equipment (especially respirators). Assume all protective

gear worn at the fire scene is contaminated and hazardous until it is washed.

- Be aware of the potential for explosion of overheated pesticide containers. Nearby containers should be moved or kept cool.
- The principal objective is to contain the fire and prevent contamination of surrounding areas. Use only as much water as is absolutely necessary. Heavy hose streams should be avoided, and any necessary dikes should be built to prevent flow of contaminated runoff into lakes, ponds, streams, wells, or sewers.

REVIEW QUESTIONS – CHAPTER 6

Write the answers to the following questions. When you are satisfied with your answers, see if they are correct by checking them with the chapter text.

1. One safe way to open a bag containing pesticides would be to tear it open. (True or False)

2. The recommended water pH for mixing most pesticides is between _____ and _____.

3. List some of the desirable characteristics of a pesticide storage area?

_____

_____

4. Pesticides should be stored:
   a. in any convenient container
   b. only in their original containers
   c. in containers too heavy for children to handle
   d. in any container as long as it is tagged with the name of contents
   e. none of the above

5. Liquid formulations and small containers of dry formulations should be stored on metal shelving since metal will not absorb spilled pesticides and is easier to clean than other surfaces. (True or False)

6. Treated seed should be treated with the same care as the pesticide itself and should be stored in a locked storage facility. (True or False).

7. Chemical fires can usually be extinguished by ordinary means and therefore it is not necessary that you inform your local fire department that you store agricultural chemicals. (True or False)

8. What is the best way to dispose of a registered pesticide?

_____

_____

9. How do you triple rinse a container?

_____

_____

10. Who do you contact for assistance with disposal problems?

_____

11. Should a poisoning incident occur from a pesticide you are transporting, you will not be liable. (True or False)

12. What is the safest way to transport pesticides?

_____

_____

13. You are legally responsible if a curious child or adult is accidentally poisoned from pesticides left unattended and exposed in your vehicle. (True or False)

14. What types of pesticides are most likely to be flammable and have the following statement on their label: **"Do not use or store near heat or open flame?"**

_____

_____

15. List three precautions you could take to prevent fire hazards.

_____

_____

_____

16. What should you do first in the event of a pesticide fire?

_____

17. List some of the clues that show a pesticide has deteriorated.

_____

_____

_____

18. Why should you keep an inventory of pesticides and mark purchase dates on the containers?

_____

CHAPTER 7

THE PESTICIDE LABEL

One of the more important tools for safe and effective use of pesticides is the product label. Pesticide manufacturers are required by law to put certain information on the label, information which when not followed can result in a pesticide accident and legal action against the violator. Labels are legal documents providing directions on how to mix, apply, store, and dispose of a pesticide product. This chapter will teach you how to read and apply the information on pesticide labels.

Parts of the Label

Some labels are very easy to understand; others are complicated. It is the user's responsibility to read and understand the label before buying, using, storing, or disposing of a pesticide. To help you better understand labels, each of the label components will be discussed in this section. The numbers preceding the descriptions correspond to the numbered parts of the sample label at the end of this chapter.

1. Trade, Brand or Product Names

Every manufacturer has trade names for its products. Most companies register each trade name as a trade mark and will not allow any other company to use that name without permission. Different trade names are used by different manufacturers, even though the products contain the same active ingredient. The brand or trade name shows up plainly on the front panel of the label and is the one used in advertisements and by company salespersons.

The brand name often indicates the type of formulation and the percent active ingredient. For example, Sevin 50WP is a brand name; Sevin is the registered trade name and the formulation is a wettable powder containing 50 percent active ingredient.

2. Ingredient Statement

Every pesticide label must list every active ingredient and the percentage of it in the container. Inert ingredients are not usually named, but the label must show what percentage of the total contents they comprise. The ingredient statement must list the official chemical and common names of the active ingredients. Let's discuss an example:

Sevin 50WP
Active ingredient:
carbaryl (1-naphthyl N-methyl carbamate) ... 50%
inert ingredients 50%

The **Chemical Name** is the complex name that identifies the chemical components and structure of the pesticide. This name must be listed in the ingredient statement on the label. For example, the chemical name of Sevin is 1-naphthyl N-methyl carbamate.

Because chemical names are usually complex, many are given a shorter **Common Name.** Only those common names officially accepted by the EPA may be used in the ingredient statement on the pesticide label. The official common name is usually followed by the chemical name in the list of active ingredients. The common name for Sevin is carbaryl. By purchasing pesticides according to the common or chemical names, you will be certain of getting the right active ingredient, no matter what the brand name or formulation.

3. Use Classification Statement

Every pesticide product is classified by the EPA as either restricted use or unclassified/general use. Every pesticide product classified restricted use must carry this statement in a prominent place at the top of the front panel of the pesticide label:

RESTRICTED USE PESTICIDE
For retail sale to and use only by certified applicator or persons under their direct supervision and only for those uses covered by the certified applicator's certification.

4. Type of Pesticide

The type of pesticide is usually listed on the front panel of the pesticide label. This short statement indicates in general terms what the product will control. Examples:

• **insecticide** for control of certain insects on fruits, nuts and ornamentals

• **herbicide** for control of woody brush and weeds

• **fungicide** for control of plant and animal pathogens

5. Net Contents

The front panel of the pesticide label shows how much product is in the container. This is expressed as pounds or ounces for dry formulations or as gallons, quarts, or pint for liquids. Liquid formulations may also list the pounds of active ingredient per gallon of product.

6. Name and Address of Manufacturer

The law requires that the manufacturer or formulator of a product put the name and address of the company on the label. This tells you who made or sold the product.

7. Registration Numbers

An EPA registration number (e.g., EPA Reg. No. 999-000) must appear on all pesticide labels. This indicates that the pesticide product has been registered and its label approved by the EPA. In cases of special local needs, pesticide products may be approved for use in a specific state. These registrations are designated, for example, as EPA SLN No. MI-860009. In this case, SLN indicates "special local need" and MI means that the product is registered for use in Michigan.

8. Establishment Numbers

An EPA establishment number (for example, EPA Est: No. 000) must also appear on the pesticide label. It identifies the facility that produced the product in case a problem arises or the product is found to have been adulterated in any way.

9. Signal Words and Symbols

Every pesticide label must include a signal word. This important designation gives the user an indication of the relative toxicity of the product to humans and animals.

The signal word must appear in large letters on the front panel of the pesticide label along with the statement, **"Keep Out of Reach of Children."** The following signal words may be found on pesticide labels.

• **DANGER-POISON, SKULL AND CROSSBONES** — These words and symbol must appear (in red letters) on all products that are highly toxic by any route of entry into the body. *Peligro*, the Spanish word for danger, must also appear on the label.

• **DANGER** — Products with this signal word can cause severe eye damage or skin irritation.

• **WARNING** — This word signals that the product is moderately toxic orally, dermally, or through inhalation, or causes moderate eye or skin irritation. *Aviso*, the Spanish word for warning, must also appear on the label.

• **CAUTION** — This word signals that the product is slightly toxic orally, dermally, or through inhalation or causes slight eye or skin irritation.

TOXICITY	**HIGH** May Cause Death! See a physician immediately.	**MODERATE** Possible Serious Illness See a physician if symptoms persist.	**LOW or SLIGHT** May Cause Illness See a physician if symptoms persist.
INDICATION ON LABEL	**DANGER POISON** 	**WARNING**	**CAUTION**

The words DANGER and POISON, WARNING, or CAUTION indicate the toxicity level.

Choose the least toxic chemical that will give the desired level of pest control. Chapter 5, "Pesticides and Human Health," further describes signal words.

10. Precautionary Statements

All pesticide labels contain additional statements to help applicators decide the precautions to take to protect themselves, their employees, and other persons (or animals) that could be exposed. Sometimes these statements are listed under the heading, **"Hazards to Humans and Domestic Animals."** They may be composed of several sections.

Routes of Entry Statements - The statements which immediately follow the signal word, either on the front or side panels of the pesticide label, indicate which route or routes of entry (mouth, skin, lungs) are particularly hazardous and need protection. Many pesticide products are hazardous by more than one route, so study these statements carefully. A **DANGER** signal word followed by **"May be fatal if swallowed or inhaled"** gives you a far different warning than, **DANGER** followed by **"Corrosive — Causes eye damage and severe skin burns."**

Specific Action Statements - These statements usually follow immediately after the route of entry statements. The specific action statements help prevent pesticide poisoning by recommending necessary precautions and protective clothing and equipment. These statements are directly related to the toxicity of the pesticide product (signal word) and the routes of entry.

Protective Clothing and Equipment Statements - Pesticide labels vary in the type of protective clothing and equipment statements they contain. Many labels carry no statement at all. The best way to determine the correct type of protective clothing and equipment is to consider the signal word, the route of entry statements, and the specific action statements on the label.

11. Statement of Practical Treatment

This section lists first aid treatments recommended in case of poisoning.

All **DANGER** labels and some **WARNING** and **CAUTION** labels contain a note to physicians describing the appropriate medical procedure for poisoning emergencies and may identify an antidote. **The label should always be available for emergencies. In the event of a pesticide poisoning, take the label to the hospital with you.**

12. Environmental Hazards

Pesticides can be harmful to the environment. Some products are classified restricted use because of environmental hazards alone. Watch for special warning statements on the label concerning hazards to the environment.

Special Toxicity Statements - If a particular pesticide is especially hazardous to wildlife, it will be stated on the label. For example: "This product is highly toxic to bees," or "This product is toxic to fish."

These statements alert pesticide users to the special hazards posed by use of the product. They should help applicators choose the safest product for a particular job and remind them to take extra precautions.

General Environmental Statements - Some of these statements appear on virtually every pesticide label. They are reminders to follow certain common sense actions to avoid contaminating the environment. The absence of any or all of these statements does not indicate that you do not need to take adequate precautions. Sometimes these statements follow a **"specific toxicity statement"** and provide practical steps to avoid harm to wildlife. Examples of general environmental statements include: "Do not apply when runoff is likely to occur," and "Do not apply when weather conditions favor drift."

Physical or Chemical Hazards

This section of the label describes any special fire, explosion, or chemical hazards the product may pose. For example: **"Flammable** - Do not use, pour, spill, or store near heat or open flame. Do not cut or weld container."

Hazard statements (hazards to humans and domestic animals, environmental hazards, and physical or chemical hazards) are not located in the same place on all pesticide labels. Some labels group them under the headings listed above. Other labels may list them on the front panel beneath the signal word. Still other labels list the hazards in paragraph form somewhere else on the label under headings such as "Note" or "Important." Prior to use, the label should be examined for these statements to ensure knowledgeable and safe handling.

13. Reentry Statement

Some pesticide labels contain a reentry interval precaution. This statement tells how much time must pass before people can reenter a

treated area without appropriate protective clothing and equipment. Reentry intervals are set by both the EPA and some states. Reentry intervals set by states are not always listed on the label; it is your responsibility to determine if one has been set. Contact your state pesticide regulatory agency (MDA) to determine whether any state reentry intervals have been established for the pesticide you intend to use. It is illegal to ignore reentry intervals.

The reentry statement may be printed in a box under the heading **"Reentry"** or it may be in a section with a title such as **"Important,"** or **"Note,"** or **"General Information."**

If no reentry statement appears on the label or none has been set by your state, then all unprotected workers must wait at least until sprays have dried or dusts have settled before reentering without protective equipment. That is the minimum legal reentry interval.

Read the label!

Directions for Use

These instructions are the best way to find out how to apply the product. The use instructions will tell you:

- the crop, animal, or site the product is intended to protect
- the proper equipment to be used and mixing instructions
- how much to use (rate) and how often to apply
- compatibility with other often used products
- phytotoxicity and other possible injury
- where and when the material should be applied

Labels for agricultural pesticides often list the minimum number of days which must pass between the last pesticide application and the harvest of crops, or the slaughter or grazing of livestock. These **Preharvest Intervals** (days to harvest) or **Preslaughter Intervals** are set by EPA to allow time for the pesticide to break down on or in the crop or in the meat of livestock. Adhering to these intervals prevents the poisoning of grazing animals and prevents residues greater than the tolerance on food, feed, or animal products.

Failure to follow the instructions on a pesticide label can result in a serious pesticide accident and constitutes a legal violation subject to civil or criminal prosecution. Remember, the label is a legal document. The user is liable for personal injury, crop damage, or pollution incurred through misuses of a pesticide.

New Regulations

By law, the pesticide label must contain information on how the applicator must comply with the following regulations if the pesticide falls under the stipulation of the particular regulation:

SARA Title III Law

Endangered Species Act

Worker Protection Standards

For specific information on each of these regulations, see Chapter 9, "Pesticide Regulations."

