SM 1

UF IFAS Extension
UNIVERSITY of FLORIDA

Applying Pesticides Correctly

by Frederick M. Fishel

SM 1 Applying Pesticides Correctly
A Study Guide for the General Certifications Standards (Core) Exam
7th Edition

Frederick M. Fishel, editor

Frederick M. Fishel
UF/IFAS Department of Agronomy
Pesticide Information Office

Produced by UF/IFAS Communications
Director: Ruth Borger
Copy editor: Darryl Palmer
Graphic designer: Michele Linette Wood/Hope Crawford
Cover photograph: Sunset in Cedar Key, Florida. UF/IFAS Photo.
All photos by UF/IFAS Pesticide Information Office unless otherwise credited.

UF/IFAS Extension Bookstore
Building 440, Mowry Road
PO Box 110011
Gainesville, FL 326211-0011
352-392-1764
352-392-2628 (fax)
800-226-1764 (VISA/MasterCard orders only)
ifasbooks.ufl.edu

About This Manual

This manual is for pesticide applicators studying to become certified as licensed pesticide applicators to control pests under the provisions of the Florida Pesticide Law and its rules. The material presented in this manual offers pesticide applicators the basic knowledge that they must have in order to be fully prepared for the General Certification Standards (Core) exam.

Pesticide applicators may want to use this manual as a source of periodic review, general reference, or as the basis for providing training to any unlicensed pesticide handlers who work under their direct supervision.

This manual has nine main chapters:

Chapter I – The Law and Pesticide Application
Chapter II – Principles of Pesticides and Pest Control
Chapter III – Understanding Pesticide Labeling
Chapter IV – Pesticide Formulations
Chapter V – Pesticides and the Environment
Chapter VI – Harmful Effects and Emergency Response
Chapter VII – Personal Protective Equipment
Chapter VIII – Transportation, Storage and Security, and Disposal of Pesticide Wastes
Chapter IX – Pesticide Application Procedures

Although the subjects are somewhat related, the manual has been designed so each chapter may be studied independently. To aid use and study, each chapter contains:

- a detailed table of contents,
- a set of learning objectives,
- a list of key vocabulary words, and
- a set of review questions and answers.

The subject matter and degree of detail presented in the review questions are, in almost every case, very similar to that of the questions which make up the actual General Certification Standards exam. The manual's appendices contain tables with related useful information:

Appendix A: Managing heat stress
Appendix B: Developing a facility emergency contingency plan
Appendix C: County emergency management telephone numbers
Appendix D: Hazardous wastes
Appendix E: Pesticide storage checklist
Appendix F: Contact information for University of Florida/IFAS County Extension Offices

This project, which has the support of UF/IFAS Cooperative Extension, the Florida Department of Agriculture and Consumer Services (FDACS), the USDA, and the US-EPA, represents a continuation of a long-standing effort to produce pesticide applicator training materials that are useful and that can improve the safety and efficacy.

Acknowledgements

The greater portion of this manual stems from the *National Pesticide Applicator Certification Core Manual* (2006) – produced by the National Association of State Departments of Agriculture Research Foundation. Other sources of information include:

Fishel, F.M. 2013. Interpreting Pesticide Label Wording. UF/IFAS EDIS Document PI-34. http://edis.ifas.ufl.edu/pi071

Fishel, F.M. 2014. Pesticide Effects on Nontarget Organisms. UF/IFAS EDIS Document PI-85. http://edis.ifas.ufl.edu/pi122

Fishel, F.M. 2014. Understanding Safety Data Sheet Language. UF/IFAS EDIS Document PI-35. http://edis.ifas.ufl.edu/pi072

Fishel, F.M. 2012. Personal Protective Equipment for Handling Pesticides. UF/IFAS EDIS Document PI-28. http://edis.ifas.ufl.edu/pi061

Nesheim, O.N., F.M. Fishel, and M.A. Mossler. 2014. Toxicity of Pesticides. UF/IFAS EDIS Document PI-13. http://edis.ifas.ufl.edu/pi008

These and other EDIS documents are housed at: http://edis.ifas.ufl.edu/

Fred Fishel
UF/IFAS Department of Agronomy, Pesticide Information Office

Table of Contents

Chapter I

The Law and Pesticide Application

Chapter I

TABLE *of* CONTENTS

Learning Objectives

After you complete your study of this chapter, you should be able to:

- Identify the federal law governing pesticides and their use.
- Explain the meaning of the term, "registration," as it relates to pesticides.
- Explain the meaning of the term, "re-registration," as it relates to pesticides.
- Identify the three Florida Statutes that govern pesticide applicator licensing in Florida.
- Identify the regulatory agencies that administer the principal laws and rules governing pesticide applicators in Florida.
- Identify the kinds of applicators governed by the Florida Mosquito Control Law.
- Name the two basic types of pesticide applicator licenses issued under the Structural Pest Control Act and identify the applicator certification categories associated with each.
- Distinguish between the applicator classes "Private," "Public" and "Commercial" as defined in the Florida Pesticide Law.
- Name the 5 pesticides that have Florida-specific regulations.

Terms to Know

Applicator class: A term indicating the organizational system for certified applicators licensed under the Florida Pesticide Law. Depending upon the kind of employment engaged in, a licensee is classified as either a Private, Public, or Commercial applicator.

Certification category: An indication officially made on a license of where and how the license holder may legally conduct pesticide applicator activities.

Certified applicator: An individual who has been recognized (certified) by the Florida Department of Agriculture and Consumer Services as being competent to use or supervise the use of restricted use pesticides.

Continuing education unit (CEU): Approximately one hour of study credit used to make up the total credits required for applicator recertification.

Extremely Hazardous Substance: A classification established by EPA for certain chemicals, some of which are active ingredients in pesticide products. Storage facilities containing such substances must be formally reported if these substances are present in more than certain amounts.

FDACS (Florida Department of Agriculture and Consumer Services): State agency that enforces the provisions of FIFRA and the Florida Pesticide Law.

FIFRA (Federal Insecticide, Fungicide, and Rodenticide Act): Federal law that provides the overall framework for the federal pesticide program.

Florida Pesticide Law: The law that governs the use of pesticides in Florida, which is administered by the Florida Department of Agricultural and Consumer Services (FDACS).

Limited Certification: A designation on a license issued under the Structural Pest Control Act that enables the licensee to apply pesticides only under certain prescribed circumstances.

Ordinance: Laws developed by local government officials; ordinances are enforced at the city or county government level.

Recertification: The process by which licensed pesticide applicators accumulate continuing education units in order to keep the license valid.

Restricted use pesticide (RUP): Pesticide for retail sale to, and use by, only certified applicators or persons under their direct supervision and only for those purposes covered by the applicator's certification.

Federal Pesticide Laws

To protect public health and welfare and to prevent adverse effects to the environment, pesticides must be regulated. The purpose of the federal and state pesticide acts is to regulate in the best public interest the labeling, sale and distribution, storage, transportation, use and application, and disposal of pesticides. In essence, pesticides are under regulatory scrutiny from the time of their inception in the laboratory to their ultimate use in the field or their disposal in an approved manner. With the possible exception of human and veterinary drugs, no other class of chemicals receives such extensive testing in the United States before being registered and marketed.

Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA)

The US Congress enacted legislation that regulates the production, transportation, sale, use, and disposal of all pesticides. The Federal Insecticide, Fungicide, and Rodenticide Act, commonly referred to by its initials, FIFRA, was enacted in 1947. It was amended in 1972, then again in 1975, 1978, and 1988. This statute is administered by the US Environmental Protection Agency (EPA).

FIFRA provides the overall framework for the federal pesticide program. Under FIFRA, this framework states that the EPA is responsible for registering or authorizing pesticide

products for use in the United States. Pesticide registration decisions are based on a detailed assessment of the potential effects of a product on human health and the environment when used according to label directions. These EPA-approved labels have the force of law. Anyone who uses a pesticide in any way not in accordance with the label precautions may be subject to civil and/or criminal penalties. FIFRA also requires that the EPA reevaluate older pesticides to ensure that they meet more recent safety standards. FIFRA requires the EPA, states, tribes, and territories to establish programs to protect workers and to provide training and certification for applicators.

A major provision of FIFRA gives EPA the authority to stop the sale or use of any pesticide. The EPA can issue removal orders and seize products to keep them out of the market. Also, state restrictions on pesticides cannot be more liberal than those of FIFRA. Individual states, including Florida, may impose stricter regulations on a pesticide, but the labeling and packaging must be uniform nationwide. Uniform packaging standards include container type, size, and color.

All pesticides are classified according to their toxicity, use pattern, and environmental effects. The two main classifications are unclassified use and restricted use, though unclassified pesticides are commonly referred to as general use pesticides. It should be noted that the EPA has classified very few pesticides as general use. Most pesticides that might be expected to fit into the general use category currently remain unclassified. Normally they have a lower toxicity than restricted use pesticides and so less potential to harm humans or the environment. They can be bought and used by the general public without special permits or restrictions. The EPA classifies a pesticide as restricted use if use of the pesticide might result in an unreasonable adverse effect on human health and/or the environment; however, application by trained persons according to label directions would protect against such an effect. This restricted use classification must be stated on the label (Figure 1.1).

Restricted Use Pesticide

Due to high acute inhalation toxicity and carcinogenicity. 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.

Figure 1.1 Restricted use pesticide designation.

Some active ingredients in pesticides may be listed in both use categories depending on the formulation, the application method, and the intended uses. For example, an emulsifiable concentrate formulation of a certain insecticide used on fruit trees might be classified as restricted use if it contains a high percentage of active ingredient (e.g., 70 percent). But the same chemical with a low percentage of active ingredients (e.g., 5 percent) in a granular formulation used to treat turf insects could be classified as a general use pesticide.

Restricted use pesticides (RUP) may be sold only to certified and licensed applicators. A certified applicator is an individual who has been recognized (certified) by the state, tribe, territory, or agency responsible for regulating pesticides as being competent to use or supervise the use of restricted use pesticides. Certified applicators must know how to read a pesticide label and be able to follow directions to use them properly and safely. Under FIFRA there are two types of pesticide applicators - private and commercial. A private applicator is defined as a certified applicator who uses or supervises the use of any restricted-use pesticide for the purpose of producing an agricultural commodity (e.g., field and forage crops, fruit, vegetables, nursery stock, Christmas trees, greenhouse plants, livestock, etc.) on his/her own property or property he/she rents or leases. Commercial applicators are individuals who use or supervise the use of any restricted use pesticide for any purpose on any property except for those provided for under the definition of a private applicator.

The certification process by all the states, tribes, and territories must be accomplished through EPA-approved programs. Each state is responsible for implementing the certification program. In addition, all states have signed cooperative agreements with the EPA that designate an agency within the state (i.e., FDACS) to enforce the provisions of FIFRA. In some situations, more than one agency within a state may be designated to enforce various components of FIFRA (e.g., some states have structural pest control boards responsible for regulating the structural pest control industry).

States, tribes, territories, and some local jurisdictions have their own legal requirements concerning pesticide use (these are presented in sections of this chapter). You are responsible for knowing about these requirements and complying with them. Be sure you are up-to-date on legal requirements at all governmental levels; laws and regulations are constantly evolving as pesticide application becomes more complex and more is learned about potential hazards. Ignorance of the law is never an accepted excuse for a violation.

Pesticide Registration

No pesticide can be registered or offered for sale unless its labeling provides for reasonable safeguards to prevent injury to humans and adverse effects on the environment. There are several types of registration and exemption actions that enable pesticides to be used in the United States:

- The federal registration of pesticides under Section 3 of FIFRA
- Special local need registrations under Section 24(c)
- Emergency exemptions under Section 18
- Exemption of minimum-risk pesticides from registration under Section 25(b) of FIFRA

Another process involves experimental use permits (EUPs). Under Section 5 of FIFRA, EUPs allow manufacturers to field test pesticides under development. Manufacturers of conventional pesticides are required to obtain experimental use permits before testing new pesticides or new uses of pesticides if they conduct experimental field tests on 10 or more acres of land or one or more acres of water. Biopesticides (i.e., pesticides derived from natural materials) also require EUPs when used in experimental settings.

The EPA also has a role in regulating devices used to control pests. A "device" is any instrument or contrivance (other than a firearm) intended for trapping, destroying, repelling, or mitigating any pest. A black light trap is an example of a device. Unlike pesticides, the EPA does not require devices to be registered with the agency but does require the producing establishment to be registered. Devices are subject to certain labeling, packaging, record-keeping, and import/export requirements.

Pesticide Re-registration

Since the passage of the FIFRA amendments in 1988, the EPA has been conducting a comprehensive review of older pesticides (those initially registered before November 1, 1984) to consider their health and environmental effects and to make decisions about their future use. The EPA examines health and safety data for these pesticide active ingredients and determines whether they are eligible for re-registration. To be eligible, a pesticide must have a substantially complete database and must not cause unreasonable risks to human health or the environment when used in accordance with its approved label directions and precautions.