Additional Pesticide Information - MSDS

In addition to pesticide labels, information about a particular pesticide is printed on a Material Safety Data Sheet (MSDS). These forms include information about the pesticide such as medical conditions that it may aggravate, whether it is carcinogenic, and what are its primary routes of entry. MSDS are available from chemical dealers and are dated to help you identify that the information is current.

③ **RESTRICTED USE PESTICIDE**
For retail sale to and use only by Certified Applicators, or persons under their direct supervision, and only for those uses covered by the Certified Applicator's certification.

CHEMCO ① NO PEST INSECTICIDE④

Reg. U.S. Pat. & TM Off.

ACTIVE INGREDIENT:	BY WEIGHT
② deltathion (1,2 phospho-(5)-4 chloromethane).....	50%
INERT INGREDIENTS.....	50%
TOTAL	100%

⑦ EPA Reg. No. 999-000 ⑧ EPA Est. No. 000

⑩ **HAZARDS TO HUMANS AND DOMESTIC ANIMALS**

Wear long-sleeved clothing, full length trousers, eye protection, and protective gloves when handling. Wash hands and face before eating or using tobacco. Bathe at the end of work day, washing entire body and hair with soap and water. Change clothing daily. Wash contaminated clothing thoroughly before reusing.

⑪ **STATEMENT OF PRACTICAL TREATMENT**

If Swallowed: Do not induce vomiting. Contains aromatic petroleum solvent. Call a physician or poison control center immediately. **If In Eyes:** Flush with plenty of water for at least 15 minutes. Get medical attention. **If On Skin:** Wash with plenty of soap and water. Get medical attention if irritation persists. **If Inhaled:** Remove to fresh air immediately. Get medical attention.

NOTE TO PHYSICIAN: "No Pest" is a cholinesterase inhibitor. Treat symptomatically. If exposed, blood cholinesterase tests may indicate significance of exposure (baseline data are useful). Atropine, only by injection, is the preferable antidote. Oximes, such as pralidoxime, protopam, may be therapeutic if used early; however, use only in conjunction with atropine. In case of severe acute poisoning, use antidote immediately after establishing an open airway and respiration.

⑫ **ENVIRONMENTAL HAZARDS**

This pesticide is toxic to birds and extremely toxic to fish. Do not apply directly to water. Do not contaminate water by cleaning of equipment or disposal of waste. This product is highly toxic to bees exposed to direct treatment or residues on blooming crops or weeds. Avoid use when bees are actively foraging.

"No Pest" is a pesticide which can move (seep or travel) through soil and can contaminate groundwater which may be used as drinking water. "No Pest" has been found in groundwater as a result of agricultural use. Users are advised not to apply "No Pest" where the water table (groundwater) is close to the surface and where the soils are very permeable (i.e., well drained soils such as loamy sands). Your local agricultural agencies can provide further information on the type of soil in your area and the location of groundwater.

⑬ **REENTRY STATEMENTS**
Do not apply this product in such a manner as to directly or through drift expose workers or other persons. The area being treated must be vacated by unprotected persons.

Do not enter treated areas without protective clothing until sprays have dried.

Written or oral warnings must be given to workers who are expected to be in a treated area or in an area about to be treated with this product. When oral warnings are given, warnings shall be given in a language customarily understood by workers. Oral warnings must be given if there is reason to believe that written warnings cannot be understood by workers. Written warnings must include the following information: "WARNING! Area treated with "No Pest" insecticide on (date of application). Do not enter without appropriate protective clothing until sprays have dried. If accidental exposure occurs, follow the instructions below." (Written warnings must include the STATEMENT OF PRACTICAL TREATMENT given at the beginning of this label).

PESTICIDE DISPOSAL

STORAGE: Store in original container only. Keep container closed when not in use. Store "No Pest" in a well ventilated clean dry area out of reach of children and animals. Do not store in areas where temperature averages 115°F (46°C) or greater. Do not store in or around the home or home garden. Do not store near food or feed. In case of spill or leak on floor or paved surfaces, soak up with sand, earth or synthetic absorbent. Remove to chemical waste area.

PESTICIDE DISPOSAL: Pesticide wastes are toxic. Improper disposal of excess pesticide, spray mixture or rinsate is a violation of federal law. If these wastes cannot be disposed of by use according to label instructions, contact your State Pesticide or Environmental Control Agency or the Hazardous Waste Representative at the nearest EPA Regional Office for guidance.

CONTAINER DISPOSAL: Metal Containers: Triple rinse (or equivalent). Then offer for recycling or reconditioning or puncture and dispose of in a sanitary landfill, or by other procedures approved by state and local authorities. **Plastic Containers:** Triple rinse (or equivalent). Then offer for recycling or reconditioning, or puncture and dispose of in a sanitary landfill, or incineration, or, if allowed by state and local authorities, by open burning. If burned, stay out of smoke. Glass Containers: Triple rinse (or equivalent). Then dispose of in a sanitary landfill or by other approved state and local procedures.

KEEP OUT OF REACH OF CHILDREN

⑨  **DANGER POISON** 

PELIGRO

⑥ CHEMCO CHEMICAL COMPANY, East Lansing, MI 48823 ⑤ Net Contents - 1 gallon

REVIEW QUESTIONS – CHAPTER 7

Write the answers to the following questions. When you are satisfied with your answers, see if they are correct by checking them with the chapter text.

1. Labels are legal documents. (True or False)

2. Regardless of the signal words they bear, all pesticide labels must carry the words, **"Keep Out of Reach of Children."** (True or False)

3. The skull and crossbones symbol must appear on every pesticide label. (True or False)

4. Which signal word(s) on a pesticide label would indicate that the product is highly toxic to humans?
   a. "WARNING"
   b. "CAUTION"
   c. "Keep Out of Reach of Children"
   d. "DANGER-POISON"
   e. "POISON"

5. Labels should be removed from pesticide containers and kept in a notebook so they remain clean and legible. (True or False)

6. A certain active ingredient has only one technical chemical name and one accepted common chemical name, but may be in products with several different trade/brand names. (True or False)

7. What are Material Data Safety Sheets and where can you obtain them?

_____

_____

To answer questions 8 through 14, refer to the segment of the No Pest sample label found on the previous page.

8. Should a face shield or goggles be worn when handling No Pest? (Yes or No)

9. If a person filling a spray tank accidently swallows several mouthfuls of No Pest concentrate, should they be immediately administered syrup of ipecac to induce vomiting? (Yes or No)

10. Regardless of the container material (glass, metal, or plastic), all empty No Pest containers should be:
   a. burned
   b. punctured
   c. reused
   d. triple rinsed
   e. saved

11. Containers of No Pest can be kept in the home as long as the storage area is locked. (True or False)

12. Could use of this product present a hazard to any wildlife or other nontarget animals? (Yes or No). List three groups of animals of particular concern: _____, _____ and _____.

13. Should No Pest be applied to a permeable soil with a water table close to the surface? (Yes or No)

14. No person should be allowed to enter an area still wet from a treatment with No Pest unless they are provided with _____.

15. If warning signs are to be posted in a No Pest treatment area, the name of the pesticide is all that is required to be written on the sign. (True or False)

CHAPTER 8

PESTICIDE APPLICATION EQUIPMENT

Now that you have identified the pest, selected the proper pesticide, safely transported and stored the chemical, you are ready to have the chemical go to work for you. This chapter covers how to select the proper equipment and how to precisely apply the pesticide. Applying chemicals properly saves money and protects the environment.

Pesticides may be applied as sprays, dusts, granules, gases (vapors), fogs, baits, rubs or dips. The vast array of available equipment must be matched to the pesticide material as well as the size and type of job. To make an effective, safe and efficient application, the equipment must be properly selected, operated, calibrated and maintained.

Choosing appropriate application equipment and operating and maintaining it properly is as important to effective pest control as selecting the pesticide. The substantial investment involved requires that the choice be based on a thorough familiarity with all alternatives, including the most recent developments in application technology. Many problems of current concern (e.g., drift, nonuniform coverage, failure of a pesticide to effectively reach the target organism, selective control) are at least partially solvable through newly developed application techniques and equipment. When you choose application equipment, be sure that it is well adapted for your purposes, cost effective, has maximum efficiency, and will apply materials in an environmentally sound manner.

Methods of Application

Before discussing specific types of application equipment, we need to briefly review the various ways to apply pesticides. The particular method of application chosen depends on the nature and habits of the target pest, the plant, the pesticide, available application equipment, and the relative cost and efficiency of alternative methods. The application method is often predetermined by one or more of these factors, although there is frequently a choice between two or more methods. Always bear in mind that your principal objective is to effectively bring the pesticide into contact with the target organism(s).

Common methods of applying pesticides are outlined here:

1. **Foliar applications** apply pesticide to the aerial portions of either a plant or weed.

2. **Soil applications** apply pesticide directly to the soil rather than to a growing plant or weed.

3. **Seed treatment** covers seed with an insecticide or fungicide (or both) prior to planting.

4. **Broadcast applications** uniformly apply pesticide to an entire area. They are made either prior to or after emergence of the crop.

5. **Band applications** place a pesticide in or beside a crop row rather than over the entire field area (see broadcast application).

6. **Furrow applications** place an insecticide or a fungicide in a narrow line in the soil directly over the seed at planting time. Always read the label to be certain that a furrow application is permissible — some insecticides, in particular, are toxic to seeds.

7. **Split-boot applications** place a mixture of liquid insecticide and liquid starter fertilizer in the soil to the side of the seed at planting time. The mixture should be applied at least one inch on either side of the seed and at the same depth.

8. **Spot treatments** apply pesticide to small, discrete areas.

9. **Directed-spray applications** direct a herbicide specifically at target weeds to minimize contact with the plant.

10. **Soil incorporation** uses planting or cultivating equipment to mix the pesticide with the soil.

11. **Soil injection** applies a pesticide beneath the soil surface. This is a common application method for fumigants and termiticides.

Application Equipment

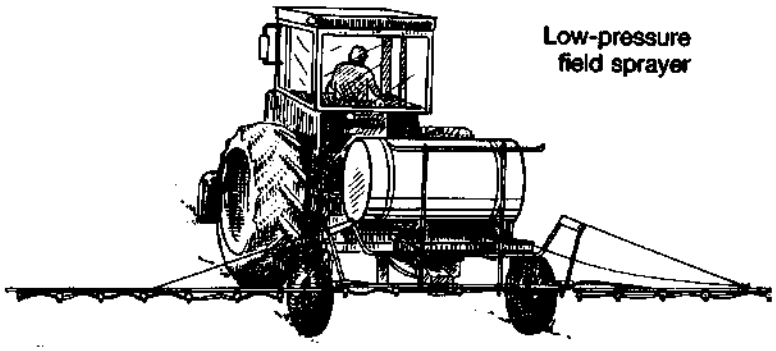
We use a variety of equipment in an attempt to place the pesticide on the target in a uniform pat-

tern, and offer safety to nontarget plants, animals and people. Common equipment is described here.

Types of Sprayers

1. **Hand Sprayers.** Hand sprayers are for applying pesticides in structures such as greenhouses and can be used for small jobs such as spot treatments. You can use them in restricted areas where a power unit would not work. Keep wettable powders in suspension by shaking the sprayer.

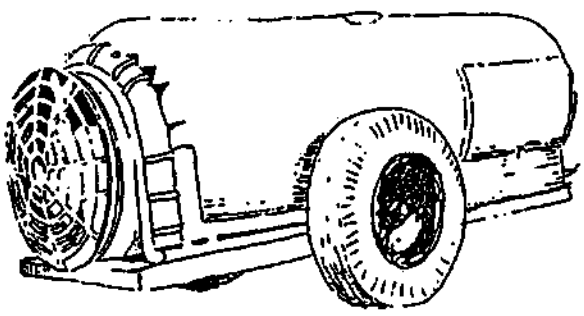
2. **Low-Pressure Field Sprayers.** These sprayers are designed to deliver low to moderate volume at 15 to 50 psi. Most of them are used for treating field and forage crops, pastures, fence rows and structures. They also may be used to apply fertilizer-pesticide mixtures and may be mounted on tractors, trailers, trucks and aircraft.



Low-pressure field sprayer

3. **High-Pressure (or Hydraulic) Sprayers.** This type of sprayer delivers large volumes at high pressure, up to 1,000 psi. It is used to spray fruits, vegetables, trees, landscape plants, and livestock. When fitted with the correct pressure regulators, high-pressure sprayers can be used at low pressures. Applications usually are made at high rates (usually 50 or more gallons per acre). They have good spray coverage and penetration but may drift easily due to the high pressure.

4. **Air Blast Sprayers.** These units use a high-speed, fan-driven air stream to break the nozzle output into fine drops which move with the air stream to the target. The air is directed to either one or both sides as the sprayer moves forward. These sprayers are used to apply pesticides to landscape plants, fruits and vegetables, and for insect control. Most air blast sprayers can be adapted to apply either high or low volumes of spray. Since air speeds exceed 100 mph, drift becomes a major concern and it is hard to confine the spray to a limited target area.



Air blast sprayer

5. **Air Curtain Sprayers.** This is a new technology for fruits and vegetables using controlled droplet applicator nozzles (CDA) mounted on a boom. It uses low volumes of pesticides applied in a curtain of air to the target area.

6. **Ultra-Low-Volume (ULV) Sprayers.** These sprayers deliver undiluted pesticides using aerial equipment, ground sprayers or portable units for indoor application. Since water is not added, there is danger of over application.

Rope Wick Applicators

This type of application uses a long horizontal tube filled with a liquid systemic herbicide. Wicks or a wetting pad is then attached to the outside and as the unit moves through the field, the herbicide is applied to only the weeds that brush against it. It is effective for eliminating weeds growing taller than the crop.

Granular Applicators and Dusters

1. **Granular Applicators.** These include: (a) hand-carried knapsack and spinning disk types for broadcast coverage, (b) mounted equipment for applying bands over the row in row crops and vegetables, and (c) mounted or tractor-drawn machines for broadcast coverage. Granular applicators minimize pesticide drift and eliminate mixing of chemicals, but high cost and limited use are major concerns.

2. **Dusters.** These include hand carried, squeeze bulbs, bellows or a fan powered by a hand crank. Power dusters use a powered fan or blower to propel the dust to the target. They range from knapsack or backpack types to those mounted on or pulled by tractors. Their capacity in area treated per hour compares favorably with sprayers. Drift is a major concern when using dusts outside.

Fumigant Applicators

There are three types of fumigant applicators.

1. **Smokes.** This simple method of applying pesticides is used in greenhouses and enclosed rooms. Containers are ignited and the pesticide is carried in the smoke. Place warning signs on all doors when fumigating.

2. **Low Pressure.** The low-pressure fumigators are gravity or pump fed units.

3. **High Pressure.** Most high-pressure units are pressure generated by the fumigant or a compressed gas to force the fumigant into the soil or space being fumigated.

Aerosol Generators and Foggers

Aerosol generators work by using: atomizing nozzles, spinning disks, or small nozzles at high pressure. Fogs are usually generated by thermal generators using heated surfaces. Truck- and trailer-mounted machines are for outdoor use. Most hand-operated or permanently mounted automatic machines are for indoor use.

Use and care for an aerosol generator is similar to a sprayer. Be sure that the pesticides are registered for use in generators and foggers.

Basic Components of Sprayers

Like a hydraulic system, a sprayer has four basic components:

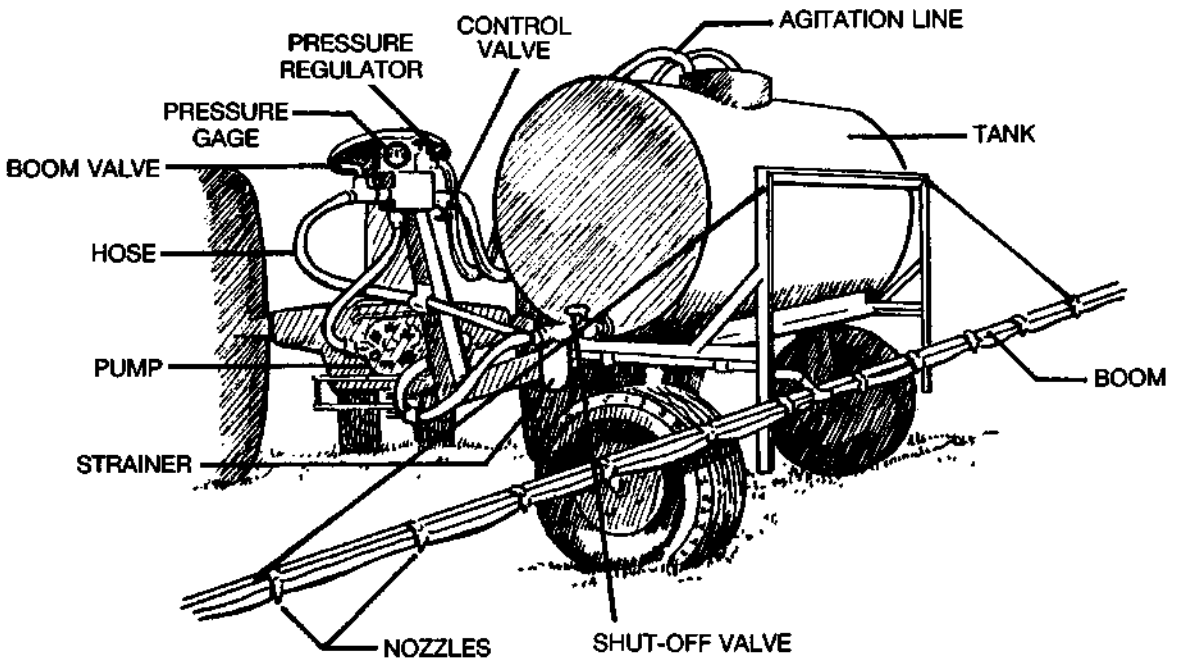
1. Tank - to hold fluid
2. Pump - to move the fluid
3. Valving - to deliver the fluid
4. Output - a cylinder for hydraulics, a nozzle for a sprayer

Beyond the four basic components of a sprayer, the following items make the sprayer more efficient. We will only discuss some common components.

Tanks

Tanks should have large openings for easy filling and cleaning. They should allow for straining during filling and have mechanical or hydraulic agitation. Square tanks and ones with flat bottoms make agitation and cleaning more difficult. The tank should be made of corrosion-resistant material such as stainless steel or glass-reinforced plastic. If made of mild steel, it should have a protective plastic lining or coating. Tanks

Sprayer Components



should have a drain at the lowest part and outlets should be sized to the pump capacity. If you use dual tanks, make sure the plumbing allows for agitation and adequate withdrawal rates in both tanks. Tanks should have a gauge to show the liquid level visible from the operator's position.

Flush out the tank, pump, lines and nozzles after each day's use and each separate pesticide use. If switching to another pesticide where contamination must be prevented, wash out with detergent and water two or three times and then flush with water. Phenoxy herbicides such as 2,4-D are difficult to remove. After using them, follow the special cleaning procedures noted on the pesticide label. Keep the tank clean inside and out. Tighten or repair all leaky tank seals and fittings. Make sure sight gauges can be read.

Pumps

The pump is the heart of the spraying system and must deliver adequate flow at needed pressure. Pumps should resist corrosion and abrasion. The most common pumps for agricultural applications are centrifugal, roller and piston.

Control Valves

The control valve is a quick-acting, positive shut-off. Control valves should be large enough so as not to restrict flow and should be easy to reach. On-off action should be quick and positive and be able to cut off all flow or flow to any section of the spraying system. There may be a central control valve and also individual boom valves.

Booms

The boom is either a steel pipe with nozzles or a steel bar for supporting hoses that have nozzles.

Nozzles

Nozzles are the most critical part of the sprayer. The nozzle controls the rate and pattern of distribution. Specifically, the rate and pattern of distribution depend on:

- the nozzle design or type,
- its operating pressure,
- the size of the opening,
- its discharge angle, and
- its distance from the target.

There are seven basic nozzle types, all other patterns are variations of these seven:

1. **Solid stream** - used in hand guns to spray a distant target. It is also used in a nozzle body to apply pesticides in a narrow band or inject them into the soil. The solid stream nozzle combined with a disc is used in air blast sprayers.

2. **Flat fan** - there are three types of flat fan nozzles:

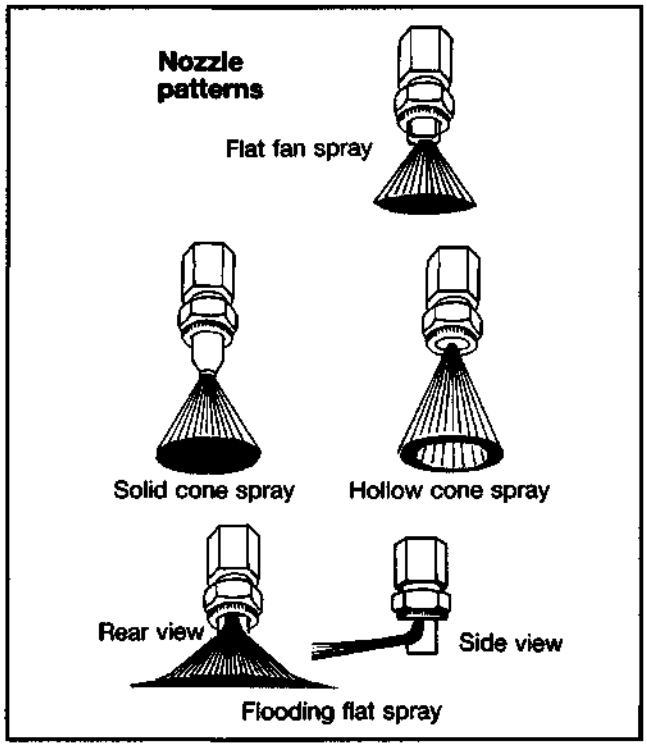
   - The *regular flat fan nozzle* makes a narrow oval pattern with lighter edges. It is used for broadcast spraying. This pattern is designed to be used on a boom and to be overlapped 30-50 percent for even distribution.

   - The *even flat fan nozzle* makes a uniform pattern across its width. It is used for band spraying and for treating walls and other surfaces.

   - The *flooding nozzle* makes a wide-angle flat spray pattern. It works at lower pressures than the other flat fan nozzles. Its pattern is fairly uniform across its width. It is used for broadcast spraying.

3. **Hollow cone** - there are two types of hollow cone nozzles: the core and disc, and the whirl chamber. The hollow cone pattern is circular with tapered edges and little or no spray in the center. It is used for spraying foliage and produces a fine droplet size.

4. **Solid cone** - nozzle produces a circular pattern. The spray is well distributed throughout the pattern with larger droplet size than the hollow cone produces.



5. **Atomizing** - nozzle makes a fine mist. It is used indoors in the greenhouse industry, fumigation and livestock buildings.

6. **Broadcast** - nozzle forms a wide flat fan pattern. It is used on boomless sprayers and to extend the effective swath width when attached to the end of the boom.

7. **Rotary** - also called controlled droplet applicator (CDA), forms droplets of uniform size. Liquid enters the center of the spinning cup, and like the centrifugal pump it forces the liquid up grooves on the inside of the cup. When droplets are heavy enough, they fly off the edge of the spinning cup. Varying the speed of the cup produces droplets of different sizes. Fast speed produces small droplets, slow speed produces large droplets.

Operation and Maintenance

Always read and follow the operator's manuals for your spray equipment. Check for leaks in lines, valves, seals and in the tank after filling with water and during calibration.

Be alert for nozzle clogging and changes in nozzle patterns. If nozzles clog or other trouble occurs in the field, be careful not to contaminate yourself while correcting the problem. Wear protective clothing while making repairs.

Store sprayers correctly after use. Clean all parts thoroughly. Drain the pump and plug its openings or fill the pump with light oil or antifreeze. Follow the manufacturers guide for storage.

Specifics on **calibration techniques** for commercial applicators are included in the commercial pesticide applicators category manuals available from the Michigan State University Cooperative Extension Service. For more information, contact the Pesticide Education Office at (517) 355-0117. Private applicators should study Appendix A - Calibration Procedures at the end of this chapter.

Avoiding Drift

Pesticide drift has been identified by both the chemical industry and the Environmental Protection Agency as one of the principal concerns facing agriculture. Where significant drift occurs, it can damage sensitive plants, pose health hazards, contaminate soil and water in adjacent areas, and cause considerable friction among neighbors. Although it is impossible to eliminate drift entirely, it can be reduced to acceptable levels.

Drift can be defined simply as the movement of pesticides through the air to nontarget areas, and may occur either as solid or liquid particles or as vapors.

Drift Occurrence

Particle drift - At the time of application, small spray droplets may be carried by air movement from the application site to other areas. The distance a particle of pesticide spray can drift is determined by one or more factors: a) the speed of an existing crosswind; b) the distance from the spray nozzle to the ground: and c) the size of the particle itself. Normally, only areas in the immediate vicinity of the application site are affected by particle drift.