FIFRA, as amended in 1996 by the Food Quality Protection Act (FQPA), requires that all pesticides meet new safety standards. The EPA must be able to conclude "with reasonable certainty" that no harm will come to infants, children, or other sensitive individuals exposed to pesticides. All pesticide exposures from food, drinking water, and home and garden use must be considered in determining allowable levels of pesticides in food. The cumulative effects of pesticides and other compounds with common mechanisms of toxicity also must be considered.

Through the re-registration program, the EPA is ensuring that older pesticides meet contemporary health and safety standards and product labeling requirements, and that their risks are moderated. In addition, the FQPA created a new program that requires the EPA to review every registered pesticide on a 15-year cycle. The public always will have assurance that pesticides are being reviewed periodically to meet current scientific and regulatory standards.

Florida Pesticide Laws

Pesticide applicators licensed in Florida must know their obligations under Florida law. Several state laws govern certified applicators working in Florida; however, not every Florida law about pesticides necessarily pertains to every applicator (for example, one law pertains only to commercial applicators performing mosquito control). It is also important to realize that certain Florida laws must be understood and obeyed by all certified applicators.

The upcoming sections contain brief discussions about the principal laws governing certified applicators in Florida. The intent is to provide enough information for the reader to be able to answer the question, "Does this particular law apply to me?" The reader should note that the discussions in this unit DO NOT contain the particular language of the laws themselves – to be sure of exactly what a given law requires, one must either carefully read the law or obtain the services of a lawyer.

Three words of legal terminology having completely different meanings that should not be used interchangeably and that licensed applicators should be aware of are:

- **Law:** legal acts written and passed by elected officials (thus, Florida laws are the enforceable acts of the Florida Legislature). The entire organized collection of state law is referred to as Florida Statutes, abbreviated as FS. Each particular law becomes a specifically numbered Chapter of Florida Statutes. For example, Chapter 487 Florida Statutes, abbreviated as Ch 487 FS, contains one Florida law.
- **Rule:** details of the law that will include such things as the price of a licensing fee, the minimum qualifications needed for a particular license, the kinds of information one must keep written records of, etc.
- **Regulation:** collectively, all of the rules that have been written about all of the laws are referred to as regulations.

A copy of a particular law and its rules can be obtained by contacting the government agency responsible for writing the

rules. A listing of the laws and rules that govern various groups of licensed pesticide applicators in Florida is presented in Table 1.1.

State law	Chief topics covered	State agency[1]
Chapter 252 FS	Storage facility and pesticide spill reportage	FDCA
Chapter 388 FS	Public health pest control and applicator licensing	FDACS
Chapter 403 FS	Waste management and container burning	FDEP
Chapter 482 FS	Pest control businesses and applicator licensing	FDACS
Chapter 487 FS	Pesticide registrations and applicator licensing	FDACS

[1]FDCA = Florida Department of Community Affairs; FDACS = Florida Department of Agriculture and Consumer Services; FDEP = Florida Department of Environmental Protection.

Table 1.1 Laws and rules governing pesticide use in Florida.

Chapter 388 Florida Statutes

Often referred as the Florida Mosquito Control Law (Ch 388 FS), this law and its rules govern all applicators engaged in public health or nuisance pest control work except those who use pesticides for such purposes but apply them only to their own property. All aspects of public health pest control, including using aerial equipment for mosquito control or applying pesticides to aquatic areas to control mosquito larvae, are regulated under this law.

This particular law says a pesticide applicator (or his or her immediate supervisor) must be licensed before applying *any class* of pesticide (i.e., either restricted use or general use pesticides) in a public health pest control program. Applicators having a valid public health pest control applicator license who intend to use aerial application equipment must additionally obtain the aerial applicator certification required by the rules.

Typically, applicators licensed under Ch 388 FS are employees of a mosquito control district, county or city government, or are people who offer contract services to control pest insects that may adversely affect public health. The state agency office that administers this law and its rules is a part of the Florida Department of Agriculture and Consumer Services.

Detailed information concerning this law and its rules can be obtained by contacting:

Bureau of Licensing and Enforcement
3125 Conner Blvd., Bldg. 8
Tallahassee, FL 32399-1650
(850) 617-7997

Chapter 482 Florida Statutes

Also known as the Structural Pest Control Act, this law (Ch 482 FS) was originally written to govern the business activities of people who run Pest Control Operator (PCO) businesses. Over the years, various parts of this law and its accompanying rules have been changed. Currently, this law and its rules license and regulate several different kinds of pesticide applicators. Some of these licensed applicators may engage in pest control business; others may not. The various kinds of pesticide applicator activities licensed and governed by this law and its rules are listed in Table 1.2.

Under this Florida law and its rules, only persons who have a valid pest control business license (in one of the four business licensing categories shown in Table 1.2) may solicit, contract for, offer, or conduct pesticide application services on a for-hire basis. This law governs all for-hire pesticide applications except for the following two cases:

- For-hire pesticide applications made by a public health pest control contractor are *not* regulated by Ch 482 FS (for more detail about this group, see the preceding section on Ch 388 FS).
- For-hire pesticide applications made to areas legally defined as "agricultural areas" are not regulated by Ch 482 FS (for more detail about this group, see the following section on Ch 487 FS).

Obtaining a PCO business license in any of the four pest control business categories (see Table 1.2) is usually not a simple matter. First, the person must qualify to take the licensing exam. Qualifying for the exam involves a combination of education and work experience. Details about qualifications and examinations for PCO licensing can be found in the law (Ch 482 FS) and its accompanying rules.

License type	Applicator license category
Pest Control Business	Structural Fumigation Pest Control (contract services to tent and fumigate buildings) Termites and Other Wood-Destroying Organisms Pest Control (contract services using non-fumigants to control termites, carpenter ants, etc.) Lawn and Ornamental Pest Control (contract services to treat trees, shrubs, flower beds, and turfgrass) General Household Pest Control (contract services to treat roaches, ants, etc. in homes, restaurants, etc.)
Limited Certification	Structural Pest Control (non-fumigants applied in public or privately-owned buildings by the building's owner or by his/her full-time employee) Lawn and Ornamental Pest Control (non-fumigants applied to grounds surrounding a public or privately-owned building by the building's owner or by his/her full-time employee) Commercial Landscape Maintenance (certain non-fumigants applied to ornamental plant beds or shrubbery)

Table 1.2 Licenses issued under Ch 482 FS.

As indicated in Table 1.2, Ch 482 FS also enables applicators to obtain various kinds of Limited Certification pesticide applicator licenses. People holding a limited certification license may *not* solicit, contract for, advertise, or engage in, any type of for-hire pesticide applicator business. Other limitations are also imposed; these vary depending upon the particular license category. Each category is described in detail in the law (Ch 482 FS) and its rules. If he or she desires, a person may be licensed in more than one limited certification category at the same lime. In general, a limited certification license in either the Structural Pest Control category or the Lawn and Ornamental Pest Control certification category is intended for the following people:

- Government employees who use pesticides as part of their regular on-the-job duties. (For example, someone who works for a county school board and applies pest control measures in school buildings.)
- Private sector employees who use pesticides as part of their regular on-the-job duties. (For example, a condominium maintenance worker who performs pest control on the condominium's lawns and shrubs or in the clubhouse kitchen and bathrooms.)
- Commercial property owners who use pesticides on their commercial property. (For example, the owner of a rental duplex who performs pest control in the apartments he or she offers for rent.)

Similarly, a limited certification license in the Commercial Landscape Maintenance category is intended for the following people:

- An owner/operator of a for-hire landscape maintenance business who wants to use chemical weed control measures in a customer's shrubbery or ornamental plant beds.
- An employee of a for-hire landscape maintenance business whose job duties include using chemical weed control measures in a customer's shrubbery or ornamental plant beds.

The reader should note that this Ch 482 FS governs the actions of all applicators licensed in any of the seven categories *regardless of the class of pesticide* applied (i.e., either restricted use and general use pesticides). Also, certain provisions govern people other than licensed applicators. For example, this law says no person, including a homeowner treating his own home, except a licensed applicator may legally apply a fumigant pesticide (a true gas) in a residential building.

The state agency office that administers this law and its rules is a part of the Florida Department of Agriculture and Consumer Services. Detailed information concerning this law (Ch 482 FS) and its rules can be obtained by contacting:

Bureau of Licensing and Enforcement
3125 Conner Blvd., Bldg. 8
Tallahassee, FL 32399-1650
(850) 617-7997

Chapter 487 Florida Statutes

Also known as the Florida Pesticide Law, this law (Ch 487 FS) governs the following activities:

- People who must be licensed as Pesticide Dealers (a person must have this license before attempting to sell any restricted use pesticide in Florida).
- People who must be licensed as Pesticide Applicators, but who are not governed by either Ch 388 FS or by Ch 482 FS.

In general, the information in this manual is not intended for Pesticide Dealers. For this reason, dealer licensing is mentioned but not discussed in detail. Persons interested in obtaining a pesticide dealer license should contact the FDACS' Bureau of Compliance Monitoring to request an application (telephone: 850-617-7851).

The remainder of this discussion about Ch 487 FS is for pesticide applicators who:

- Do not work in Public Health Pest Control (see Ch 388 FS).
- Do not operate a Pest Control (PCO) business (see Ch 482 FS).
- Do not work under the terms of a Limited Certification License (see Ch 482 FS).

All others who want to buy and use restricted use pesticides, for anything or anywhere, must first obtain an applicator license as specified in the Florida Pesticide Law (Ch 487 FS) and its accompanying rules. These rules describe three different applicator classes (Table 1.3).

The following is a more detailed description of these Ch 487 FS applicator classes:

A *private applicator* is a licensed applicator who applies restricted use pesticides by ground application for the purpose of producing an agricultural commodity on property owned or rented by the applicator or the applicator's employer.

The license is for owners and employees of farms, ranches, groves, nurseries, gardens, and other establishments that produce agricultural commodities. The license is valid for application of restricted use pesticides for ornamental turf production at a nursery or sod farm, but not for maintenance of ornamentals and turf, such as at a golf course.

A *public applicator* is a licensed applicator employed by a federal, state, county, city, or other local agency or government entity who uses restricted use pesticides on the job. This license is valid only for work performed for the government agency during the course of employment. The following must have a public applicator license:

- Employees of municipal electric companies, city and county parks, government-owned railways, state and federal highway departments, state universities, and water management districts, who use restricted use pesticides on the job.
- Extension agents, public university researchers, and vocational agriculture instructors who use or demonstrate the use of restricted use pesticides must have a public applicator license *including* the demonstration and research category.
- Federal and state personnel conducting pest eradication or control using restricted use pesticides must have a public applicator license *including* the regulatory pest control category.

A *commercial applicator* is a person who uses restricted use pesticides in any agricultural or related area (see category discussion in the following section) for any purpose other than as provided by the other license classifications. This includes the following uses:

- Contract application of restricted use pesticides for someone else (when someone other than the owner or an employee of the firm makes the application).
- Non-contract application of restricted use pesticides for any purpose other than agricultural production, but not including work-related applications made by government employees.

Within the limitations of the particular commercial license, a licensed commercial applicator may also function as either a private applicator or a public applicator.

Pest Control Categories

In addition to defining applicator classes, Ch 487 FS also defines various pest control categories. These categories specify where or how a particular licensed applicator may apply restricted use pesticides. Regardless of license class, each applicator must be licensed in at least one pest control category. An applicator may be licensed in more than one category at the same time. A licensed applicator or trained persons working under direct supervision may make pesticide applications only in accordance with the categories specified on his or her license. A list of the pest control categories is presented in Table 1.4.

Applicator class	Applicator's occupation or employer	Intended purpose of the pesticide applications
Private Applicator	Farmer, rancher, nurseryman, other establishments producing agricultural commodities on their property or their employer's property only	Agricultural commodity production (pesticide applied by the grower or his employee)
Public Applicator	State agency, city or county government, public utility company, university	Pesticide applied by an employee as part of normal job-related duties
Commercial Applicator	For-hire contractors of pesticide applications	For-hire pest control not regulated by Ch 388 FS or Ch 482 FS
	Pesticide applicators working in private industry	Pesticide demonstration and research by private industry; pesticide applications used in private industry to produce marketable products

Table 1.3 Summary of pesticide applicator classes authorized by Ch 487 FS.

Florida-specific Rules

In general, the rules contained in Ch 487 FS focus on matters concerning pesticides themselves. Several rules limit how, when, or where specific pesticides can be used in Florida. These specifically regulated pesticides include:

- Aldicarb
- Bromacil
- Methyl bromide
- Organotin antifouling paints
- Organo-auxin herbicides

There are also miscellaneous rules that specify details about:

- Storing restricted use pesticides
- Proper disposal of certain kinds of waste pesticide materials
- The details of examinations for each applicator type and license category
- Licensing fees
- License renewal and continuing education requirements
- Unlicensed persons working under a licensed applicator's direct supervision
- Records that licensed applicators must keep and how long pesticide records must be maintained
- Who must be contacted in the event of serious accident or injury
- Description of wrongful acts and the types of penalties that may be imposed (fines up to $10,000)

Information in greater detail may be found in the references listed at the end of this chapter in the "Additional Information" section. Information relevant to specific categories is presented in greater detail in the appropriate category exam study manuals.