Vapor drift - Vapor drift is the movement of a pesticide from the target area as a vapor and result from the tendency of chemicals to volatilize. Where vapor drift occurs, it may affect sensitive areas up to one mile or more from the application site.

Aerial Applications and Drift

Aerial applications are particularly susceptible to drift since the materials are released from greater heights and a greater percentage of smaller droplets are formed than with ground equipment. Factors that influence drift include particle size, specific gravity, evaporation rate, height of release, air movements, weather conditions, and the aerodynamic forces created by the aircraft.

Oil-spray Droplets and Drift

Oil-spray droplets tend to drift farther than water-spray droplets because they are usually lighter and smaller and thus remain airborne for a longer period. Using the same hydraulic nozzles and the same spraying pressure, smaller droplet sizes are produced with oils than with water. In addition, the rate of evaporation of water-base sprays is higher than that of oil-base sprays for equal-size droplets unless anti-evaporant materials are added to the formulation.

Impact of Weather Conditions

Weather conditions directly affect the direction, amount, and distance of drift. **Avoid applications when the wind is blowing toward sus-**

ceptible plants or sensitive areas or when wind speed is in excess of limits stated on the product label. You may have to cease operations until conditions change. Consult weather forecasts whenever possible. One danger is that unpredictable changes in air movement may occur and carry the drift in an unexpected direction.

During early morning and late evening, the difference in the air temperature at ground level and at some distance above ground is considerably less than during the middle of the day. As the ground warms up, the air temperature near the ground becomes significantly higher than the air above it. This warmer air rises and may set up convection and thermal air currents which lift small particles; these suspended particles may be carried some distance before they settle out. For this reason, and because wind speeds are frequently lower, it is often better to apply pesticides either in the early morning or in the evening.

Drift Control

The following measures help prevent or lessen drift:

- Use the lowest reasonable pressure.
- Set the boom only as high as is needed for good coverage.
- Leave an untreated border around the field.
- Angle nozzles of ground sprayers slightly forward toward the ground in the direction of travel.
- Where practical, use a nozzle type which produces the largest droplets at a given rate and pressure.
- Use nozzles with the largest openings possible for the rate and pressure required.
- Use nonvolatile or low-volatile formulations whenever possible.
- Spray when wind speed is low.
- Do not spray aerially during a temperature inversion (when ground air is two to five degrees cooler than the air above).
- Spray when adjacent susceptible vegetation is mature or not present.
- Use a drift control agent.

Drift Control Agents

A number of drift control agents are now available which reduce the potential for drift. These are described here.

Foams. Several foam additives and air-inducing nozzle systems are now available to apply chemicals in low-expansion foam sprays. The large foam particles produced by these systems tend to limit drift. **Caution** must still be exercised, however, since some small particles may be produced and foam particles are much lighter than liquid droplets.

Invert Emulsions. An invert emulsion is a mixture in which water droplets are dispersed in oil. They are normally quite thick and thus less susceptible to drift. Special equipment is usually required for mixing and applying invert emulsions.

Thickeners. Spray additives such as cellulose, gels, and swellable polymers are used to produce large drops up to 5,000 microns.

Any of these agents can be used with either ground or aerial spraying systems. It is important to note that none of the drift control agents totally eliminates the production of small droplets. Even though they may comprise only one or two percent of the total volume sprayed, these droplets still have the potential to cause significant adverse effects.

REVIEW QUESTIONS – CHAPTER 8

Write the answers to the following questions. When you are satisfied with your answers, see if they are correct by checking them with the chapter text.

1. List three common methods of application and explain each one.

1) _____

2) _____

3) _____

2. List three types of pesticide sprayers and describe each one.

1) _____

2) _____

3) _____

3. For what type of application equipment do you fill a long horizontal tube with a liquid systemic herbicide?

4. _____ is a major concern when using dust applicators outside.

5. List three types of fumigant applicators.

1) _____

2) _____

3) _____

6. Fogs are usually produced by _____ generators using heated surfaces.

7. What are the four basic components of sprayers and their purpose?

1) _____

2) _____

3) _____

4) _____

8. The _____ is the heart of the spraying system and must deliver adequate flow at needed pressure.

9. _____ are the most critical part of the sprayer. They control rate and pattern of distribution.

10. List three things that affect the rate delivered at the nozzle and the pattern distribution.

1) _____

2) _____

3) _____

11. List four basic nozzle types and describe each one.

1) _____

2) _____

3) _____

4) _____

12. _____ nozzle is also called controlled droplet applicator (CDA).

13. What should you always read to correctly operate your spray equipment?

14. Define drift.

_____

_____

15. List three types of drift and explain each one.

1) _____

_____

2) _____

_____

3) _____

_____

16. _____ droplets tend to drift farther than _____ droplets because they are usually lighter and smaller and thus remain airborne for a longer period.

17. Weather conditions directly affect the _____, _____, and _____ of drift.

18. When is it often best to apply pesticides and why?

_____

_____

_____

19. List six drift control measures.

1) _____

2) _____

3) _____

4) _____

5) _____

6) _____

20. List three drift control agents and describe each one.

1) _____

2) _____

3) _____

APPENDIX A

CALIBRATION PROCEDURES FOR PRIVATE APPLICATORS

Calibrating Boom Sprayers

The following calibration steps are recommended for boom sprayers.

1. Check to be sure that all nozzles are made by the same manufacturer and have the same part number.

2. Thoroughly clean all screens and nozzles.

3. Fill the sprayer tank with water and check the uniformity of the spray patterns of all the nozzles. Check the volume of delivery of each nozzle by placing identical containers under each nozzle. All containers should fill at the same rate. Replace nozzles that do not have uniform patterns or do not fill at the same rate.

4. Select an operating tractor speed (generally 3 to 5 mph). Note the tachometer reading and gear used.

5. Select an operating pump pressure. Adjust the pressure to the desired psi while the pump(s) are operating at normal speed and water is actually flowing through the nozzles.

6. Measure and record the width of the swath covered by the sprayer.

7. Measure and mark off a course. This should be at least 300 feet or longer. Remember, the accuracy of the test increases as the length of the course increases.

8. Using a stop watch, measure the amount of time it takes the sprayer to cover the course. Be sure the sprayer is moving at the speed selected in Step 4 when it crosses the beginning of the course. Do not start from a dead stop at the beginning of the course.

9. With the sprayer standing still and operating at the selected pump pressure, collect the water from several nozzles for the exact number of seconds determined in Step 8.

10. Pour all of the water collected in Step 9 into a calibration jar or large measuring cup and measure the amount collected. Determine the average output for a single nozzle by dividing the total amount collected by the number of nozzles from which the water was collected in Step 9.

11. Determine the total amount of water sprayed for all nozzles by multiplying the average amount for one nozzle calculated in Step 10 by the total number of nozzles on the boom. This value is an estimate of the total amount of spray delivered over the test course.

12. Convert the amount determined in Step 11 to gallons per acre using the following equation:

gallons per acre = total amount of water sprayed / length of course / width of swath × conversion factor (F)

The conversion factor (F) is used to transform the amount measured in the test to gallons per acre. For this equation the values used for the conversion factor are as follows:

F = 340.3, when the amount determined in Step 10 is in fluid ounces;

F = 5,445, when the amount determined in Step 10 is in pints;

F = 10,890, when the amount determined in Step 10 is in quarts;

F = 43,560, when the amount determined in Step 10 is in gallons;

For example, 35.5 pints of water were applied in a calibration test that covered a course 800 feet long and 20 feet wide. The number of gallons of water or spray delivered per acre is calculated as follows:

35.5 / 800 / 20 × 5,445 = 12.08 gallons per acre

If the estimated amount of spray delivered is too little, it can be increased by one or a combination of the following:

1. Increase pump pressure;

2. Decrease tractor speed;

3. Replace nozzles with nozzles that have a larger orifice.

If the estimated amount of spray delivered is too large, it can be decreased by one or a combination of the following:

1. Decrease pump pressure;

2. Increase tractor speed;

3. Replace nozzles with nozzles that have a smaller orifice.

Be sure to run another calibration test if any of these adjustments are made. Once the sprayer is delivering a satisfactory rate, calculate the number of acres that can be treated by one tankful by the following equation:

treated acres per tank	=	tank capacity (gallons)	/	application rate (gallons/acre)

Using the value of 12.08 gallons per acre determined in the previous example and a sprayer tank size of 400 gallons, the number of acres that can be treated by one tankful is 33.11 acres (400/12.08). To determine the amount of pesticide to be added to the tank to spray 33.11 acres, multiply the number of acres treated with one tankful by the recommended pesticide rate. If the recommended rate of pesticide is 1 quart/acre in the above example, 33.11 quarts or approximately 8.25 gallons of formulated pesticide would be added to the tank.

Calibrating Air Blast Sprayers

Calibrating air blast sprayers is very similar to boom sprayers; the main difference is in how the amount of spray is measured. Since it is very difficult to collect the spray output from an air blast sprayer, the amount sprayed over a given area can be measured as follows:

1. Fill the sprayer completely or to some mark on the inside of the tank with water. Place a marker on the ground next to where the sprayer wheels are sitting so that the sprayer can be returned to this exact same spot.

2. Measure and mark off a test course and measure the width of the swath covered by the air blast spray. The test course should be at least an acre.

3. Spray the test course.

4. Return the sprayer to the place it was filled and measure the amount of water it takes to refill the sprayer to the mark established in Step 1.

5. Convert the amount determined in Step 4 to gallons per acre using the following equation:

gallons per acre	=	total amount of water sprayed	/	length of course	/	width of swath	×	conversion factor (F)

The conversion factor (F) is used to transform the amount measured in the test to gallons per acre. For this equation the values used for the conversion factor are as follows:

F = 340.3, when the amount determined in Step 4 is in fluid ounces;

F = 5,445, when the amount determined in Step 4 is in pints;

F = 10,890, when the amount determined in Step 4 is in quarts;

F = 43,560, when the amount determined in Step 4 is in gallons;

For example, 50 gallons of water were applied in a calibration test that covered a course 800 feet long and 30 feet wide. The gallons delivered per acre is 90.75 gallons (50/800/30 × 43,560).

6. Calculate the number of acres that can be treated by one tankful by the following equation:

acres treated per tank	=	tank capacity (gallons)	/	application rate (gallons/acre)

Using the value of 90.75 gallons per acre determined in the above example and a sprayer tank size of 400 gallons, the number of acres that can be treated by one tankful is 4.41 acres (400/90.75).

7. Determine the amount of pesticide to be added to the tank by multiplying the number of acres treated with one tankful by the recommended pesticide rate. If the recommended rate of pesticide is 1 quart/acre in the above example, 4.40 quarts or 1 gallon plus 12 fluid ounces of formulated pesticide would be added to the tank.

Calibrating Granular Applicators

Calibrating granular applicators is somewhat different than for sprayers. Because the material is applied "as is" and not mixed with water or other carriers and the size of granules differs among different formulations and manufacturers, the exact same material that is to be applied must be used in the calibration test. Special care must be taken when handling these materials during the calibration test.

For broadcast granular applications, follow the steps below:

1. Measure the width of the swath covered by the broadcast applicator.

2. Measure and mark off a test course. Since actual pesticide is used for the calibration test, the course should be laid out in a field that is to be treated with the same pesticide. If the field is to have headlands, this area is recommended for the test course.

3. Disconnect the spreading mechanism (if one is used) and attach a catch pan, plastic bag or other container that will not break or split.

4. Operate the applicator at the desired settings and ground speed with same pesticide to be applied. Be sure to operate only over the test course and to catch all the material that flows through the unit.

5. Weigh the material collected on a postal scale or other sensitive instrument.

6. Convert the amount weighed to pounds per acre using the following equation:

pounds per acre	=	total amount material applied	/	length of course	/	width of swath	×	conversion factor (F)

The conversion factor (F) is used to transform the amount measured in the test to pounds per acre. For this equation the values used for the conversion factor are as follows:

F = 2,723, when the amount determined in Step 5 is in dry ounces;

F = 43,560, when the amount determined in Step 5 is in pounds.

For example, the number of pounds applied per acre in a calibration test where 7 ounces of granular pesticide were collected over a test course 500 feet long with a swath 20 feet wide, is 1.90 pounds per acre (7/500/20 × 2,723). If this amount is different from the recommended rate, the settings should be adjusted accordingly.