Chapter 252 Florida Statutes

The Florida Hazardous Materials Emergency Response and Community Right-to-Know Act (Ch 252 FS) requires a person to report the storage of active ingredients of certain pesticides if they are stored in amounts greater than a given quantity. The amount that triggers reportage depends on the active ingredient and the formulation. For some formulations, storing l0 pounds of active ingredient requires a formal report be made.

Any person responsible for a storage site that contains a threshold planning quantity of any pesticide active ingredient listed by the EPA as an extremely hazardous substance must notify the State Emergency Response Commission (SERC), give the location of the storage site, give the name of the person responsible for the storage site, and pay an initial notification fee. Thereafter, the person responsible for the storage site is required to pay an annual registration fee if the site has had a threshold planning quantity of any extremely hazardous substance during the previous calendar year.

Other parts of this law require reporting spills of one pound of active ingredient or more of pesticides listed as extremely hazardous substances. Failure to comply with the notification and reportage requirements, for either storage or spills of listed active ingredients, is punishable by either substantial fines or imprisonment.

The SERC requires the information be submitted on prescribed forms. The necessary forms are provided at no charge, by the SERC. A copy of the law (Ch 252 FS), and the rules that specify the details of the law, a list of the chemicals, and what amount of a chemical triggers reportage, and the

Pest control category	Eligible applicator class(es)	Typical use patterns
Private Applicator	Private	Applications by farmers, nurserymen, and ranchers
Aerial Application	Public or Commercial	*Any pesticide* applied by airplane or helicopter
Agricultural Animal	Public or Commercial	Agency or contractor work treating livestock
Agricultural Row Crop	Public or Commercial	Agency or contractor work in vegetable and field crops
Agricultural Tree Crop	Public or Commercial	Agency or contractor work in groves or orchards
Aquatic Pest Control	Public or Commercial	Agency or contractor work on surface waters or their shorelines
Chlorine Gas Infusion	Public or Commercial	Agency or contractor use of chlorine gas in swimming pools, hot tubs, or spas
Demonstration & Research[1]	Public or Commercial	Agency or contractor work in demonstration or test plots
Forest Pest Control	Public or Commercial	Agency or contractor work in timberland, forest nurseries, or seed orchards
Natural Areas Weed Management	Public or Commercial	Agency or contractor work in conservation and recreation lands and natural communities
Organotin Antifouling Paint	Public or Commercial	Agency or contractor work treating large boats or submersed structures
Ornamental and Turf	Public or Commercial	Agency or contractor work on golf courses, parks, cemeteries, or athletic fields *only*
Raw Agricultural Commodity Fumigation	Public or Commercial	Agency or contractor use of fumigants in harvested and stored crops
Regulatory Inspection and Sampling	Public	Agency work in inspection of pesticides
Regulatory Pest Control	Public	Agency use of pesticides in control of regulated pests
Right-of-Way Pest Control	Public or Commercial	Agency or contractor work treating roadside, pipeline, or power line rights-of-way
Seed Treatment	Public or Commercial	Agency or contractor use of non-fumigants on seeds
Sewer Root Control	Public or Commercial	Agency or contractor work to prevent root growth in sewer lines or pipes
Soil and Greenhouse Fumigation	Public or Commercial	Agency or contractor use of soil fumigants
Wood Treatment	Public or Commercial	Agency or contractor use of wood preservatives

[1]Demonstration and Research is a secondary category issued only in combination with another category.

Table 1.4 Pest control license categories available under Ch 487 FS.

forms needed for making notification can be obtained by contacting:

Florida State Emergency Response Commission
2555 Shumard Oak Blvd
Tallahassee, FL 32399-2100
Telephone: 800-635-7179

Chapter 403 Florida Statutes

The Florida Resource Recovery and Management Act (Ch 403 FS) and its rules regulate open burning - and the rules expressly mention burning emptied pesticide containers. The intent of this law is to have persons consider "alternative" ways, such as recycling, to dispose of emptied containers. In result, the rules place specific limitations on the use of open burning as a container disposal option. These limitations specify:

- Who may burn pesticide containers;
- Where pesticide containers may be burned;
- What kinds of containers may be burned;
- The amount of containers that may be burned at one site;
- The minimum distance between any two burn locations;
- How containers must be prepared before burning;
- The minimum setback distance of the burn site from workers, inhabited buildings, and public roads;
- The time of day that burning must be conducted;
- How (and by whom) the burn must be supervised; and
- What kind of containment structure must be used for the fire.

A copy of the rules that specify the details for open burning of emptied pesticide containers can be obtained by contacting:

Florida Department of Environmental Protection
Division of Waste Management
2600 Blair Stone Road
MS 4500
Tallahassee, FL 32399-2400
Telephone: 850-245-8705
Fax: 850-245-8703

Local Laws

Several state laws discussed in this unit allow county or city laws to also regulate the activities of pesticide applicators. Local laws are known as ordinances. However, local government is limited to regulating only certain kinds of activities having to do with pesticides. For example, local government ordinances about land use or zoning, building codes, waste management, and waste disposal procedures within a given county must be obeyed by licensed pesticide applicators.

Often, the specific details of local ordinances are quite different in neighboring counties. Licensed applicators operating in a particular county or city must be sure to check with local government officials and determine what, if any, specific requirements govern the kinds of work practices mentioned above.

Conclusion

Knowing about and understanding the appropriate Florida laws and rules is *your responsibility*. If something comes up, pleading ignorance of the law will not serve you as a defense. A licensed pesticide applicator is always held to a higher standard of conduct than the standard of conduct legally expected of persons who are not licensed.

Remember, from a practical standpoint, *the label is the law* - it is your best "first source" of information (Figure 1.2). Before handling any given pesticide product, your first action should *always* be to carefully read the product label and follow its directions completely and exactly. But beyond that, you must also know and follow Florida laws and rules.

Figure 1.2 Pesticide labels should be considered the first source of information.

Test Your Knowledge

Q: Which federal agency is responsible for enforcing FIFRA?
A. USDA
B. Department of Homeland Security
C. EPA
D. US Fish and Wildlife Service
A: C

Q: Which statement about FIFRA is false?
A. Approved pesticide labels have the force of law.
B. State restrictions on pesticides can be more liberal than those of FIFRA.
C. The EPA has the authority to remove pesticide products from the market.
D. FIFRA regulates the registration and licensing of pesticide products.
A: B

Q: Which regulatory agency is responsible for administering the three Florida laws that govern applicator licensing?
A. FDEP
B. FDACS
C. FWS
D. SERC
A: B

Q: Which applicator class would a person who is employed by a government agency and applies restricted use pesticides to Florida state highway rights-of-way fall into?
A. Commercial
B. Private
C. General
D. Public
A: D

Q: Who would you contact for information regarding licensing of applicators for application of pesticides to homes and private lawns?
A. FDACS Bureau of Compliance Monitoring
B. FDACS Bureau of Entomology and Pest Control
C. FDACS Bureau of Pesticides
D. FDACS Bureau of Mosquito Control
A: B

Q: Which applicator class would a person who applies restricted use pesticides to their own property for production of agricultural commodities fall into?
A. Commercial
B. Private
C. General
D. Public
A: B

Q: Which applicator class would persons engaged in public health or nuisance pest control work fall into?
A. Commercial
B. Private
C. General
D. Public
A: D

Q: What three pesticide licensing categories are available to those seeking a Limited Certification license?
A: The categories are:
- Limited Structural Pest Control
- Limited Lawn and Ornamental Pest Control
- Limited Commercial Landscape Maintenance

Q: How can the public have assurance that pesticides continuously meet current scientific and regulatory standards?
A: Each pesticide goes through "pesticide re-registration" every 15 years.

Q: Which pesticide is *not* specifically regulated by Florida rules?
A. Bromacil
B. Glyphosate
C. Methyl bromide
D. Aldicarb
A: B

Q: Which agency would you contact for reporting storage of certain pesticide active ingredients if they are stored in amounts greater than a threshold quantity?
A. FDACS
B. FDHP
C. FWS
D. SERC
A: D

Additional Information

Fishel, F.M. 2005. Specifically Regulated Pesticides in Florida - Bromacil. UF/IFAS EDIS Fact Sheet PI-75, http://edis.ifas.ufl.edu/PI112 (accessed February 2014).

Fishel, F.M. 2006. Federal Regulations Affecting Use of Pesticides. UF/IFAS EDIS Fact Sheet PI-131, http://edis.ifas.ufl.edu/PI168 (accessed February 2014).

Fishel, F.M. 2006. Specifically Regulated Pesticides in Florida - Aldicarb. UF/IFAS EDIS Fact Sheet PI-74, http://edis.ifas.ufl.edu/PI111 (accessed February 2014).

Fishel, F.M. 2009. Specifically Regulated Pesticides in Florida – Organotin Antifouling Paints. UF/IFAS EDIS Fact Sheet PI-179, http://edis.ifas.ufl.edu/PI215 (accessed February 2014).

Fishel, F.M., J.A. Ferrell, G.E. MacDonald, and B.J. Brecke. 2012. Florida's Organo-Auxin Herbicide Rule. UF/IFAS EDIS Fact Sheet SS-AGR-12, http://edis.ifas.ufl.edu/WG051 (accessed February 2014).

Florida Department of Agriculture and Consumer Services Bureau of Compliance Monitoring, Pesticide Applicator Certification and Licensing Section, 3125 Conner Drive, Bldg. 8, L-29, Tallahassee, FL 32399-1650, Phone: 850-617-7851, http://www.freshfromflorida.com/Divisions-Offices/Agricultural-Environmental-Services/Agriculture-Industry/Pesticide-Applicator-Certification/Pesticide-Applicator-Certification-Licensing (accessed February 2014).

Nesheim, O.N. and F.M. Fishel. 2008. Proper Disposal of Pesticide Waste. UF/IFAS EDIS Fact Sheet PI-18, http://edis.ifas.ufl.edu/PI010 (accessed February 2014).

UF/IFAS Pesticide Information Office, P.O. Box 110710, Bldg. 164, Gainesville, FL 32611-0710, Phone: 352-392-4721, http://pested.ifas.ufl.edu/ (accessed February 2014).

Chapter II

Principles of Pesticides and Pest Control

Chapter II

TABLE *of* CONTENTS

Learning Objectives

After you complete your study of this chapter, you should be able to:

- Identify the main groups of common pests.
- Understand the meaning of the term "IPM."
- Explain why identification is the first logical step to establish a pest management plan.
- Describe the differences between key, occasional, and secondary pests.
- Explain what is meant by pest management goals, eradication, suppression, and prevention.
- Describe "thresholds" and how they're used in IPM programs.
- Identify reasons why a pesticide application may fail.
- Know how pesticide resistance can develop and ways its development can be minimized.

Terms to Know

Action threshold: The pest level at which some type of pest management action must be taken.

Bioaccumulation: The accumulation of toxic substances, such as pesticides, or other organic chemicals in an organism that occurs when the substance is absorbed at a rate greater than that at which the substance is lost.

Biomagnification: The tendency for certain pesticides to progressively become more concentrated in each type of organism when moving from the bottom to the top organism within a food chain.

Contact pesticide: Pesticide that is not absorbed systemically by treated plants or animals. These pesticides must directly touch the pest or a site the pest frequents to be effective.

Economic threshold: The level where the economic losses caused by pest damage, if the pest population continued to grow, would be greater than the cost of controlling the pests.

Eradication: One of the three primary pest control goals that refers to the total elimination of a pest from a designated area.

Integrated Pest Management (IPM): The coordinated use of pest and environmental information and available pest control methods to prevent unacceptable levels of damage by the most economical means with the least possible hazard to people, property and the environment.

Key pest: A pest that causes major damage on a regular basis.

Mode of action: How the pesticide works – specific system(s) in the pest that are affected by the pesticide.

Occasional pest: A pest that causes damage only once in a while because of its life cycle or environmental influences, or as a result of human activities.

Persistence: Length of time a pesticide remains active to control pests.

Pesticide: Any material that is applied to plants, the soil, water, harvested crops, structures, clothing and furnishings, or animals to kill, attract, repel, or regulate or interrupt the growth and mating of pests, or to regulate plant growth.

Pesticide resistance: The ability of an insect, fungus, weed, rodent, or other pest to tolerate a pesticide that once controlled it.

Prevention: One of the three primary pest control goals that strives to inhibit the onset of a pest outbreak.

Quarantine: Regulatory method to control the introduction and dissemination of pests into new areas.