For band or in-furrow granular applications, follow the steps below:

1. Measure and mark off a test course of 1,000 feet.

2. Disconnect all the drop tubes and collect the granules in bags or cans while operating over the test course.

3. Weigh the material collected on a postal scale or other sensitive instrument. If the length of the test course was not 1,000 feet, calculate the amount of pesticide that would be have been applied to 1,000 feet by using the following equation:

ounces per 1,000 feet	=	measured amount applied in test	/	length of course	×	conversion factor (F)

The values to be used for the conversion factor (F) are:

F = 16,000, when measured in pounds;

F = 1,000, when measured in dry ounces.

For example, the number of ounces that would be applied to 1,000 feet where 8 ounces is collected over a test course of 500 feet, is 16 ounces (8/500 × 1,000).

4. If the recommended rate is given as an amount per acre, convert the recommended rate per acre to ounces per 1,000 row feet using the following equation:

dry ounces per 1,000 row feet	=	recommended formulated product per acre	/	row width	×	conversion factor (F)

The conversion factor (F) is used to tranform the recommended units per acre to dry ounces per 1,000 row feet. The values of F for this equation are:

F = 0.03061, when the recommendations are in pounds per acre;

F = 0.001913, when the recommendations are in dry ounces per acre.

For example, the number of dry ounces of formulated pesticide needed to treat 1,000 row feet in a field with 36-inch rows, when the recommended rate is 2 pounds of formulated product per 1,000 row feet, is 2.20 ounces (2 × 36 × 0.03061).

5. Compare the recommended rate calculated in Step 4 to the test rate calculated in Step 3. Adjust the settings if these values are different. Repeat the test until the recommended values and test values are equal.

REVIEW QUESTIONS – APPENDIX A
(Private Applicators only)

Write the answers to the following questions. When you are satisfied with your answers, see if they are correct by checking them with the appendix text.

1. What is the difference between calibrating a sprayer to apply a broadcast spray or to apply narrow bands?

2. List six advantages of properly calibrating your pesticide application equipment.

1) _____

2) _____

3) _____

4) _____

5) _____

6) _____

3. Once a sprayer has been test calibrated, there is no need to monitor the application rate in the field. (True or False)

4. How many acres per tankful could be treated with a sprayer that delivers 15 gallons per acre and has a 200-gallon tank?

5. List three things a grower could do to increase the application rate of a sprayer.

1) _____

2) _____

3) _____

6. How many gallons of a 4 lb emulsifiable concentrate would be needed to treat 80 acres at the recommended rate of 1 pint of formulated product per acre?

7. How many pounds of granular insecticide would be needed to treat a 40 acre field, with 36-inch rows, at the recommended rate of 4 dry ounces of formulated product per 1000 row feet?

CHAPTER 9

PESTICIDE LAW AND REGULATIONS

Pesticide usage has increased from approximately 300 million lbs. of active ingredient in 1964 to approximately 900 million lbs. of active ingredient in 1984. This fact, along with the progress in technology to monitor and detect pesticide residues, has increased the need for laws and regulations that adequately protect people and safeguard the environment. In this chapter you will learn about the state and federal laws that regulate pesticide applicators.

Federal Laws

The basic federal law regulating pesticides is the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA), first enacted in 1947. This law was amended in 1972, 1978, and 1988.

FIFRA is administered by the Environmental Protection Agency (EPA). The Michigan Department of Agriculture (MDA) has a cooperative agreement with EPA to enforce the provisions of FIFRA in Michigan. The major provisions of FIFRA are listed here.

- All pesticides are under federal control. States have the authority to certify applicators, register pesticides, and initiate programs designed to meet local needs.
- Pesticides must be classified as either "general use" or "restricted use." General use pesticides are those that can be purchased and used by anyone. Restricted use pesticides (RUPs) are pesticides that are hazardous enough to limit their sale and use only to persons who have demonstrated competence in their use (that is, **certified pesticide applicators**).
- Applicators who violate the provisions of FIFRA can be served a civil or criminal penalty:

Civil Penalties - A private applicator who violates FIFRA after a written warning, or other citation for a prior violation, may be fined up to $1,000 for each offense. A commercial applicator may be fined up to $5,000 for each such offense.

Criminal Penalties - A private applicator who knowingly violates FIFRA is guilty of a misdemeanor and upon conviction, may be fined up to $1,000 or imprisoned for up to 30 days, or both. For a commercial applicator, the fine is up to $25,000 and he or she may be imprisoned for up to one year.

FIFRA defines the term "misuse" as, "to use any pesticide in a manner inconsistent with its labeling." It specifies that the following activities do **not** constitute misuse:

- Using a pesticide for a pest not noted on the label if the application is made to the plant, animal or site specified on the label.
- Mixing pesticides with fertilizer when such mixture is not prohibited by the labeling.
- Any manner of application unless expressly forbidden by the label.
- Using a pesticide at dosages less (but not more) than the labeled dosage.

These exemptions apply only if the pesticide is otherwise used as directed on the label provided that the pesticide is labeled for use on the plant and you follow all other label instructions. **Do not** use these exemptions unless you are certain of their results as the exempted uses may not be covered by the pesticide manufacturer's warranty.

Michigan Laws

To assure that essential and commonly used pesticides will remain available, the Michigan Legislature passed the Pesticide Control Act of 1976. This legislation gives the director of agriculture authority to certify private and commercial applicators as required by the federal law and to prescribe standards for certification. The certification of pesticide applicators is administrated by MDA. Two classes of **certified applicators** exist under the law.

Private Applicators - includes persons using or supervising the use of restricted use pesticides to produce an agricultural commodity on their own or their employer's land, or on lands rented by them. The "production of an agricultural commodity" is taken to mean production for sale into commerce, and includes crops, livestock, ornamentals, forest products, and other products regarded as being agricultural commodities. Persons using pesticides on home gardens or other non-agricultural commodities are not private applicators under the law.

Commercial Applicators - Includes all persons using pesticides other than the private applicators. Since this is a diverse group, two subtypes of commercial applicators have been formed.

1. **Licensed Commercial Applicators** - Persons who apply or supervise the application of pesticides (either general or restricted use) on a for-hire basis. These are owners, or employees of a licensed pesticide application business.

2. **Nonlicensed Commercial Applicators** - Persons other than private or licensed commercial applicators who use restricted use pesticides. Homeowners desiring to use restricted use pesticides are included in this subtype.

Pesticides are used in a large number of different operations. Special commodity or site specific categories have been established for the commercial applicators under Michigan law. There are no separate categories for private applicators except that special certification is required for both fumigation (soil, grain and space) and aerial applications.

The following are some important provisions of the Michigan Pesticide Control Act you should know:

- Any person using or supervising the use of restricted use pesticides must be certified by the director of the MDA.
- Licensed commercial applicators must employ at least one certified applicator to use or supervise the use of both general use and restricted use pesticides.
- Commercial applicators for hire must obtain an annual license and provide proof of financial responsibility.
- Noncertified applicators applying restricted use pesticides must be under the control and supervision of a certified applicator.
- Dealers who sell restricted use pesticides must obtain an annual license and submit a record of sale to the director.
- Restricted use pesticides may be made available only to certified applicators.
- Pesticides must be used according to labeled directions.

People exempt from certification and licensing include:

1. Employees of a certified private applicator while acting under the supervision of such an applicator.

2. Commercial applicators applying general use pesticides indoors other than insecticides, rodenticides, avicides and molluscicides.

3. Persons applying general use pesticides on their own premises, or employees of such persons on such premises.

4. Doctors of medicine and doctors of veterinary medicine applying pesticides during the course of their normal practice.

5. Persons conducting laboratory type research involving restricted use pesticides.

Penalties for Violators. Private applicators who knowingly violate this act can be fined up to $1,000. Commercial applicators who knowingly violate this act can be fined up to $5,000. If the violation is with malicious intent, the applicator can be charged up to $25,000. The director of MDA can levy administrative fines up to $1,000.

The Pesticide Control Act of 1976 was amended in 1988. The amendments include the establishment of a new class of applicators, referred to as "registered applicators." This class is for commercial and private applicators' employees who apply pesticides. This is optional for the employees of private applicators, however, **for a private applicator to receive protection from civil liability in the event of a law suit from injuring people or property, all employees must be either certified or registered applicators.** All

commercial applicators must be either certified or registered.

Important Terms

Reciprocity - Each state has its own certification regulations. Agreements between states to allow certified applicators in one state to use pesticides in another state is called reciprocity. Currently, Michigan has reciprocal agreements with Indiana, Ohio and Wisconsin, however, if an applicator plans to use pesticides in another state, he or she should check with MDA to see if Michigan has reciprocity with that state.

Restricted Use Pesticides - Sales or distribution of restricted use pesticides shall be limited to licensed restricted use pesticide dealers for resale or distribution to applicators certified under this act. Commercial applicators are required to keep records of restricted use pesticides as prescribed by rule which includes name of pesticides applied, amount used, purpose, date, place where applied and the method and rate of application. The records must be maintained for a minimum of two years after application.

Enforcement - The MDA has the responsibility for enforcing the FIFRA as amended including failures of pesticides to perform when used in accordance with label instructions and the misuse of pesticides. If you have a complaint involving a pesticide, notify the nearest MDA office. Delays in making a complaint greatly reduce the chances of a satisfactory investigation. The MDA needs to receive the complaint within 60 days of the action or, in cases involving crops, before one-quarter of the crop has been harvested. Make the complaint as soon as you have reason to suspect pesticide misuse or failure.

Endangered Species Act

Endangered species of plants and animals are protected from pesticides by product labels which prohibit the application of specific pesticides within endangered species habitat ranges. The program is based on jeopardy opinions (risk analysis) issued by the Fish and Wildlife Service (FWS) and then implemented by EPA under FIFRA labeling requirements. For each pesticide product that has an effect on an endangered species, the act requires that the label include a list of states and counties where the product effects the endangered species and its application restricted. There will be county maps available where pesticides are sold or from your local county extension office to further delineate habitat areas. For further information on endangered species, call the U.S. Fish and Wildlife Service, Department of the Interior, at (517) 337-6650.

Worker Protection Standards

Presently, both the EPA and MDA have issued proposed worker protection standards for agriculture employees. If the EPA's proposed standards are not enacted (which supersede MDA's proposed standards), then MDA's standards will be enacted. Following is MDA's proposed revisions:

- establishment of reentry periods
- posting and notification
- use of protective clothing, safety devises, handwashing and other methods of protection
- notification of poison treatment facilities

Laws Enforced by Michigan Department of Natural Resources

The Michigan Department of Natural Resources (MDNR), Waste Management Division administers both the federal (RCRA) and state (Act 64) hazardous waste regulations. Pesticide applicators must be aware of these regulations because many of the waste materials that are generated by an applicator may be hazardous. When waste is classified as a hazardous waste, strict disposal and handling requirements must be followed.

Containers - Containers that have held certain products or wastes can be hazardous if they are not empty. A pesticide applicator can always ensure that a container is empty, and therefore non-hazardous, by triple-rinsing the container before disposal. Questions about hazardous waste requirements should be directed to the MDNR Waste Management Division at (517) 373-2730.

Spills - The Waste Management Division also administers Act 245, Michigan's Water Resources Commission Act. Any spills or discharges of any polluting material (pesticides) that will potentially reach any surface or ground water must be controlled. Any spills or discharges of pesticides should be reported to the Pollution Emergency Alerting System (PEAS) at 1-800-292-4706.

Sanitary Landfills - The Waste Management Division administers Act 641, Michigan's Solid Waste Management Act. These regulations place

restrictions on materials that can be placed in a sanitary landfill. Remember that no free liquids can be placed in any landfill in the state. Containers that are "empty" as described above, may be placed in a licensed sanitary landfill.

SARA Title III - The Environmental Response Division of the MDNR administers the Superfund Amendments and Reauthorization Act of 1986 (SARA), Title III Emergency Planning and Community Right-to-Know. The purpose of this legislation is to protect people from chemical emergencies by requiring state and local agencies to gather information about the quantity and location of hazardous chemicals in their community.

Farmers have two primary responsibilities under this law. The first is **Facility Notification** whereby a farmer must notify the proper authorities if he or she has a specified quantity of an EPA designated "Extremely Hazardous Substance" (EHS), present on the farm at any one time. This notification must take place by May 17, 1987 or within 60 days of obtaining the EHS. The second responsibility is **Emergency Notification**. This portion of the legislation requires farmers to immediately report any releases (spill, leaks, etc.) of an EHS at or above a specified quantity.

For more information on these requirements or for a list of the EHS's, see the MSU Extension bulletin E-2173 or contact the MDNR Title III Office at (517) 373-8481.

Animal Damage Control and Pest Control in Water - DNR permits are required for animal damage control (i.e., pigeons) and pest control in public waters or private waters that empty into public water (Aquatic Nuisance Control Permit). Contact your local DNR field office or call (517) 373-1220 for information.