Residual pesticide: Pesticide that controls pests for weeks, months, or even years.

Secondary pest: A pest that becomes a problem when a key pest is controlled or eliminated.

Selectivity: The degree to which a pesticide will kill a certain type of pest.

Suppression: One of the three primary pest control goals that attempts to reduce pest populations to a tolerable level or to a point below the economic injury level.

Systemic pesticide (translocated): Pesticides that are absorbed by the pest and then transported within the treated pest.

Introduction to Pest Control

Historical records contain many examples of how pests have had major impacts on humans throughout the centuries. One of the most infamous was the Black Plague of Europe when millions of people died in the 14th century from a mysterious scourge. At that time, the loss in human life represented approximately a third of Europe's population. Only centuries later was it determined that a bacterial disease spread by rat fleas was the cause. Rat fleas became infected with bacteria while feeding on diseased rats. When rats were unavailable as a food source, the fleas sought other warm-blooded hosts, often humans, vectoring the disease. Today this disease, known as bubonic plague, can be treated if properly diagnosed. Controlling rats and other rodents and fleas can reduce disease incidence.

One historical occurrence that directly influenced the population of the United States was the destruction of Ireland's potato crop by a pest in the 19th century. A fungal disease called late blight (Figure 2.1) essentially eliminated potatoes. Potatoes not destroyed in the field rotted in storage during the winter. Up to a million Europeans starved to death during the Great Irish Potato Famine, and more than a million migrated to the United States. Late blight continues to be a major problem of potatoes, but today it is managed through the use of resistant cultivars, proper sanitation practices, and fungicides.

Photo UF/IFAS EDIS publication HS-1010

Figure 2.1 Potato late blight.

The above examples illustrate the potential enormity and complexity of pest problems. But what is a pest? A pest is anything that:

- Competes with humans, domestic animals, or desirable plants for food or water.
- Injures humans, animals, desirable plants, structures, or possessions.
- Spreads disease to humans, domestic animals, wildlife, or desirable plants.
- Annoys humans or domestic animals.

Types of pests include:

- Insects, such as roaches, mosquitoes, aphids, and fleas.
- Insect-like organisms, such as mites, ticks, and spiders.
- Microbial organisms (disease-causing organisms), such as bacteria, fungi, viruses, mycoplasmas, and nematodes.
- Weeds are plants growing where they are unwanted.
- Mollusks such as slugs and snails.
- Vertebrates, which include fish, birds, and a variety of mammals, from rats to deer, are competitors for our livestock and crops.

In addition, some pests destroy buildings and other structures and reduce the aesthetic and recreational value of the landscape (Figure 2.2). It is important to understand that not all organisms are pests. In some situations a species may be a pest, but not in others. An organism should not be considered a pest until it is proven to be one. The competition between humans and pests has evolved over time, and so have the methods of control.

Photo UF/IFAS EDIS publication ENY-325

Figure 2.2 Severe chinch bug damage to St. Augustinegrass lawn.

Pest Control – A Historical Perspective

Mystery surrounded the causes of crop failures and human and animal diseases for many centuries. The first pest control measures were crude – weeds were pulled, rats were clubbed, and beetles were plucked from foliage. The earliest known uses of chemicals as pesticides date back to 2,500 B.C., when sulfur was burned to control insects and mites. Through the years, experimentation and good fortune led to the recognition of additional chemicals with pesticidal activity. Early plant-derived insecticides included hellebore to control body lice, nicotine to control aphids, and pyrethrins to control a wide variety of insects. Lead arsenate was first used in 1892 as an orchard spray (Figure 2.3).

In France during the late 19th century, a mixture of lime and copper sulfate was sprayed on grapevines to deter local school children from picking the grapes. By luck, the farmer found the mixture also controlled downy mildew, a serious fungal disease of grapes. Later named Bordeaux mixture, it remains a widely used fungicide worldwide.

Until the 1940s, pest control chemicals were derived from plants and inorganic compounds. During World War II, DDT, a synthetic chemical, played a very important role saving Allied soldiers from insect-transmitted diseases. DDT was hailed as

the insecticide to solve all insect problems. The introduction of countless other synthetic organic pesticides followed. These synthetic products launched the modern-day chemical industry and began a new era in pest control.

Photo UF/IFAS Archives

Figure 2.3 Orchard spraying circa 1900.

Given significant success at a relatively low cost, the use of pesticides became the primary means of pest control. They provided season-long crop protection against pests and complemented the benefits of fertilizers and other production practices. The success of modern pesticides, particularly in agriculture and human health, encouraged widespread acceptance and eventual reliance on them.

In recent years, however, some drawbacks of heavy dependence on pesticides have become increasingly apparent. One of the most disturbing is the development of pest resistance to pesticides. Since the resistance of the San Jose scale to lime sulfur was recognized in 1908, hundreds of insects have become resistant to one or more pesticides worldwide. It was ironic that within only a few years after the introduction of DDT, resistance was confirmed in the housefly in Sweden. Pesticide resistance also has arisen in more than 400 weed biotypes and many plant pathogens. A dramatic example is the Colorado potato beetle in the eastern United States (Figure 2.4). This insect pest has developed resistance to four major groups of insecticides, making control with chemicals difficult to achieve.

Growing concerns about the environmental and health hazards associated with pesticides have also become significant factors challenging pesticide use. In 1962, Rachel Carson published *Silent Spring*, a book that examined pesticides and their effects on the environment. DDT and other chlorinated hydrocarbons were her primary concern because of their stability and persistence in the environment. Their long residual activity was a major factor contributing to their effectiveness, but a negative effect was their ability to accumulate in the fatty tissue of some animals, known as bioaccumulation. In certain situations, biomagnification of the insecticides occurred. Biomagnification is the process whereby some organisms accumulate chemical residues in higher concentrations than those found in the organisms they consume (Figure 2.5). Ecologists refer to a food chain as the sequence of animals feeding in the natural environment. A particular plant, animal, or microorganism is eaten by an animal which is in turn eaten by another animal. At each succeeding level, an animal normally eats a number of individuals from the previous level. Organisms with pesticides in their tissues are eaten by fish, which are in turn eaten by birds. The birds at the top of the food chain accumulate the highest concentration of pesticide residues.

Photo Scott Bauer, USDA Research Service, Bugwood.org

Figure 2.4 Colorado potato beetle.

Photo National Pesticide Applicator Certification Core Manual

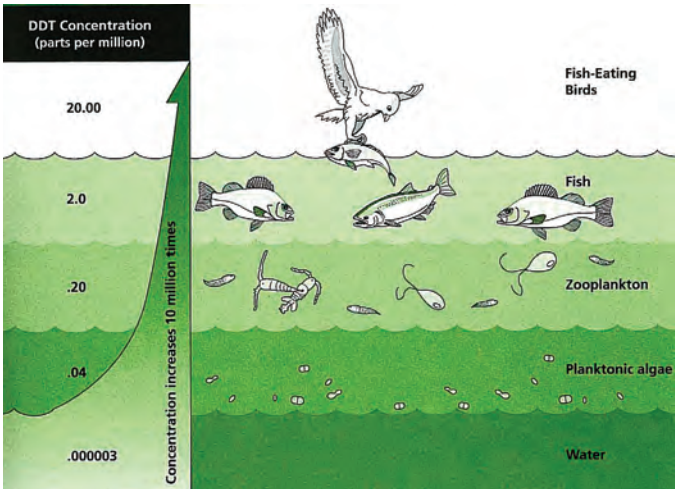


Figure 2.5 Illustration of biomagnification.

Since the publication of *Silent Spring*, the United States has experienced a level of environmental awareness and interest second to no other period in history. The US Environmental Protection Agency (EPA) was created in 1970 with a mandate from Congress. Its task was then, and remains today, to implement by regulation the laws passed by Congress to protect the environment and the health of humans and other

animals. Since the 1972 EPA ban on DDT use in the United States, regulatory action has been taken against many chemicals, including pesticides, thought to pose significant environmental and health hazards. Public concern has led to stringent regulation of pesticides and changes in the types of pesticides used.

Pest Management Methods

Once a pest problem is anticipated or identified, you can begin planning your pest management program. You must know what management methods are available and the benefits and limitations of each. Select methods that are the most effective and the least harmful to people and the environment. Whenever possible, combine the use of several compatible methods into an integrated pest management (IPM) program, and target the pest at the most susceptible stage for control. IPM refers to the coordinated use of pest and environmental information and available pest control methods to prevent unacceptable levels of damage by the most economical means with the least possible hazard to people, property and the environment. Available pest control methods include:

- Biological control
- Mechanical control
- Cultural control
- Physical/environmental modification
- Host resistance or genetic control
- Chemical control
- Regulatory methods

Biological Control

Most pests have natural enemies that control or suppress them effectively in some situations. Natural enemies, including pathogens, are being used successfully as biological control agents to manage certain insect, mite, fungal, fish, and weed pests (Figure 2.6).

Biological control is often directed against pests that are not native to a geographical area. Introduced pests are often problems in their new location because they lack natural enemies to help control them. Biological control involves locating the native home of an introduced pest and finding suitable natural enemies there. After extensive testing and evaluation, selected natural enemies are imported, reared, and released. If successful, the introduced natural enemies become established within large areas and effectively lower target pest populations for long periods of time with no further need for intervention. The process is complicated because it is often difficult to locate the native home of some pests, and natural enemies cannot be released until it is proven that they will not become pests themselves. Laws have been enacted that strictly control the importation of all organisms, including biological control agents, into the United States. Other countries have similar restrictions.

Photo UF/IFAS EDIS publication SS-AGR-96

Figure 2.6 Melaleuca weevil feeding on the foliage of the invasive melaleuca tree.

Biological control also involves the mass release of large numbers of natural enemies into fields, orchards, greenhouses, or other locations to control specific pests. This method usually does not have long-term results, so these natural enemies must be released periodically. Several natural enemies are reared or cultured commercially. Predatory mites are used to control plant-feeding spider mites (Figure 2.7). Parasitic wasps and lacewings are used to control various insect pests. Nematodes and fungi are being studied as biological control agents for certain weeds and some insects. General predators such as praying mantids and lady beetles are sold with claims made for biological control. In many cases, however, their effectiveness has not been established.

Maintaining populations of natural enemies by avoiding damaging cultural practices or the indiscriminate use of pesticides can be one of the most economical means of control. If pesticides are part of your control program, select types that are known to be less toxic to natural enemies or, if recommended, apply pesticides at lower-than-label rates to avoid harming natural enemies. Sometimes it is possible to modify certain parts of the environment, such as by planting crops or ground covers, to maintain or enhance natural enemies.

Photo UF/IFAS EDIS publication EENY-359

Figure 2.7 Predatory mite.

Mechanical Control

Mechanical control involves the use of devices, machines, and other physical methods to control pests or alter their environment. Traps, screens, barriers, fences, and nets are examples of devices used to prevent pest activity or remove pests from an area.

Cultivation is one of the most important methods of controlling weeds. It is also used for some insects and other soil-inhabiting pests. Mechanical devices such as plows (Figure 2.8), disks, mowers, cultivators, and bed conditioners physically destroy weeds or control their growth and disrupt soil conditions suitable for the survival of some microorganisms and insects.

Figure 2.8 Mechanical plowing of field.

Exclusion is a mechanical control technique that consists of using barriers to prevent pests from getting into an area. Window screens, for example, exclude flies, mosquitoes, and other flying insects. Patching or sealing cracks, crevices, and other small openings in buildings can exclude insects, rodents, bats, birds, or other pests. (Figure 2.9) Fences and ditches make effective barriers against many vertebrate pests. Wire or cloth mesh excludes birds from fruit trees. Sticky material painted onto tree trunks, posts, wires, and other objects prevents crawling insects from crossing.

Photo UF/IFAS EDIS publication ENY-268

Figure 2.9 Bat netting.

Traps physically catch pests within an area or building. Several types of traps are commonly used. Some kill animals that come in contact with them. Others snare animals so they can then be relocated or destroyed. Traps are either mechanical devices or sticky surfaces. (Figure 2.10)

Figure 2.10 Rodent bait station.

Cultural Control

The goal of cultural control is to alter the environment, the condition of the host plant or site, or the behavior of the pest to prevent or suppress an infestation. It disrupts the normal relationship between the pest and the host plant or site and makes the pest less likely to survive, grow, or reproduce. Cultural practices and sanitation are two examples of cultural control.

Many cultural practices influence the survival of pests. In turf, mowing, irrigation, aeration, and fertilization are all important ways of producing healthy turf and preventing pest buildup and damage (Figure 2.11). In agricultural crops, selection of crop plant varieties, timing of planting and harvesting, irrigation management and timing, crop rotation, and use of trap crops help reduce populations of weeds, microorganisms, insects, mites, and other pests. Weeds also can be managed by mulching (with plastic, straw, shredded bark, or wood chips) and by using cover crops.

Figure 2.11 Mowing – a form of cultural control.