Laws Enforced by Michigan Departments of Public Health and Labor

The Michigan Department of Public Health (MDPH) and the Michigan Department of Labor (MDL) jointly enforce the Michigan Occupational Safety and Health Act (MIOSHA), Act 154, which was amended on April 7, 1986 to include what is commonly known as the Michigan Right-to-Know Act, Act 80. This act incorporated the Federal Hazard Communication Standard into the MIOSHA Right-to-Know through adoption.

The MIOSHA Right-to-Know requires employers to:

- Obtain and retain for employees review Material Safety Data Sheets (MSDS) on all hazardous chemicals.
- Develop and implement a written employee training program.
- Ensure that all containers of hazardous materials are properly labeled.

If you have concerns or complaints concerning MIOSHA Right-to-Know, notify either MDPH, Division of Occupational Health at (517) 335-8250 or MDL, Division of Safety Standards at (517) 322-1831. Be advised that pesticides are not exempt from the provisions of the MIOSHA Right-to-Know.

These two departments also enforce the Occupational Safety and Health Act (OSHA) of 1970, which requires anyone with eight or more employees to keep records and make periodic reports of all work-related deaths, injuries and illnesses. Minor injuries needing only first aid treatment need not be recorded. But a record must be made if the injury involves:

- medical treatment
- loss of consciousness
- restriction of work or motion
- transfer to another job

Other Regulations

Transportation of Pesticides

Shipment of pesticides and other dangerous substances across state lines is regulated by the Federal Department of Transportation (DOT). DOT issues the rules for hauling these materials.

DOT standards tell you which pesticides are dangerous to people, and may create a health hazard during transportation.

If you haul pesticides between states, you should know that:

1. They must be in their original packages. Each package must meet DOT standards.

2. The vehicle must have a correct sign. Manufacturer's must put the correct warning signs on each package.

3. The pesticides may not be hauled in the same vehicle with food products.

4. You must contact DOT right away after each accident:

- when someone is killed
- when someone is injured badly enough to go to hospital
- when damage is more than $50,000.

5. You must tell DOT about all spills during shipment.

Local laws may require you to take additional precautions.

Aerial Application

Application of pesticides from airplanes also is regulated by the Federal Aviation Administration (FAA) and by Michigan Aeronautics Commission. FAA judges the flying abilities of pilots, and the safety of their aircraft.

FAA rules indicate that an aerial applicator may only apply pesticides as directed on the label.

Pesticide Residues

The pesticide that stays in or on raw farm products or processed foods is called a **residue**. EPA sets residue tolerances under regulations authorized by the Federal Food, Drug, and Cosmetic Act. A **tolerance** is the concentration of a pesticide that is judged safe for human use. The same pesticide may have a different tolerance on different products.

Residues in processed foods are considered to be food additives and are regulated as such. If too much residue is found on a farm or food product the product may be seized or condemned. The label will tell you how many days before harvest the pesticide may be applied, i.e., the time necessary for the pesticide to break down to legal tolerance levels. Follow the label exactly so you can be sure that you are not breaking the law.

REVIEW QUESTIONS – CHAPTER 9

Write the answers to the following questions. When you are satisfied with your answers, see if they are correct by checking them with the chapter text.

1. The basic federal law regulating pesticides is referred to as _____.

2. Restricted use pesticides can be sold only to _____.

3. Who can apply restricted use pesticides?

_____

4. The Michigan Department of Agriculture administers the pesticide certification program. (True or False)

5. Select the letter of the **false** statement. Certified private applicators can legally apply restricted use pesticides to produce an agricultural commodity:
   a. on their own land
   b. on their employer's land
   c. on land rented by them
   d. if they are a self-employed applicator

6. Commercial applicators do not include:
   a. persons who apply pesticides on a for-hire basis
   b. homeowners desiring to use restricted use pesticides
   c. persons who apply pesticides to their own property
   d. b and c
   e. all of the above

7. Commercial applicators for hire must obtain an annual license and provide proof of financial responsibility. (True or False)

8. The employees of both private and commercial applicators who apply pesticides, must become registered applicators under the 1988 amendments to the Michigan Pesticide Control Act. (True or False)

9. Private and commercial applicators are subject to criminal and civil penalties for unlawful conduct under the Michigan Pesticide Control Act. (True or False)

10. Agreements between states to allow certified applicators in one state to use pesticides in another state is called _____.

11. Endangered species of plants and animals are protected from pesticides by product labels which will prohibit the application of specific pesticides within endangered species habitat ranges. (True or False)

12. The _____ administers both the federal (RCRA) and state (Act 64) hazardous waste regulations.

13. Pesticide containers may be placed in a licensed sanitary landfill only if they have been triple rinsed. (True or False)

14. What is the purpose of the SARA Title III, Emergency Planning and Community Right-to-Know Act?

_____

_____

_____

15. What are the two requirements farmers must be concerned with under SARA Title III?

1) _____

2) _____

16. Shipment of pesticides and other dangerous substances across state lines is regulated by the federal _____.

17. What is a pesticide residue?

_____

18. If too much residue is found on a food product, the product may be seized or condemned. (True or False)

GLOSSARY

Abiotic: Not relating to living organisms.

Absorption: The uptake of a chemical into plants, animals, or minerals. Compare with adsorption.

Activator: A chemical added to a pesticide to increase its activity.

Active ingredient: A component of a pesticide product which has pesticide activity. Active ingredients are normally mixed with inert or inactive ingredients in the formulation process.

Acute exposure: Exposure to a single dose of pesticide.

Acute toxicity: A measure of the capacity of a pesticide to cause injury as a result of a single exposure.

Additive: Same as adjuvant.

Adherence: Sticking to a surface.

Adjuvant: A chemical added to a pesticide formulation to increase its effectiveness or safety.

Adsorption: The binding of a chemical to surfaces of mineral or soil particles. Compare with absorption.

Agitation: The process of stirring or mixing in a sprayer.

Allelopathy: The production of growth inhibitors by one plant which retard the development of another plant.

Annuals: Plants that live less than 12 months.

Antagonism: The loss of activity of a chemical when exposed to another chemical.

Antibiotic: Chemical compounds produced by microorganisms which are toxic to other microorganisms.

Antidote: A practical treatment for poisoning, including first aid.

Anti-siphoning device: An attachment to the filling hose designed to prevent backward flow into the water source.

Antitranspirant: A chemical which reduces water loss (transpiration) by coating the leaves of a plant.

Aqueous: A term used to indicate the presence of water in a solution.

Avicide: A chemical used to control birds.

Band application: Placement of a pesticide in a narrow area either over or along the crop row.

Biennials: Plants that live for two growing seasons.

Biological Control: Control by predators and parasites, either naturally occurring or introduced.

Biological Degradation: The breakdown of a pesticide due to the activities of living organisms, especially bacteria and fungi.

Biology: The science that deals with the structure, function, development, evolution, and ecology of living organisms.

Biotic: Relating to living organisms.

Biotype: Usually refers to a subdivision of a race.

Bipyriyliums: A group of synthetic organic pesticides which includes the herbicide paraquat.

Blight: A disease characterized by general and rapid killing of leaves, flowers and stems.

Brand name: The specific, registered name given by a manufacturer to a pesticide product; same as trade name or proprietary name.

Broadcast application: The uniform application of a pesticide to an entire field or area.

Broadleaf weeds: Plants with broad, rounded, or flattened leaves.

Broad-spectrum pesticide: A pesticide that is effective against a wide range or species; usually applied to insecticides and fungicides.

Calibration: Measurement of the delivery rate of application equipment.

Carbamate: A synthetic organic pesticide containing carbon, hydrogen, nitrogen, and sulfur.

Carcinogen: A substance which has the ability to cause cancer.

Carrier: A liquid or solid material added to a pesticide active ingredient or formulated product to facilitate its field application.

Cell: The basic structural unit of all living organisms: An organism may be composed of a single cell (e.g. bacteria) or many cells working together (all "higher" organisms, including man).

Chemical degradation: The breakdown of a pesticide by oxidation, reduction, hydrolysis or other chemical means.

Chemical name: The scientific name of an active ingredient which complies with accepted guidelines established by chemists.

Chemigation: The application of an agricultural chemical by injecting it into irrigation water.

Chlorinated hydrocarbon: A synthetic organic pesticide that contains chlorine, carbon, and hydrogen. Same as organochlorine.

Chlorophyll: The green photosynthetic substance in plants which allows them to capture solar energy.

Cholinesterase: An enzyme found in animals that helps control the activity of nerve impulses.

Chronic exposure: Exposure to small, repeated doses of a pesticide over a period of time.

Chronic toxicity: A measure of the capacity of a pesticide to cause injury as a result of small, repeated exposures over a period of time.

Closed mixing system: Systems in which liquid pesticide concentrates are transferred from their original containers to mix or spray tanks through a closed series of hoses, pipes, etc.; they are designed to prevent or minimize exposure to the concentrates.

Common name: (1) The standard, commonly-used name of a pesticide active ingredient established by appropriate professional societies. (2) A commonly used name of a particular species. Unlike scientific names, there may be a number of common names for the same species.

Companion crop: A crop (usually an annual) which germinates quickly and grows rapidly, and is planted with a perennial crop to compete with weeds and allow the perennial to become established.

Compatibility agents: Chemicals which enhance the effective mixing of two or more pesticide products.

Concentration: The amount of active ingredient in a given volume or weight of formulation.

Contact herbicide: A herbicide that kills primarily by contact with plant tissue rather than as a result of translocation; only the portions of the plant which actually come in contact with the chemical are affected.

Cotyledon: A seed leaf.

Damping-off: Rotting of seedlings at or below the soil line; may occur either before or after emergence.

Days to harvest: The minimum number of days allowed by law between the final application of a particular pesticide and the harvest date.

Days to slaughter: The minimum number of days allowed by law between the final application of a particular pesticide and the date an animal is slaughtered.

Deflocculating agent: A material added to a suspension to prevent settling.

Defoliant: A chemical which causes the leaves of a plant to drop prematurely.

Degradation: The breakdown of a pesticide into a simpler compound which is usually, but not always, nontoxic; degradation may be either chemical, physical, or biological or any combination of the three.

Deposit: The amount of a pesticide on a treated surface immediately following an application.

Dermal: Of the skin; through or by the skin.

Dermal Toxicity: Ability of a chemical to cause injury when absorbed through the skin.

Desiccant: A chemical used to draw moisture from a plant or plant part.

Dicot: A plant with two cotyledons or seed leaves.

Diluent: Any liquid or solid material used to dilute or carry an active ingredient.

Dilute: To make thinner by adding water, another liquid or a solid.

Directed-spray application: A herbicide is directed specifically at target weeds in an effort to minimize contact with crop.

Dispersing agent: A material that reduces the attraction between particles.

Dormant: State in which growth stops temporarily. May refer to plants, plant parts, microorganisms, and certain animals.

Dose, dosage: Quantity of a pesticide applied.

Drift: (1) The movement of pesticides through the air to nontarget areas either as solid or liquid particles or as vapors. (2) (Legal definition) The drifting or movement of pesticide by air currents or diffusion onto property beyond the boundaries of the target area to be treated with pesticide, other than by pesticide overspray.

Drop-nozzle application: A directed-spray application using drop extensions.

Dust: A finely-ground, dry pesticide formulation in which the active ingredient is combined with an inert carrier such as talc, clay, powdered nut

hulls, or volcanic ash; dusts are applied in the dry form.

Ecology: The science which studies the interrelationships of living organisms and their environment.

Economic damage: The amount of injury which will justify the cost of applied control measures.

Economic injury level: The population density at which a pest causes a reduction in the value of the crop that is greater than the cost of control.

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

Emergence: The first appearance of plant at or above the soil surface.

Emulsifiable concentrate (EC or E): A pesticide formulation produced by mixing the active ingredient and an emulsifying agent in an organic solvent.

Emulsifier: A substance which facilitates the formation and maintenance of an emulsion.

Encapsulated pesticide: A pesticide formulation in which the active ingredient is encased in extremely small capsules made of inert synthetic polymers. The pesticide is released gradually over a period of time.

Entomology: The science that deals with the study of insects.

Environment: All of our physical, chemical, and biological surroundings such as climate, soil, water and air and all species of plants, animals and microorganisms.

Enzymes: Proteins which increase the rate of specific chemical reactions.

EPA: The Environmental Protection Agency.

Epidemic: A temporary widespread outbreak of a disease.

Eradication: The complete elimination of a pest from a site, area or a geographic region.

Erosion: Movement of soil and associated materials, principally by water and wind.

Exposure: To come in contact with a pesticide.

FDA: Food and Drug Administration.

FIFRA: The Federal Insecticide, Fungicide and Rodenticide Act: federal law dealing with pesticide regulations and use.

Flowable (F or L): A pesticide formulation in which the active ingredient is impregnated on a diluent such as clay which is then finely ground and suspended in a small amount of liquid; the resulting "paste" or "cream-like" formulation is added to water in the spray tank and forms a suspension.

Foaming agent: A material designed to reduce drift, which causes a pesticide mixture to form a thick foam.

Foliar application: Application of a pesticide to the aerial portions of either a crop or weed.

Food chain: A group of plants, animals, or microorganisms linked together as sources and consumers of food.

Formulation: The pesticide product as purchased, usually consisting of a mixture of active and inert ingredients.

Fumigants: Pesticides or mixtures of pesticides which produce vapors that are toxic when absorbed or inhaled.

Fumigation: The application of a fumigant.

Fungicide: A chemical used to control fungi.

Fungus: A largely undifferentiated, usually microscopic organism lacking chlorophyll and conductive tissues and living either as a saprophyte or parasite. The vegetative body of a fungus is normally composed of hyphae, and reproduction is by sexual or asexual spores.

Furrow application: Placement of an insecticide or fungicide in a narrow line in the soil directly over the seed at planting time.

Gall: A pronounced swelling or outgrowth on a plant.

Germination: Sprouting of a plant seed.

Granules (G): A dry pesticide formulation made by applying a liquid formulation of the active ingredient to particles of clay or another porous material. Granules are applied in the dry form and have a particle size substantially larger than dusts.

Herbaceous plant: A plant that does not develop woody tissue.

Herbicide: A chemical used to kill or inhibit plant growth.

Host: A plant or animal that is invaded by a parasite and serves as its food source.

Hydrolysis: Decomposition of a chemical compound by reaction with water.

Hyperplasia: Overdevelopment of plant tissue

due to increased cell division.

Hypertrophy: Overdevelopment of plant tissue due to abnormal cell enlargement.

Hypoplasia: Underdevelopment of plant tissue due to decreased cell division.

Hypotrophy: Underdevelopment of plant tissue due to reduced cell enlargement.

Immune: Not susceptible to a disease or poison.

Impermeable: Cannot be penetrated. Semipermeable means that some substances can pass through and others cannot.

Incompatibility: When two or more pesticides cannot be effectively mixed without a loss in activity, an increase in toxicity or hazard to the applicator, or harm to the crop or the environment.

Inert ingredients: The materials in a pesticide formulation which have no pesticide activity.

Inhalation toxicity: A measure of the capacity of a pesticide to cause injury when absorbed through the lungs.

Inorganic pesticides. Pesticides of a mineral origin that do not contain carbon.

Insecticide: A chemical used to control insects.

Integrated pest management (IPM): An ecological approach to pest management in which all available necessary techniques are consolidated into a unified program so that pest populations can be managed in such a manner that economic damage is avoided and adverse side effects are minimized.

Invert emulsion: An emulsion in which water is dispersed in oil rather than oil in water; invert emulsions are normally quite thick and thus less susceptible to drift.

Juvenile: An immature stage of an insect, nematode or animal.

Label: The information printed on or attached to the pesticide container or wrapper.

Labeling: The pesticide label and all additional product information such as brochures and flyers provided by the manufacturer and handouts provided by the dealer.

Larvicide: A pesticide used to kill insect larvae.

LC50: The concentration of an active ingredient in air which is expected to cause death in 50 percent of the test animals so treated. A means of expressing the toxicity of a compound present in air as dust, mist, gas or vapor. It is generally expressed as micrograms per liter as a dust or mist but in the case of a gas vapor as parts per million (ppm).

LD50: The dose of an active ingredient taken by mouth or absorbed by the skin which is expected to cause death in 50 percent of the test animals so treated. If a chemical has an LD50 of 10 milligrams per kilogram (mg/kg), it is more toxic than one having an LD50 of 100mg/kg.

Leaching: Movement of a substance downward or out of soil as the result of water movement.

Lethal: Causing or capable of causing death.

Life cycles: The progression of stages in the development of an organism.

Mammals: Warm-blooded animals that nourish their young with milk. Their skin is more or less covered with hair.

Material Safety Data Sheets (MSDS): Sheets of information on toxicity, first aid, personal protection and other safety data. MSDS are available from dealers or manufacturers.

Meristemic regions: Shoot tips, root tips, expanding buds and other areas of a plant characterized by active cell division and giving rise to new growth.

Metamorphosis: A change in the shape, form or size of an insect.

Microorganism: An organism which can only be seen with a microscope.

Miscible liquids: Two or more liquids that can be mixed and will remain mixed under normal conditions.

Miticide: A chemical used to control mites.

Mode of action: The way in which a pesticide exerts a toxic effect.

Molluscicide: A chemical used to control snails and slugs.

Monocot: A plant having a single cotyledon or seed leaf.

Muck soil: An organic soil in which the organic matter is well decomposed; higher in mineral matter than peat.

Mutagenic: Capable of producing genetic change.

Mutation: A change, usually harmful, in inherited genetic material.

Narrow-spectrum pesticide: A pesticide that is effective against only one or a few species; the

term is usually applied to insecticides and fungicides.

Necrosis: Localized death of living tissue such as the death of a certain area of a leaf.

Necrotic: Showing varying degrees of dead areas or spots.

Nematicide: A chemical used to control nematodes.

Nematodes: Small, slender, colorless roundworms that live saprophytically in soil or water or as parasites of plants, animals, or fungi; plant-parasitic nematodes are so small that they cannot be seen except through a microscope.

Neoprene: A synthetic rubber characterized by superior resistance.

Neurotoxic: A pesticide which is harmful to nerve tissue.

Nitrophenols: Synthetic organic pesticides containing carbon, hydrogen, nitrogen and oxygen.

Nonselective herbicide: An herbicide which will kill or harm all or most plant species.

Nontarget organisms: All plants, animals and microorganisms other than the intended target(s) of a pesticide application.

Noxious weed: A plant defined as being especially undesirable or troublesome.

Nurse crop: Same as companion crop.

Oil solution: A liquid pesticide formulation in which the active ingredient is dissolved either in oil or some other organic solvent.

Oncogen: A substance which has the ability to cause tumors; the tumor may or may not be cancerous.

Oral: Of the mouth; through or by the mouth.

Oral toxicity: Ability of a pesticide to cause injury when taken by mouth.

Organic compounds: Chemicals that contain carbon.

Organic soil: A soil which contains a high percentage (usually greater than 20%) of organic matter throughout its upper layers.

Organochlorine: Same as chlorinated hydrocarbon.

Organophosphate: A synthetic organic pesticide containing carbon, hydrogen and phosphorus; parathion and malathion are two examples.

Ovicide: A chemical that destroys eggs.

Parasite: A living organism which obtains all or part of its food from other living organisms.

Peat: Unconsolidated soil material made up primarily of undecomposed, or slightly decomposed, organic matter which has accumulated under conditions of excessive moisture.

Penetrant: An adjuvant which enhances the absorption of a systemic pesticide.

Pathogen: Any disease-producing organism.

Percolation: Downward seepage of water through the soil.

Perennials: Plants that live for more than two years.

Persistence: A measure of how long a pesticide remains in an active form at the site of application or in the environment.

Pesticide concentrate: A pesticide formulation as it is sold and prior to dilution.

Pesticide registration: The registration of pesticides and pesticide users by the Environmental Protection Agency; or by the state to meet a special local need.

pH: A measure of the acidity or alkalinity of a solution.

Pheromones: A substance produced by an insect to communicate with other members of the same species.

Phloem: The tissue in higher plants which transports organic nutrients manufactured in the leaves to other portions of the plant.

Photodecomposition: Degradation of a pesticide by light.

Photosynthesis: The process in green plants of synthesizing carbohydrates from carbon dioxide and water, using light energy captured by chlorophyll.

Physiology: The branch of biology that deals with the functions and activities of living organisms.

Phytotoxicity: Injury to plants due to exposure to a chemical.

Plant growth regulator: A substance which increases, decreases or changes in some manner the normal growth or reproduction of a plant.

Plant pathology: The science that deals with nature and causes of plant disease.

Postemergence: After the emergence of a specified weed or crop.

PPB: Parts per billion.

PPM: Parts per million.

PPT: Parts per trillion.

Preemergence: Before the emergence of a specified weed or crop.

Preplant: Prior to planting a crop.

Preplant-incorporated: Mixing a pesticide with the soil just prior to planting.

Propagation: Reproduction by either sexual or asexual means.

Propriety name: Same as brand name.

Protectant: A chemical applied to a plant or animal in anticipation of a pest problem to prevent infection or injury.

PSI: Pounds per square inch.

Pubescent: Having hairy leaves or stems.

Pupa: An intermediate "resting" stage of an insect which undergoes complete metamorphosis.

RCRA: The Resource Conservation and Recovery Act; a federal law that regulates the transport, storage, treatment and disposal of hazardous waste.

Reentry safety interval: The length of time that must elapse after a pesticide application before people who are not using personal protective equipment can enter the treated site without being likely to experience any adverse effect due to exposure to pesticide residues.

Registered pesticide: A pesticide which has been approved by the Environmental Protection Agency for use as stated on the label; or the state to meet a special local need.

Residual pesticide: A pesticide which continues to be effective for an extended period of time after application.

Residue: (1) The amount of a pesticide remaining in or on raw farm products or processed foods. (2) Undesirable persistance of a pesticide at the site of application.

Residue tolerance: The maximum amount of a pesticide that may legally remain in or on a raw farm product intended for consumption by people or livestock.

Resistance (pesticide): The genetically-acquired ability of an organism to tolerate the toxic effects of a pesticide.

Resistant variety: A variety which has the ability to overcome, completely or in some degree, the effect of a pest or other damaging factor.

Respiration: (1) The process by which living cells utilize oxygen to transform the energy in food molecules into biologically useful forms. (2) The act of breathing.

Restricted-use pesticide: Pesticides designated by the Environmental Protection Agency for restricted use because without additional regulatory restrictions, unreasonable adverse effects on the environment, including injury to the applicator could occur. A "restricted-use" pesticide may be used only by, or under the direct supervision of, a certified applicator.

Resurgence: A dramatic increase in the population level of a target pest sometime after a pesticide application due to the destruction of its natural enemies by the pesticide; pest numbers may soon surpass pretreatment levels.

Rhizome: An underground horizontal stem of perennial plants which produces roots and leafy shoots at nodes and thereby gives rise to new plants by vegetative reproduction.

Rodenticide: A chemical used to control rodents.

Rootstock: (1) An underground horizontal stem similar to a rhizome which is capable of producing new plants through vegetative reproduction. (2) A root or piece of a root used for grafting.

Rosette: A circular cluster formed by basal leaves of certain broadleaf plants, particularly biennials.

Row-spacing: The distance between rows.

Rust: A disease caused by one of the rust fungi and usually characterized by orange, brown, or red masses of spores.

Safener: A chemical added to a pesticide to keep it from injuring plants.

Saprophyte: An organism which obtains its food from dead or decaying organic matter.

Scientific name: The Latin name of the genus and species of an organism, designated by taxonomists and universally accepted. Scientific names are often used to avoid confusion which can result from the use of common names, which may vary from one area to another.

Scouting: Checking a crop on a regular basis and in a prescribed manner to determine pest population levels and the extent of pest damage.

Secondary pest outbreak: A pest outbreak which occurs when a species which formerly caused little damage suddenly begins causing significant damage because of the destruction of its natural enemies by pesticide applications directed against another (primary) pest.

Seed protectant: A chemical applied to seed before planting to protect seeds and new seedlings from disease and insects.

Seed treatment: Coverage of seed with an insecticide or fungicide prior to planting.

Selective herbicide: A herbicide which is effective only against certain species and is able to control unwanted plants without serious injury to desirable species.

Serial application: The application of one pesticide to a site immediately or shortly after the application of another.

Signal words and symbols: Standardized designations of relative levels of toxicity which must, by law, appear on pesticide labels.

Site: The crop, animal or area infested by a pest and to which a pesticide is applied.

Slurry: A thick suspension of a finely-divided pesticide in a liquid.

Smut: A disease caused by one of the smut fungi and usually characterized by masses of black, powdery spores.

Soil application: Application of a pesticide directly to the soil rather than to a growing crop or weed.

Soil incorporation: The use of tillage implements to mix a pesticide with the soil.

Soil injection: Application of a pesticide beneath the soil surface.