Sanitation, or source reduction, involves eliminating food, water, shelter, or other necessities important to the pest's survival. In crop production, sanitation includes such practices as removing weeds that harbor pest insects or rodents, eliminating weed plants before they produce seed, destroying diseased plant material or crop residues, and keeping field borders or surrounding areas free of pests and pest breeding sites. Animal manure management is an effective sanitation practice used for preventing or reducing fly problems in poultry and livestock operations. In non-agricultural areas, certain pests are controlled by draining standing water. Closed garbage containers and frequent garbage pickup eliminate food sources for flies, cockroaches, and rodents; removing soil, trash, and other debris from around and under buildings reduces termite and fungal rot damage and prevents rodent nesting.

Physical/Environmental Modification

Pests that occur in enclosed areas may sometimes be suppressed by altering physical and environmental conditions such as water, air movement, temperature, light, and humidity. Refrigeration, for example, protects stored food products, furs, and other items from insect pests: Lowered temperatures can either kill the insect pests, causing them to stop feeding, or prevent egg hatching or development. Lowering the humidity of stored grains and other food products reduces damage from molds and some insects. Increasing air movement in glass or plastic houses often helps to suppress fungal diseases from developing on plants (Figure 2.12).

Figure 2.12 Altering environmental conditions can be achieved in greenhouses.

Host Resistance or Genetic Control

Sometimes plants and animals can be bred or selected to resist specific pest problems. For example, particular livestock breeds are selected for physical characteristics that prevent attack by some pests or provide physiological resistance to disease or parasitic organisms. Resistance also is enhanced by maintaining the host's health and providing for its nutritional needs. Certain plant varieties are naturally resistant to insects, pathogens, or nematodes. Many plants actually repel various types of pests, and some contain toxic substances. Plant resistance to insect pests can sometimes be achieved by transferring genetic material from certain insect-destroying microorganisms to hybrid seed. Genetic control has been widely used in the past and offers great promise for the future, especially when combined with new gene manipulation techniques.

Chemical Control

Chemical controls are pesticides that are either naturally derived or synthesized. Pesticides often play a key role in pest management programs and frequently may be the only control method available. Major benefits associated with the use of pesticides are their effectiveness, the speed and ease of controlling pests, and, in many instances, their reasonable cost compared with other control options. Usually pest damage stops or pests are destroyed within a few hours (for insects) to a few days (for weeds) after application of a pesticide. Using a fungicide may provide immediate, short-term protection against microorganisms.

A pesticide is defined as any material that is applied to plants, the soil, water, harvested crops, structures, clothing and furnishings, or animals to kill, attract, repel, or regulate or interrupt the growth and mating of pests, or to regulate plant growth. Pesticides include a wide assortment of chemicals with specialized names and functions. They are commonly grouped according to the type of pest they control (Table 2.1).

Each group of pesticide includes several classes or families. For example, the classes of insecticides include, among others, the organophosphates, organochlorines, carbamates, pyrethroids, botanicals, insecticidal soaps, and microbials. The pesticides within a particular class have similar chemical structures or properties or share a common mode of action. The mode of action of a pesticide is how the pesticide works. In other words, it is what specific system(s) in the pest are affected by the pesticide. The various classes of chemicals work in different ways and present different risks and problems.

Pesticides also vary in their selectivity. Fumigants, for example, are non-selective, controlling a wide variety of pests – fungi, insects, weeds, nematodes, etc. Some non-selective herbicides control any plant given a sufficient dose. In contrast, selective products control only certain species of pests or affect only a certain stage of pest development. For example, certain herbicides control broadleaf weeds while not harming grasses, and ovicides kill only the eggs of certain insects, mites, and related pests.

Pesticides may move in various ways after they come in contact with a host. Systemic pesticides are absorbed through leaves or roots and then translocated within the treated plant. Similarly, systemic insecticides can be eaten by or injected into livestock to control certain pests. By contrast, contact pesticides are not absorbed by treated plants or animals. These pesticides must directly touch the pest or a site the pest frequents to be effective.

Pesticides also vary in their persistence, or how long they remain active to control pests. Some residual pesticides control pests for weeks, months, or even years. Others provide only short-term control, sometimes lasting only a few hours.

Pesticide	Target pests/action
Avicides	Birds
Bactericides	Bacteria
Disinfectants (antimicrobials)	Microorganisms
Fumigants	Non-selective control of many classes of pests
Fungicides	Fungi
Herbicides	Weeds and undesirable plants
Insecticides	Insects and related arthropods
Miticides (acaracides)	Mites
Molluscicides	Snails and slugs
Nematicides	Nematodes
Ovicides	Eggs of insects, mites, and related pests
Predacides	Predatory vertebrates
Piscicides	Pest fish
Repellents	Repel insects, related invertebrates, birds, and mammals
Rodenticides	Rodents
Defoliants	Cause leaves of foliage to drop from plants
Desiccants	Promote drying or loss of moisture from plant tissues
Growth regulators	Alter the growth or development of a plant or animal

Table 2.1 Pesticides and the pests they target.

Regulatory Methods

Some pest problems cannot be controlled successfully at a local level. These problems involve pests that seriously endanger public health or are likely to cause widespread damage to agricultural crops or animals, forests, or ornamental plants. Quarantine or eradication programs directed by governmental

agencies according to federal and state laws are used to prevent the introduction and spread of such pests.

Quarantine is a pest control process designed to prevent entry of pests into pest-free areas. Regulatory agencies monitor airports and ocean ports. Quarantine also prevents movement of designated pests within a state. Produce and other identified items being shipped from a quarantine area must be fumigated to destroy pests before shipment. Nursery stock, plant cuttings, and budding and grafting material are also regulated to prevent the spread of pests.

In Florida, the FDACS' Bureau of Uniform Services is the first line of defense at Florida's borders to protect agriculture (Figure 2.13). The Bureau operates 23 agricultural interdiction stations located on every paved highway crossing the natural boundary of the Suwannee and St. Mary's rivers. Agricultural vehicle inspections are conducted at each location around the clock, 365 days a year, by 224 law enforcement personnel.

Figure 2.13 FDACS utilizes the latest technology at its inspection stations.

These officers support and supplement all FDACS' regulatory and law enforcement programs by conducting inspections of highway shipments of agricultural, horticultural, aquacultural, and livestock commodities. These regulations and programs ensure compliance with federal and state marketing agreements and various laws, rules and regulations implemented to provide the consuming public a quality food product and/or prevent, control and eradicate specific plant and animal pests and diseases which could economically devastate segments of Florida's agricultural industry.

Eradication is the total elimination of a pest from a designated area. Often, these pests are under quarantine restrictions. When eradication is required, the geographical extent of pest infestation is determined and control measures are taken to eliminate this pest from the defined area. Procedures may include an area-wide spray program, releasing sterile insects, using mechanical and cultural practices, and intensive monitoring for pests within and around the borders of the infested area.

Government agencies are authorized to destroy weeds and plants that cause fire hazards, harbor harmful pathogens or animals, or are noxious to people or livestock in and around agricultural areas (Figure 2.14). Similar authority applies to diseased or infected livestock or poultry and to weeds and nuisance plants in residential, commercial, and industrial areas.

Mosquito abatement is an important pest control function undertaken to protect public health. Under the authority of mosquito abatement laws, state agencies drain or treat standing water that provides breeding sites for mosquitoes.

Figure 2.14 Kudzu – a legally regulated weed in Florida.

IPM: A Logical Step-by-Step Process

All of the components of an IPM approach can be grouped into five major steps:

1. Pest identification
2. Monitoring the population
3. Developing a goal
4. Putting IPM to work
5. Evaluating the results

Pest Identification

Accurate identification is the first step in an effective pest management program (Figure 2.15). Never attempt a pest control program until you have accurately identified the pest. The more you know about the pest and the factors that influence its development and spread, the easier, more cost-effective, and more successful your pest control will be.

Correct identification of a pest allows you to determine basic information about it, including its life cycle and the time it is most susceptible to being controlled. Your local UF/IFAS Extension office can provide assistance.

Figure 2.15 Accurate identification is the key first step in pest management.

To be able to identify and control pests, you need to know:

- The physical features of the pests likely to be encountered
- The characteristics of the damage they cause
- Their development and biology
- Whether they are key, occasional, or secondary pests
- Your pest control goal is: prevention, eradication, or suppression

Most pests may be classified either as *key pests*, *occasional pests*, or *secondary pests*.

Key pests may cause major damage on a regular basis unless they are controlled. Many weeds, for example, are key pests because they compete with crop or ornamental plants for resources and require regular control efforts to prevent or reduce damage.

Occasional pests become troublesome only once in a while because of their life cycles or environmental influences, or as a result of human activities. For instance, ants sometimes become occasional pests when sanitation practices change, providing them with food where previously none existed. They also may move into buildings after a rainfall or other event destroys an outdoor food source.

Secondary pests become problems when a key pest is controlled or eliminated. For example, some weed species become pests only after key weeds, which are normally more successful in competing for resources, are controlled. Certain species of fleas, ticks, and blood-feeding bugs attack people only when their natural hosts, such as pet dogs or cats, are no longer present.

Monitoring the Population

The key to a successful IPM program is regular monitoring. Monitoring involves measuring pest populations and/or the resulting damage or losses (Figure 2.16). The procedures for monitoring vary with the pest and the situation.

Figure 2.16 Monitoring refers to measuring the pest population.

Scouting and trapping are commonly used to monitor insects and their activity (Figure 2.17). Weather and temperature data are particularly helpful to determine a pest's life cycle or to predict how long it takes a certain pest to develop. Models have been developed for a number of insects and plant diseases to predict the need for and timing of pesticide applications.

Figure 2.17 Sticky trap for monitoring indoor pests.

Thresholds are the levels of pest populations at which you should take pest control action if you want to prevent pests in an area from causing unacceptable injury or harm. Thresholds may be based on aesthetic, health, or economic considerations. These levels, which are known as "action thresholds," have been determined for many pests.

A threshold often is set at the level where the economic losses caused by pest damage would be greater than the cost of controlling the pests if the pest populations continued to grow. These types of action thresholds sometimes are called "economic thresholds."

In some pest control situations, the threshold level is zero. Even a single pest in a situation is unreasonably harmful. For example, the presence of any rodents in food processing facilities forces action. In homes, people generally take action to control some pests, such as rodents or roaches, even if only one or a few have been seen.

Developing a Goal

The goal of most IPM programs is to maintain pest damage at economically acceptable levels. Once the goal of the program has been determined, the strategy for a sound IPM program is to coordinate the use of multiple tactics into a single integrated system. There are three primary pest control goals: *prevention*, *suppression*, and *eradication*. In many situations, some combination of two or all of these goals is utilized.

Prevention. Often economical and environmentally sound ways are available to prevent loss or damage from pests. Such techniques include planting weed- and disease-free seed and growing varieties of plants resistant to diseases or insects. Other choices are using cultural controls to prevent weedy plants from seeding and choosing planting and harvesting times that minimize pest problems. Sanitation methods often reduce the buildup of pests. Other preventive methods involve excluding pests from the target area or host and using practices that conserve natural enemies. Making sure that plants, poultry, or livestock receive adequate water and nutrients often reduces stress and susceptibility to diseases or pests.

Pesticides are sometimes used for pest prevention. For instance, growers treat some crops and landscapes with preplant or preemergence herbicides because they know weed seeds are present (Figure 2.18). If plant pathogens have already infected susceptible plants, economic damage usually cannot be prevented. For this reason, fungicides are normally applied before infection occurs whenever environmental conditions favor infection. Likewise, pesticides are applied to structural lumber before construction to protect it from insects and fungi.

Suppression. Suppressive pest control methods are used to reduce pest population levels. The methods chosen usually do not eliminate all pests but reduce their populations to a tolerable level or to a point below an economic injury level. Additional suppressive measures may be required. Suppression sometimes lowers pest populations so natural enemies are able to maintain control. Suppression is the goal of most pesticide applications. Other techniques, such as cultivation or mowing of weeds and release of biological control agents, are also used to suppress pest populations.

Figure 2.18 Applying preemergence herbicide for weed prevention.

Eradication. Eradication is the total elimination of a pest from a designated area. This is a common objective of pest control efforts in buildings or other small, confined spaces where, once the pest is eliminated, it can be excluded. For example, eliminating cockroaches, rats, and mice from commercial food establishments involves eradication. Over larger areas, however, eradication is very expensive and often has limited success. Large eradication programs are usually directed at exotic or introduced pests posing an area-wide public health or economic threat. Such programs are generally coordinated by governmental agencies. Efforts to eliminate Mediterranean fruit fly and hydrilla (an aquatic weed) in Florida are examples of this type of pest management (Figure 2.19).

The pest control strategy you choose depends on the nature of the pest, the environment of the pest, and economic or tolerance considerations. Combining prevention and suppression techniques usually enhances a pest management program. Objectives sometimes differ, however, for the same pest in different situations.