Soil organic matter: An accumulation of partially-decayed and partially-resynthesized plant and animal residues.

Soil sterilant: A chemical that prevents the growth of all plants, animals and microorganisms in the soil. Depending on the chemical, soil sterilization may be temporary or relatively long-lasting.

Solubility: The maximum amount of a pesticide that will dissolve in a specific solvent.

Soluble: Will dissolve in a liquid.

Soluble powder (SP): A finely-ground dry pesticide formulation which forms a true solution.

Solution: Mixture of one or more substances in another in which all ingredients are completely dissolved.

Solvent: A liquid which will dissolve a substance to form a solution.

Special local need (SLN): An existing or imminent pest problem within the state which cannot be adequately controlled by the use of any available federally-registered pesticide product. The EPA can approve temporary use of a pesticide to alleviate the need.

Species: The basic unit of taxonomic classification designating a group of closely-related individuals who are capable of interbreeding.

Split-boot application: Placement of a mixture of liquid insecticide and liquid starter fertilizer in the soil to the side of the seed at planting time; the mixture should be applied at least one inch on either side of the seed and at the same depth.

Spot treatment: Application of a pesticide to small, discrete areas.

Spreader: A chemical which increases the area that a given volume of liquid will cover on a solid or on another liquid.

Sterility: The inability of a living organism to reproduce.

Sticker: A material added to a pesticide to increase its adherence.

Stolon: An above-ground horizontal stem which takes root at nodes which touch the soil surface and thereby produces new plants by vegetative reproduction.

Stomach poison: A pesticide which must be swallowed by an animal to be effective. It will not kill on contact.

Stomata: Minute openings on the surfaces of leaves and stems through which gases (e.g. oxygen, carbon dioxide, water vapor) and some dissolved materials pass into and out of plants.

Strain: A subgroup of a species with a common ancestry and distinguishing physiological characteristics.

Summer annuals: Plants that germinate from seed in the spring, flower and produce seed during the summer, and die in the summer or fall.

Surfactant: A chemical which increases the emulsifying, dispersing, spreading and wetting properties of a pesticide.

Susceptible: Capable of being diseased or poisoned; not immune.

Suspension: Finely divided solid particles mixed in a liquid.

Swath: The width of the area covered by a sprayer in one sweep or trip across the treatment site.

Symptom: (1) Any detectable change in an organism resulting from the activities of a pathogen or other pest. (2) An indication of pesticide poisoning.

Synergism: The combined activity of two or more pesticides that is greater than the sum of their activity when used alone.

Synthetic chemical: A chemical which is man-made.

Systemic pesticide: A chemical which is absorbed and translocated within a plant or animal.

Tank mix: A mixture in the spray tank of two or more pesticide products for simultaneous application.

Tap root: A single, relatively large central root which gives rise to smaller, lateral branches; usually found in dicots.

Target pest: The pest at which a particular pesticide or other control method is directed.

Taxonomy: The classification of living organisms into groups based on similarities and relationships.

Thickeners: Drift control agents such as cellulose, gels, and swellable polymers which cause the formation of a greater proportion of large spray droplets.

Tolerance: (1) The ability of a living thing to withstand adverse conditions, such as pest attacks, weather extremes, or pesticides. (2) The amount of a pesticide that may safely remain in or on raw farm products at time of sale.

Toxicant: A poisonous chemical.

Toxicity: A measure of the capacity of a pesticide to cause injury.

Toxin: A poisonous substance produced by a living organism.

Trade name: Same as brand name.

Translocation: The internal movement of food, water, minerals or other materials (e.g. pesticides) from one part of a plant to another.

Tuber: An enlarged, fleshy, usually terminal portion of a rhizome, bearing "eyes" or buds.

Ultra-low volume (ULV): A spray application of undiluted formulation at a rate less than or equal to one-half gallon per acre.

USDA: United States Department of Agriculture.

Vapor pressure: The property which causes a chemical to evaporate. The lower the vapor pressure, the more easily it will evaporate.

Variety: A subdivision of a species.

Vascular system: The conducting tissue of plants, composed principally of xylem and phloem.

Vegetative reproduction: Production of new plants from vegetative plant parts such as rootstocks, rhizomes, stolons, tubers, cuttings, etc., rather than from seed.

Vertebrate: An animal with a spinal column.

Virus: An obligate parasite often consisting only of a piece of genetic material surrounded by a protein coat. Viruses are so small that they cannot be seen with an ordinary microscope.

Volatility: The degree to which a liquid or solid changes into a gas (vapor) at ordinary temperatures when exposed to air.

Volatile: Evaporates at ordinary temperatures when exposed to air.

Water-dispersible granules: A pesticide formulation in which finely-divided powders are formulated into concentrated, dustless granules which form a suspension in water.

Water-soluble concentrate (WS): A liquid pesticide formulation in which the active ingredient is soluble in water and is formulate either with water or another solvent such as alcohol which mixes readily with water.

Weed: An unwanted plant.

Wettable powder (WP or W): A finely-divided, relatively insoluble pesticide formulation in which the active ingredient is combined with an inert carrier such as clay or talc and with a wetting or dispersing agent; a wettable powder forms a suspension rather than a true solution in water.

Wetting agent: A chemical which causes a liquid to contact surfaces more thoroughly.

Winter annuals: Plants that germinate from seed in the fall, overwinter as low-growing plants, flower and produce seed the next spring, and then die.

Woody plants: Plants which live longer than two years and have a thick, tough stem or trunk covered with a layer of cork.

Xylem: The tissue in higher plants which transports water, dissolved salts, and other materials (e.g. pesticides) from the roots to aerial portions of the plant.

PESTICIDE EMERGENCY INFORMATION

(Please post in an appropriate place)

For any type of emergency involving a pesticide, the following Emergency Information Centers should be contacted immediately for assistance.

Current as of August 1989

HUMAN PESTICIDE POISONING

Eastern Half of Michigan

within the Detroit city proper:
***(313) 745-5711**

within the 313 area code:
***1-800-462-6642**

Poison Control Center

Children's Hospital of Michigan
3901 Beaubien
Detroit, MI 48201

Western Half of Michigan

within the Grand Rapids city proper:
***(616) 774-7854**

Statewide
***1-800-632-2727**

Blodgett Regional Poison Center

Blodgett Memorial Medical Center
1840 Wealthy, S.E.
Grand Rapids, MI 49506

Upper Peninsula of Michigan

within the Marquette city proper:
***(906) 225-3497**

Upper Peninsula only:
***1-800-562-9781**

U.P. Poison Control Center

Marquette General Hospital
420 West Magnetic Street
Marquette, MI 48955

Michigan State University
Cooperative Extension Service
Extension Bulletin AM-37

PESTICIDE EMERGENCY INFORMATION:
Revised by Larry G. Olsen, Pesticide Education Coordinator, Michigan State University.
Current as of August 1989—**destroy previous editions**

SPECIAL PESTICIDE EMERGENCIES

Animal Poisoning

Your personal veterinarian:

and/or

Animal Health Diagnostic Laboratory, Michigan State University:
(517) 353-1683

Pesticide Fire

Local fire department:

and

Fire Marshal Division, Michigan State Police:
(517) 322-1924

Traffic Accident

Local police department or sheriff's department:

and

Operations Division, Michigan State Police:
***(517) 337-6102**

Environmental Pollution

Pollution Emergency Alerting System (PEAS)
Michigan Department of Natural Resources:
****1-800-292-4706***
(Toll free for environmental emergencies)

For information on pesticide disposal and local pick-up days:

Michigan Department of Natural Resources
Waste Management Division:
(517) 373-2730

* ***Telephone Number Operated 24 Hours***

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PI-082 (Rev. 4/89)

APPLICATION FEE: $50.00

MICHIGAN DEPARTMENT OF AGRICULTURE
PESTICIDE & PLANT PEST MANAGEMENT DIVISION
P.O. Box 30017, Lansing, Michigan 48909

DEPT. USE ONLY	
File Number	Co. Code
X-ref	

COMMERCIAL PESTICIDE APPLICATOR'S CERTIFICATION APPLICATION

(In accordance with Act 171, Public Acts 1976)

SEND APPLICATION IN AT LEAST 4 WEEKS PRIOR TO THE DATE YOU WISH TO TAKE THE EXAMINATION

PLEASE PRINT or TYPE

NAME Last First Middle | TELEPHONE NUMBER Area Code ( )

ADDRESS (Number & Street or RFD)

CITY | COUNTY | STATE | ZIP CODE | BIRTH DATE Mo. Day Year

BUSINESS NAME (Of employer or self employed) | BUSINESS TELEPHONE NUMBER Area Code ( )

BUSINESS ADDRESS (Number & Street or RFD)

CITY | COUNTY | STATE | ZIP CODE

ARE YOU CERTIFIED BY ANOTHER STATE? ☐ YES ☐ NO If Yes complete next two items → | STATE ISSUING CERTIFICATE | EXPIRATION DATE

HAVE YOU EVER BEEN FOUND GUILTY IN A COURT OF LAW OF MISUSE OF PESTICIDES?
☐ YES ☐ NO IF YES GIVE PARTICULARS. Use another sheet of paper.

Check The Appropriate Box
☐ INITIAL APPLICATION ☐ ADDITIONAL CATEGORIES File No. or Certificate No. _____

If additional categories are indicated, enter your File Number or Certificate Number as shown on your plastic Certification Card.

CHECK CATEGORIES OF PEST CONTROL IN WHICH YOU WISH TO BE CERTIFIED. FOR DEFINITIONS SEE REGULATION NO. 636, RULE NO. 3.

- ☐ 1. AGRICULTURAL PEST CONTROL
  - ☐ 1A. FIELD CROPS
  - ☐ 1B. VEGETABLE CROPS
  - ☐ 1C. FRUIT CROPS
  - ☐ 1D. ANIMAL
- ☐ 2. FOREST PEST CONTROL
  - ☐ 2A. WOOD PRESERVATION
- ☐ 3. ORNAMENTAL and TURF PEST CONTROL (includes 3A)
  - ☐ 3A. TURF PEST CONTROL (only)
- ☐ 4. SEED TREATMENT
- ☐ 5. AQUATIC PEST CONTROL
  - ☐ 5A. SWIMMING POOLS (only)
  - ☐ 5B. COOLING TOWERS (microbial pest control)
- ☐ 6. RIGHT-OF-WAY PEST CONTROL
- 7. INDUSTRIAL, INSTITUTIONAL, STRUCTURAL AND HEALTH RELATED PEST CONTROL
  - ☐ 7A. GENERAL PEST CONTROL (includes 7D)
  - ☐ 7B. WOOD DESTROYING ORGANISMS
  - ☐ 7C. CONTRACTUAL PUBLIC HEALTH PEST CONTROL
  - ☐ 7D. VERTEBRATE PEST CONTROL (only)
  - ☐ 7E. INTERIOR SCAPE
  - ☐ 7F. MOSQUITO CONTROL
- ☐ 8. PUBLIC HEALTH PEST CONTROL (government employees)
- ☐ 9. REGULATORY PEST CONTROL (government employees)
- ☐ 10. DEMONSTRATION AND RESEARCH PEST CONTROL

Additional standards may be elected in addition to one of the above categories
☐ AERIAL ☐ SPACE FUMIGATION

DOES YOUR TYPE OF OPERATION DIFFER FROM THE ABOVE CATEGORIES.
☐ YES ☐ NO IF SO PLEASE BRIEFLY DESCRIBE YOUR OPERATION. USE ANOTHER SHEET OF PAPER.

This is to certify that the foregoing is true and accurate to the best of my knowledge and belief and that I will comply with the provisions of Act 171, Public Acts of 1976 and all Regulations promulgated thereunder. I understand that falsifying information on this application is grounds for denying or revoking certification.

DATE | APPLICANT (signature)

APPLICATION FEE CANNOT BE RETURNED IN CASE CERTIFICATION IS NOT GRANTED

Make remittance, by check or money order, payable to **State of Michigan.**

Mail to: MICHIGAN DEPARTMENT OF AGRICULTURE
PESTICIDE & PLANT PEST MANAGEMENT DIVISION
4th Floor, Ottawa Building, N
P.O. Box 30017, Lansing, Michigan 48909

Phone: (517) 373-1087

Issued in furtherance of Cooperative Extension work in agriculture and home economics, acts of May 8, and June 30, 1914, in cooperation with the U.S. Department of Agriculture. J. Ray Gillespie, Interim Director, Cooperative Extension Service, Michigan State University, E. Lansing, MI 48824.

10M-9:89-TCM-MP-New. Price $3.00, for sale only. File 27.42 (Pesticide Applicator Certification)