Putting IPM to Work

The following steps should be taken before implementing an IPM program:

- Identify the pest.
- Set up a monitoring program.
- Know the pest level that triggers control.
- Know what control methods are available.
- Evaluate the benefits and risks of each method.

When implementing the IPM program, try to select the methods that are the most effective and the least harmful to people and the environment. Use several methods whenever possible, and be sure to use them correctly. It is also important to observe all local, state, and federal regulations regarding the methods chosen.

Top Photo: UF/IFAS EDIS publication Circular 707
Bottom Photo: Scott Bauer, USDA Research Service, Bugwood.org

Figure 2.19 Eradication is the goal for managing hydrilla and Mediterranean fruit fly.

Evaluating the Results

It is extremely important to record and evaluate the results of your control efforts. Some control methods, especially non-chemical procedures, are slow to yield measurable results. Other methods may be ineffective or even damaging to the target crop, animal, treated surface, or natural predators and parasites. Consider how well your strategies work and their impact on the environment before implementing them again.

When a Pesticide Doesn't Work

Pesticides are valuable additions to the box of tools available to pest managers. However, they should be considered as one part of the total IPM plan rather than the only solution. Pesticide failure can occur for a variety of reasons:

- Improper pest identification (incorrect pesticide selection)
- Incorrect pesticide dosage
- Improper application timing
- Pesticide does not reach target pest
- Unfavorable environmental conditions
- Poor pesticide condition due to unsuitable storage conditions
- Pesticide resistance

Pesticide Resistance

Pesticide resistance can be defined as the ability of an insect, fungus, weed, rodent, or other pest to tolerate a pesticide that once controlled it.

Populations of animals and plants possess the ability to respond to sustained changes or stresses in their environment in ways that enable the continued survival of the species. Such environmental stresses include physical factors such as temperature or humidity, biological factors such as predators, parasites, or pathogens, and environmental contaminants. In any population, a small percentage of individuals will be better able to respond to new stresses because of unique traits or characteristics that they possess. Consequently, those individuals will survive and reproduce.

Many pest species, such as insects and plant pathogens, are exceptionally well-equipped to respond to environmental stresses because of their short generation time and large reproductive potential. The use of chemical sprays to control some of these pests creates a potent environmental stress. There are now many examples of pests that have responded by developing resistance to one or more pesticides. The mechanisms of resistance can vary according to pest species and/or the class of chemical to which the pest is exposed. Resistance mechanisms include:

- An increased capacity to detoxify the pesticide once it has entered the pest's body.
- A decreased sensitivity of the target site that the pesticide acts upon.
- A decreased penetration of the pesticide into the pest.
- An impoundment of the pesticide within the organism.

Because the traits for resistance are passed from one generation to the next, continued stress from a pesticide may, over time, create resistance in the majority of individuals in a population. From an operational perspective, this process would be expressed as a gradual decrease and eventual loss of effectiveness of a chemical.

Of the factors that affect the development of resistance, which include the pest's biology, ecology and genetics, only the operational factors can be manipulated by the pesticide manager. The key operational factor that will delay the onset of pesticidal resistance and prolong the effective life of a compound is to assure the survival of some susceptible individuals to dilute the population of resistant individuals. The following operational procedures should be on a manager's checklist to steward sound pesticidal resistance management for pesticides:

- Never rely on a single pesticide class.
- Integrate chemical control with effective, complementary cultural and biological control practices.
- Always use pesticides at recommended rates and strive for thorough coverage.
- When there is more than one generation of pest, alternate different pesticide classes.
- Do not use tank mixtures of products that have the same mode of action.
- If control with a pesticide fails, do not re-treat with a chemical that has the same mode of action.

Conclusion

To be successful, a pest management program must start with the proper identification of the pest. Choosing the appropriate pest control method depends on recognizing and understanding the pest, its life cycle, habits, and habitat. IPM programs attempt to balance the need for pest control with the desire to protect the environment from risks associated with pesticide use. IPM methods include both chemical and non-chemical means to prevent and control pest populations from reaching economically damaging levels. These prevention and control tactics include biological, mechanical, cultural, physical, genetic, chemical, and regulatory methods.

Monitoring techniques used in IPM programs are critical to knowing when and what type of control measures to apply. Monitoring also helps to establish pest population thresholds that may be used for deciding when pest control action should be taken. Evaluation and recording results help to determine how well the IPM program is working and whether there are any harmful human or environmental effects.

Minimizing pesticide resistance is also an important consideration for sustaining the effectiveness of pest management programs. Many tools and techniques are available that prevent or delay the occurrence of pesticide resistance. Whenever chemical controls are used, it is critical to read and follow all label directions correctly to avoid misapplication.

If the pest has not been properly identified, even nonchemical means of pest control will fail. It is the applicator's responsibility to consider all of the factors relevant to the pest control situation. Beyond simply identifying the pest and choosing a control strategy, the applicator must consider the effects of pest control actions on the entire treatment site, whether an outdoor area or inside a structure. Use good judgment, especially when pesticides are part of the control strategy, to avoid harmful effects to other living organisms and the environment.

Test Your Knowledge

Q: Using barriers to prevent pests from getting into an area is an example of which type of pest management method?
A. Biological control
B. Mechanical control
C. Genetic control
D. Chemical control
A: B

Q: Lowering the humidity of stored grains and other food products to reduce damage from mold is an example of which type of pest management method?
A. Biological control
B. Mechanical control
C. Physical/environmental modification
D. Regulatory pest control
A: C

Q: Sealing cracks and crevices in buildings is an example of which type of mechanical control method?
A. Exclusion
B. Trapping
C. Cultivation
D. Mulching
A: A

Q: Which would be considered a preventive pest management strategy?
A. Planting weed- and disease-free seed
B. Releasing natural enemies to help reduce pest populations
C. Eliminating rodents from a commercial food establishment
D. Removing a pest from an area that is a public health concern
A: A

Q: Which would increase the likelihood of pesticide resistance?
A. A pest that has only one generation per year
B. Continual use of the same pesticides from the same chemical family
C. Limiting the number of pesticide applications
D. Applying a pesticide that has little or no residual effect
A: B

Q: What is the first logical step in a pest management plan?
A. Selecting a control measure
B. Evaluation of the control strategy
C. Identifying the pest
D. Spraying a pesticide
A: C

Q: Which IPM term best describes reduction of a pest population to a level where the harm caused by the pest is acceptable?
A. Suppression
B. Eradication
C. Elimination
D. Prevention
A: A

Q: What is the term that identifies a pest that causes major damage on a regular basis?
A. Potential pest
B. Secondary pest
C. Noxious pest
D. Key pest
A: D

Q: What is the process whereby some organisms accumulate chemical residues in higher concentrations than those found in the organisms they consume?
A. Cumulative effect
B. Biomagnification
C. Bioaccumulation
D. Ecological progression
A: B

Additional Information

Fishel, F.M. 2006. When a Pesticide Doesn't Work. UF/IFAS EDIS Fact Sheet PI-163, http://edis.ifas.ufl.edu/PI200 (accessed February 2014).

Rogers, M.E. and M.M. Dewdney. 2012. Florida Citrus Pest Management Guide: Pesticide Resistance and Resistance Management. UF/IFAS EDIS Fact Sheet ENY-624, http://edis.ifas.ufl.edu/CG026 (accessed February 2014).

Chapter III

Understanding Pesticide Labeling

Chapter III

TABLE *of* CONTENTS

Learning Objectives

After you complete your study of this chapter, you should be able to:

- Explain the differences between the following types of pesticide registration:
  - Section 3
  - Special Local Needs (SLN)
  - Emergency Exemption

- Define the term, "minimum risk pesticide."
- Explain the difference between a label and labeling.
- Understand what the four major label components consist of.
- Explain the difference in the meaning of label signal words.
- Describe the purpose of Safety Data Sheets.
- Understand the following label concepts:
  - Statement of Practical Treatment
  - Child Hazard Warning
  - Hazards to Humans and Domestic Animals
  - Personal Protective Equipment
  - Environmental Hazards
  - Use Classification
  - Brand, Common, and Chemical Names
  - Ingredient Statement
  - Net Contents
  - EPA Registration Number
  - EPA Establishment Number
  - Name and Address of Manufacturer
  - Formulation
  - Physical or Chemical Hazards
  - Limited Warranty and Disclaimer
  - Directions for Use
  - Storage and Disposal

Terms to Know

Active ingredient: The substance in a pesticide product that is intended to kill, repel, or otherwise control a target pest.

Acute effect: An illness that becomes apparent soon after an exposure to a pesticide occurs.

Application rate: Pertaining to the amount of pesticide that is applied to a known area, such as an acre.

Brand name: Name under which the manufacturer sells the product.

Caution: The signal word used on labels of the least toxic pesticides.

Certified applicator: A person who has demonstrated through an examination process the ability to safely handle and apply restricted use pesticides.

Chemical name: The official name given to a chemical compound to distinguish it from other chemical compounds.

Common name: The recognized, nonscientific name given to pesticides.

Danger: The signal word used on labels of highly hazardous pesticides due to serious health or environmental hazards.

Directions for use: The instructions found on pesticide labels indicating the proper procedures for mixing and application.

Emergency Exemption Registration: Registration that allows the sale and use of a certain pesticide product for a specific non-registered purpose during a specified period of time when there is no pesticide registered for that use.

Establishment number: A number assigned to registered pesticides by the US EPA that indicates the location of the manufacturing or formulation facilities of that product.

Formulation: A mixture of active ingredient combined during manufacture with inert ingredients.

Inert ingredients: All materials in the pesticide formulation other than the active ingredient. Some inert ingredients may be toxic or hazardous to people.

Labeling: The pesticide label and all associated materials, including supplemental labels, special local needs registration information, and manufacturer's information. The label is a legal document.

Minimum risk pesticide: EPA-exempted pesticide not requiring registration and considered to pose minimum risk to humans and the environment, provided the products satisfy certain conditions.

Personal protective equipment (PPE): Devices and garments that protect handlers from exposure to pesticides. These include coveralls, eye protection, gloves, boots, respirators, aprons and hats.

Registration number: Numbers assigned to a pesticide product to identify that the product has been approved by the US EPA.

Restricted Entry Interval (REI): A period of time that must elapse between application of a pesticide and when it is safe to allow people into the treated area without requiring that they wear PPE and receive early-entry worker training.

Restricted use pesticide: A pesticide which, when applied in accordance with its directions for use, warnings, and cautions and for uses for which it is registered or for one or more such uses, or in accordance with a widespread and commonly recognized practice, may generally cause, without additional regulatory restrictions, unreasonable adverse effects on the environment, or injury to the applicator or other persons.

Section 3 Registration: Federal EPA full registration of a pesticide – the most common type of pesticide registration

Signal word: One of three words (Danger, Warning, Caution) found on pesticide labels to indicate the relative hazard of the chemical.

Special Local Needs (SLN) Registration: Type of registration that allows individual states to expand or limit the uses of certain registered pesticides within their jurisdictions.

Statement of practical treatment: A section of the pesticide label that provides information on treating people who have been exposed to the pesticide. This includes emergency first aid information.

Toxicity: The degree or extent that a chemical or substance is poisonous.

Warning: The signal word used on labels of pesticides considered to be moderately toxic or hazardous.

Introduction

Pest problems occur in diverse settings from agricultural to commercial and residential. In Florida, pest control is a year-round consideration. Many times a pesticide will be chosen as part of the pest management plan for the problem. If a pesticide will be part of the management plan, understanding the contents of the pesticide label is essential for the product's safe and effective use.

The pesticide label is a very expensive document. The information on the pesticide label represents the research, development and registration procedures that a pesticide must undergo before reaching the consumer at the market, costs millions of dollars to the manufacturer. The US Environmental Protection Agency (EPA) requires a manufacturer to submit data from nearly 150 tests prior to that product's approval for use, including toxicity, environmental persistence and many other factors that may affect how the pesticide will be safely and effectively used. The pesticide use information obtained in this process is referred to as the label or labeling, two similar words but with different meanings.

The **label** is the information printed on or attached to the pesticide container. It has several interpretations. To the manufacturer, the label is the product's clearance to sell to consumers. To governmental agencies, including the EPA, the label is a way to control the distribution, storage, sale, use and disposal of the product. To the buyer or user, the label should be considered as the main source of information describing how to use the product correctly, legally and safely.

Labeling refers to all the information that you might receive from the company, their sales representatives or a local pesticide dealer about the product. This information may include brochures, flyers and other information accompanying the product.

Properly interpreting the pesticide label is crucial to selecting the most appropriate pesticide products for use and therefore receiving maximum benefit from their use. The length of a pesticide label varies widely, ranging from one to many pages of very fine print. While the label may seem overwhelming at first, it does not require a great amount of time to understand the information once the general format is recognized. Label content for a single product changes frequently. Applicators of pesticides should review labels of products they will be using on a regular basis.

You should read the pesticide label:

- Before purchasing the pesticide to ensure that it is the correct one for the job,
- Before mixing the pesticide to ensure the proper pesticide concentration,
- Before applying the pesticide to ensure proper use, and
- Before storing of excess chemical or disposal of the empty container.

Information contained on most labels can be divided into four major categories: safety, environmental, product and usage. This chapter discusses the contents of these categories and provides interpretations.

Figure 3.1 Pesticide labels should be consulted prior to buying, mixing, applying and storing a pesticide.

Types of Pesticide Registration

Applicators are responsible for applying only pesticides registered or exempted from registration by the EPA and Florida. These applicators may encounter two major types of

EPA registrations: Section 3 standard registration or Section 24(c) special local need. In addition, the EPA also allows emergency exemptions from registration (Section 18). Some pesticides, known as "minimum risk pesticides," require no EPA registration.

Section 3 Registrations

Federal EPA or Section 3 registrations are the most common. Section 3 registrations are granted under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA). Look for the official EPA registration number that must appear on the label (except for products that the EPA classifies as minimum-risk pesticides) to be sure you are buying an approved product.

Special Local Needs Registrations

Occasionally pest problems arise that cannot be managed with currently registered pesticides. Sometimes the commodity, target, or site is not on the registered pesticide label. In some situations, you can request a special local need (SLN) registration or an emergency exemption. Special local need (SLN) registrations are categorized as 24(c) registrations. They allow states to expand or limit the uses of certain registered pesticides within their jurisdictions. For instance, some SLNs allow uses of pesticides for crops or sites not listed on the label. Others add limitations to the uses of a federally registered pesticide to accommodate area-specific conditions. Manufacturers must provide supplemental labeling for each SLN registration.

You must have the SLN labeling in your possession to use the pesticide for that purpose. The registration numbers of special local need labeling include the SLN number and the code for the state issuing the registration. These registrations are legal only in the region, state, or local area specified in the labeling. Applying a pesticide that has an SLN registration from another state or region makes you subject to civil and criminal penalties.

Emergency Exemptions

Emergency exemptions address pest problems for which no pesticides are registered. The EPA can issue an emergency exemption at the request of the state regulatory agency. First, the state must acknowledge the need and consider it appropriate. Usually these needs are based on specific public health quarantine emergencies or crises that require the use of an unregistered pesticide. There must be no feasible alternative to the exemption. Known as a Section 18 exemption, it allows the sale and use of a certain pesticide product for a specific non-registered purpose during a specified period of time.

Regulations impose strict controls and require recordkeeping for all emergency uses. You must understand the special requirements and responsibilities involved whenever you use pesticides with emergency exemptions. The state pesticide regulatory agency prescribes application rates, safety precautions, and other vital application information. Applicators must have a copy of the Section 18 approval in their possession to legally use the product. Although they are often referred to as "labels" or "labeling," Section 18 use instructions are not true labels. The products have not been registered by the EPA. Applicators can, however, follow the instructions found on a copy of the EPA approval letter to the state authorizing the Section 18 exemption.

Minimum Risk Pesticides

In 1996, the EPA exempted from registration certain pesticides considered to pose minimum risk to humans and the environment, provided the products satisfy certain conditions. These products were exempted partly on the basis of their minimum-risk status and partly as an effort by the EPA to reduce the cost and regulatory burden on businesses. In addition, this allowed the EPA to focus its limited resources on pesticides that pose a greater risk.

Products identified as exempt under Section 25(b) of FIFRA do not require EPA label approval and do not undergo review by the agency. Furthermore, they have no label requirements for an EPA registration number, an EPA establishment number, any signal word, or any personal protective equipment (PPE).

To qualify for a Section 25(b) exemption from registration, each of the active ingredients in any such product must be on a list of specified minimum risk active ingredients. In addition, any inert ingredients in these products must also be listed as minimum risk inert ingredients.

Label requirements were established by the EPA for minimum-risk pesticides. Product labels may not claim to control microorganisms that pose a threat to human health. For example, the label may list a pest such as a mosquito or tick, but it must not claim to control any microorganisms that the pest transmits to humans.

Parts of the Label

Information contained on most labels can be divided into four major categories: safety, environmental, product and use.

This chapter discusses the contents of these categories and provides interpretations.

Safety Information

Child Hazard Warning

The front panel of every pesticide label must bear the statement, "KEEP OUT OF REACH OF CHILDREN." Poisoning is a major cause of injuries to children. According to the American Association of Poison Control Centers, pesticide exposure incidents occur in greater frequency to children under the age of six years than to older children, teens and adults on an annual basis.

Signal Word

A signal word (Table 3.1) is displayed in large letters on the front of the label to indicate approximately how acutely toxic the pesticide is to humans by ingestion. The signal word is based on the entire contents of the product, not the active ingredient alone, but takes into account the inert ingredients. The signal word does not indicate the risk of delayed or allergic effects. All highly toxic pesticides that are very likely to cause acute illness through oral, dermal, or inhalation exposure have DANGER as their signal word and will carry the word POISON printed in red with the skull-and-crossbones symbol. Products that have the DANGER signal word due to skin and eye irritation potential will not carry the word POISON or the skull-and-crossbones symbol.

Signal word	Category	Oral lethal dose[1]
DANGER, POISON/ PELIGRO (skull and crossbones)	I Highly toxic	A few drops to a teaspoonful
WARNING / AVISO	II Moderately toxic	A teaspoonful to one ounce
CAUTION	III Slightly toxic	One ounce to one pint or one pound
CAUTION	IV Relatively non-toxic	Over one pint or one pound

[1]Based on a 150-pound person.

Table 3.1 Acute toxicity label signal words.

Statement of Practical Treatment

The labels for all highly toxic pesticides (signal word DANGER, Category I) must provide information to medical professionals should an exposure occur. Examples of wording found in this section:

- "If swallowed: Immediately induce vomiting by touching back of throat with finger. Drink 1 or 2 glasses of water and induce further vomiting. Call a physician or poison control center immediately."
- "If in eyes: Hold eyelids open and flush with a steady, gentle stream of water for 15 minutes. Get medical attention."
- "If on skin, wash skin with soap and water. Get medical attention."

It is in this section that proper antidotes and treatment are recommended for medical personnel treating a victim. For this reason, the pesticide label should always be taken to the emergency medical facility when an exposure occurs. Products labeled DANGER also bear an 800 telephone number that physicians may call for further treatment advice at any time. Often labels for less toxic pesticides will also provide first-aid instructions.

Hazards to Humans and Domestic Animals

This part of the label includes precautionary statements indicating specific hazards, routes of exposure and precautions to be taken to avoid human and animal injury. The label will contain statements that indicate which route of entry (mouth, skin, eyes, and lungs) that must particularly be protected and what specific action is needed to take to avoid acute effects from exposure to the pesticide. Examples of such statements seen in this section include:

- "Causes eye and skin irritation. Harmful if swallowed, inhaled or absorbed through skin."
- "Do not get on skin or on clothing."
- "Avoid breathing vapor or spray mist."
- "Avoid contact with eyes."
- "Prolonged or repeated skin contact may cause allergic reactions in some individuals."
- "Wash thoroughly with soap and water after handling."

Pesticides that the EPA considers to have the potential to cause delayed effects must have label statements warning the user of that fact. These statements will indicate whether the product has been shown to cause problems such as tumors or reproductive problems in laboratory animals. Additional information in this section will alert users if the product has

the potential to cause allergic effects, such as skin irritation or asthma. Sometimes the labeling refers to allergic effects as "sensitization."

Personal Protective Equipment

Most pesticide labels contain specific instructions concerning the type of clothing that must be worn during the handling and mixing processes (Figure 3.2). This information is usually found following the statements regarding acute, delayed and allergic effects. Some labels may list this information after the signal word. Examples of some common statements from pesticide labels regarding personal protective equipment include:

- "chemical-resistant footwear plus socks"
- "long-sleeved shirt and long pants"
- "waterproof gloves"
- "protective eyewear"

Personal Protective Equipment (PPE)

Applicators and other handlers must wear: Long-sleeved shirt and long pants, shoes plus socks, and protective eyewear.

Discard clothing and other absorbent materials that have been drenched or heavily contaminated with this product's concentrate. Do not reuse them. Follow manufacturer's instructions for cleaning/maintaining PPE. If no such instructions for washables, use detergent and hot water. Keep and wash PPE separately from other laundry.

Figure 3.2 Pesticide labels list the minimum PPE that should be worn.

The personal protective equipment listed is the minimum protection that should be worn while handling the pesticide. Sometimes the statements will require different personal protective equipment for different pesticide handling activities, usually with greater safety equipment emphasis on operations that involve handling concentrated products. In some cases, reduced personal protective equipment is allowed when you will be applying the pesticide in safer situations, such as enclosed cabs.

Environmental Information

Environmental Hazards

This section of the label explains the nature of potential hazards and the precautions needed to prevent injury or damage to nontarget organisms or to the environment (Figure 3.3). Some general statements appear on practically every pesticide label. For example, most pesticide labels will warn the user not to contaminate water sources when applying the pesticide, cleaning application equipment or disposing of pesticide wastes. It is also in this section that information can be found if the product poses a threat to groundwater. Instructions will be provided to minimize such impacts. Some labels will mention endangered species concerns in this section. Warnings of potential toxicity to honeybees may also be stated in this section. Examples of environmental hazard statements include:

- "This product is highly toxic to honeybees."
- "This product is extremely toxic to fish and aquatic invertebrates."
- "Do not apply where runoff is likely to occur."

Environmental Hazards

This pesticide is extremely toxic to birds, mammals, fish and aquatic invertebrates. Do not apply directly to water, or to areas where surface water is present or to intertidal areas below the mean high water mark. Drift and runoff may be hazardous to aquatic organisms in neighboring areas. Do not contaminate water when disposing of equipment washwater or rinsate.

This product may contaminate water though drift of spray in wind. This product has high potential for runoff for several months. Poorly draining soils and soils with shallow water tables are more prone to product runoff that contains this product.

Figure 3.3 Potential environmental effects must be listed.

Product Information

Use Classification

EPA is required to classify pesticides for either general use or restricted use. In classifying a pesticide, EPA considers:

- The toxicity of the pesticide;
- The way in which the pesticide will be used;
- The effect of the pesticide on the environment.

When a pesticide is classified as restricted, the label will state "Restricted Use Pesticide" at the top of the front panel. Below this heading may be a reason for the restriction (Figure 3.4). Although there is a federal list of restricted active ingredients determined by EPA, some states have their own lists of restricted products. Florida follows the federal guidelines for determining if a product is restricted. To purchase and apply

restricted use pesticides, a person must be certified and licensed in the state of Florida.

RESTRICTED USE PESTICIDE
ACUTE TOXICITY and GROUND WATER CONTAMINATION

For retail sale to and use only by Certified Applicators or persons under the direct supervision of a Certified Applicator, and only for those uses covered by the Certified Applicator's certification.

Figure 3.4 The reason why a pesticide is classified as "Restricted Use" is given in a label statement.

A general use pesticide is defined as one that will not harm the applicator or the environment to an unreasonable degree when used according to label directions. General use pesticides are available to the general public for use according to label directions. Applicators in Florida who operate in areas regulated under the Bureau of Entomology and Pest Control Chapters 388 and 482, FS (mosquito and pest control operators) are required to be certified and licensed regardless of pesticide classification. In other cases, such as persons applying herbicides for aquatic and rights-of-way weed management, they may be required by their employer to be certified and licensed to apply any pesticide.

Brand (Trade) Name

Each manufacturer has a brand name for each of its products. Different manufacturers may use different brand names for the same pesticide active ingredient. For example, Pendulum®, Pre-M®, and Prowl® are trade names for the same herbicidal active ingredient, pendimethalin (Figure 3.5). It is not legal to use different brand-name pesticides interchangeably even if they contain the same active ingredient. Each product label will state specifically the sites to which it may be applied. The brand name shows plainly on the front panel of the label.

Ingredient Statement

The ingredient statement, normally on the front panel of the label, identifies the name and percentage by weight of each active ingredient. Identified by chemical or common name, the active ingredients are the components of the product that affect the target pest. The chemical name is often complex. For example, the chemical name for atrazine is 2-chloro-4-ethylamino-6-isopropylamino-s-triazine. To aid communication, EPA-approved common names may be substituted for chemical names. In this example, atrazine may be substituted for the chemical name. Usually following the list of ingredients, the amount of active ingredient is expressed as percent by weight for both liquid and dry formulations of pesticides. For liquid pesticides, the number of pounds per gallon of active ingredient will be given in this section as well. For example:

ACTIVE INGREDIENTS:
2,4-Dichlorophenoxyacetic acid 13.8%
2,4-Dichlorophenoxyacetic acid, butoxyethyl ester..... 24.5%
OTHER INGREDIENTS..... 61.7%

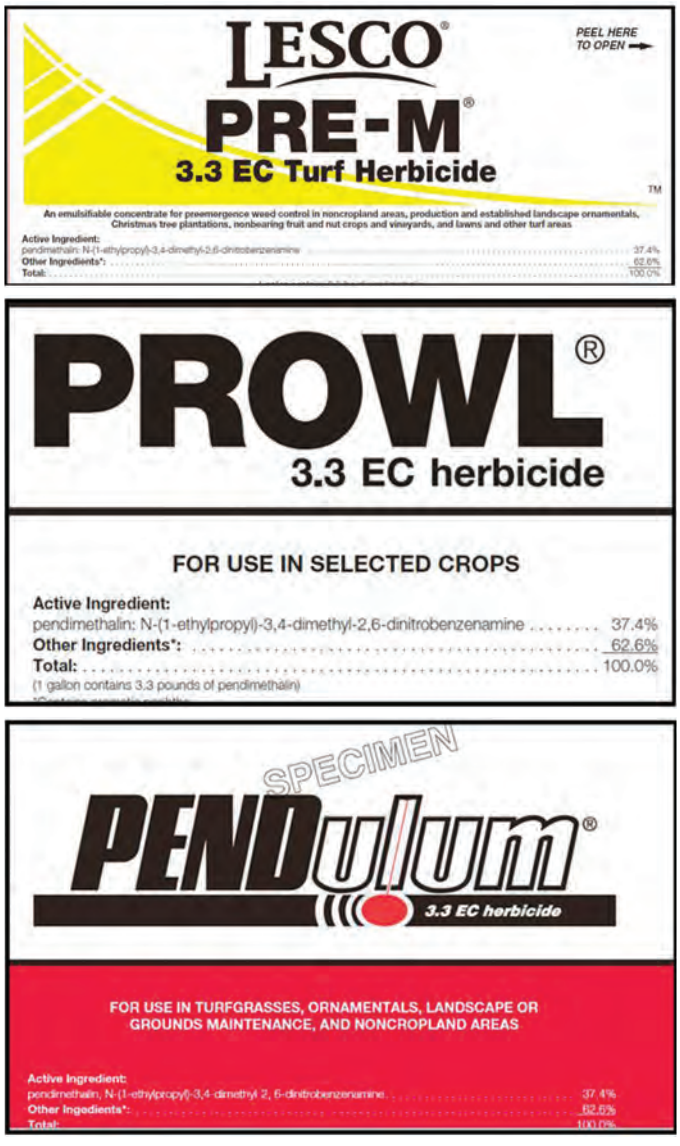


Figure 3.5 A single pesticide active ingredient may have several brand names.

Inert ingredients allow active ingredients to be formulated into many different products. As part of the formulation, they determine a product's handling properties. Inert ingredients that are not considered to be toxic need not be named, but the label must show what percent of the total contents they make up. These ingredients make the product safer, more effective and easier to handle.

Net Contents

The front panel of the pesticide label states how much is in the container (Figure 3.6). This can be expressed as pounds or ounces for dry formulations and as gallons, quarts, pints or fluid ounces for liquids.

Figure 3.6 Net contents must be expressed on the front of the container.

EPA Registration Number

This number identifies a specific product and signifies that the product has met federal registration requirements through all of the testing phases. This number must have a minimum of two sets of digits, one for the manufacturer and one for the product. For example, if the EPA registration number is 901-358, "901" indicates the manufacturer and "358" is the specific number issued to identify the product by the EPA. Sometimes there will be a third set of numbers to identify the distributor. Some states will require that some registration numbers carry a set of letters in this code as well.

EPA Establishment Number

This number identifies the facility that formulated the product. In the event of questions or concerns regarding a product, the facility that made the pesticide can be determined. Although not common, quality control problems have been tracked to the facility that formulated the product when problems with a specific product were identified.

Name and Address of Manufacturer

The law requires the maker or distributor of a product to put the company name and address on the label. This enables consumers to know who made or sold the product. In many cases, the manufacturer will also list a telephone number and/or web address where users of the product may seek technical advice.

Formulation

The front panel of some pesticide labels will describe the product formulation. The formulation name may be either spelled out or designated by an abbreviation, such as G for granular materials, WP for wettable powders, D for dusts or E or EC for emulsifiable concentrates. There are other formulations, but these are some of the more common. This information is helpful for practical purposes because it provides insight about the type of application equipment that will be needed and the product›s handling properties.

Physical or Chemical Hazards

This section will tell of special fire, explosion or chemical hazards the product may pose. For example, it will alert you if the product is so flammable that you need to be especially careful to keep it away from heat or open flame, or if it is so corrosive that it must be stored in a corrosion-resistant container. This section is not always found in the same location within the labeling. Some labeling will identify physical and chemical hazards in a designated box while other labeling may list them on the front panel beneath the signal word. Others may list hazards under headings such as "Note" or "Important." Examples include wording such as:

- "Do not use or store near heat or open flame."

Some products will include statements concerning the diluted product such as:

- "Spray solutions of this product should be mixed, stored and applied using only stainless steel, aluminum, fiberglass, plastic or plastic-lined steel containers."

Many other hazards may be found in this section.

Limited Warranty and Disclaimer

This statement conveys the manufacturer's assurance that the product conforms to the chemical description on the label and that it is fit for label purposes if used according to directions under normal conditions. The warranty does not extend to any use of the product contrary to label instructions, nor does it apply under abnormal conditions such as drought, tornadoes, hurricanes or excessive rainfall. Applicators who violate label instructions assume all liability associated with the product.

Use Information

Directions for Use

This section usually makes up the bulk of a pesticide label and begins with the wording: "It is a violation of federal law to use this product in any manner inconsistent with its labeling." Products intended for use in agriculture will have an Agricultural Use Requirements box included in this section. It will contain the statement: "Use this product only in accordance with its labeling and with the Worker Protection Standard, 40 CFR Part 170." The purpose is to inform those handling the product that the Worker Protection Standard applies to the product (Figure 3.7). When the Worker Protection Standard applies, a statement regarding information on employee notification of restricted entry intervals and applications, proper training, decontamination, emergency assistance and personal protective equipment is stated here. The directions for use section will contain information such as:

- Sites, objects, animals, plants or areas where the product may be applied.
- The amount of product to use. This may be expressed as an amount per unit area, such as per acre or per 1,000 square feet. It may also be listed as an amount to mix per unit volume of water.
- A description of how the product should be applied and by which type of application equipment it is most effectively applied.
- The timing and frequency of application. For example, a label may state specifically time intervals between applications, such as "allow 10 or more days between applications."
- Limitations on reentry to treated areas. These will be given in specific terms. The reentry intervals may be very specific and given in terms of hours or days or they will simply state "do not enter or allow others to enter the treated area until sprays have dried."
- The pests that the product controls. The user assumes all risks for applying the product for control of a pest that is not listed on any given products label.
- Any number of various limitations associated with the product, including application intervals, crop rotation restrictions, animal restrictions and warnings about the use on certain sites.

AGRICULTURAL USE REQUIREMENTS

Use this product only in accordance with its labeling and with the Worker Protection Standard, 40 CFR Part 170. This Standard contains requirements for protection of agricultural workers on farms, forests, nurseries, and greenhouses and handlers of agricultural pesticides. It contains requirements for training, decontamination, notification and emergency assistance. It also contains specific instructions and exceptions pertaining to the statements on this label about personal protective equipment (PPE), notification to workers and restricted-entry intervals. The requirements in this box only apply to uses of this product that are covered by the Worker Protection Standard.

Do not enter or allow workers to enter treated areas during the restricted-entry interval (REI) of 48 hours for all crops.

PPE required for early entry to treated areas that is permitted under the Worker Protection Standard and that involves contact with anything that has been treated, such as plants, soil, or water, is coveralls over long-sleeved shirt and long pants, chemical-resistant gloves, such as butyl rubber, nitrile rubber, or neoprene rubber, shoes and socks, protective eyewear, chemical-resistant headgear for overhead exposure.

Notify workers of the applications by warning them orally and by posting warning signs at entrances to treated areas.

Figure 3.7 Agricultural Use Requirements.

Storage and Disposal

Most, if not all, pesticide labels will contain a general statement in this section to the effect "do not contaminate water, food, or feed by storage, disposal, or cleaning of equipment" and "store in original containers only." Label information about storage generally includes temperature requirements. In many cases, minimum and maximum storage temperatures will be provided in specific terms. Some pesticides become ineffective if not stored under suitable temperatures; other pesticide labels may indicate that if freezing occurs and

crystals form, then the product may be reused if it is warmed up. Moisture is a critical concern with dry pesticides, including granular materials and wettable powders, which have a strong affinity for water. When this is the case, the label may have the statement, "store in a dry place."

CONTAINER DISPOSAL

Nonrefillable container. Do not reuse or refill this container. Offer for recycling, if available, or dispose of outer bag in a sanitary landfill or by incineration if allowed by state and local agencies.

Figure 3.8 Label instructions for disposal.

Labels include information on disposal of pesticide containers as well as excess quantities of diluted pesticide mixtures. The label will inform users that leftover mixtures that can't be applied to a labeled site may be disposed of in an approved waste disposal facility that is in accordance with appropriate federal, state and local procedures. With disposal of liquid pesticide containers, the triple- or pressure-rinse procedure will be stated in this section of the label and options such as recycling or disposal of punctured containers in a sanitary landfill will be given (Figure 3.8). Manufacturers of returnable and refillable containers will remind the user to return the containers promptly and intact to the point of purchase. The label will state that bags containing dry pesticide products should be emptied thoroughly into the application equipment and incinerated or discarded into a sanitary landfill. Although burning of pesticide containers is legal in Florida, some counties and municipalities have enacted ordinances which prohibit such activities. Applicators should consult their local authorities to determine burning regulations.

The Safety Data Sheet

Awareness of the importance of safety has increased in the pesticide and pest control industry over the past several decades. This awareness has grown in response to activities by the government and the public as well as the news media, including coverage of major chemical accidents. The Occupational Safety and Health Administration (OSHA) in 1989 expanded its Hazard Communication Standard to cover all employees who could potentially be exposed to hazardous chemicals in their work areas — regardless of the place of employment or the nature of the work. The Hazard Communication Standard requires that chemical manufacturers and importers thoroughly evaluate chemicals. Any chemical that is determined to be hazardous must have a safety data sheet (SDS), developed to communicate the hazard potential to users. Their purpose is to provide handlers of chemicals, including pesticides, with the proper procedures for handling and working with the chemical. People who are primary users of a SDS would include employees who handle a certain material in their daily occupations, those who store chemicals at their place of business and emergency response crews who need to understand procedures associated should an emergency happen to occur. The SDS is not designed for someone who may apply a lawn and garden pesticide once or twice a year. They are written in an occupational fashion for those who handle a material routinely.

A large amount of pesticide hazard information is generated in the course of fulfilling regulatory requirements for product registration. The Environmental Protection Agency requires nearly 150 various tests, yielding primarily toxicological, environmental and physical property data, much of which can be used in the SDS.

Chemical manufacturers are required by the Hazard Communication Standard to provide an SDS to the purchaser of the product at the time of the first order and, thereafter, anytime the SDS is significantly revised. In other words, a chain of supply begins with the manufacturer and funnels downward to dealers and eventually end buyers of their products. The SDS may be included with the pallet on which the product is shipped, or it may be submitted electronically or delivered by mail. As the pesticides are further distributed to satellite suppliers, dealers, or users, a copy of the SDS must accompany their original orders.

There are several sources of SDS. In a workplace, there should be a copy of each product's SDS that the business uses on file. Many land grant university extension pesticide safety and education programs will have a website containing links to such documents, chemical distributors will have them and internet or software subscriptions may be purchased.

Although the SDS is a necessary part of the Hazard Communication Standard, there is no specific format prescribed for the presentation of its contents. Therefore, SDS's from various manufacturers may differ dramatically in organization and appearance yet still present the required data. To help bring order to the SDS format, the Hazard Communication Standard requires the SDS to be presented in a consistent user-friendly, 16-section format. For data sheets prepared in accordance with the standard, the 16 section titles and their order of appearance is the same from manufacturer to manufacturer, but the amount of information within a given section is left to the discretion of each individual manufacturer.

Table 3.2 (on page 44) presents the 16 sections of the SDS with a brief interpretation of the section contents.

Conclusion

The language on pesticide labels is strictly regulated by the EPA in coordination with pesticide manufacturers to provide precise information describing how to use pesticides correctly and safely. It is the applicator's responsibility to read, understand, and follow the label directions to ensure that pesticides are applied according to regulations. The label directions are written to instruct the applicator how to use the pesticide for effective control of the target pest while minimizing harmful effects to other organisms and the environment. Make sure the pesticide has both federal and state registration for its intended use.

Be familiar with all sections on a pesticide label and know where to find the specific directions and precautions for each pest control situation that you manage. Know both the trade and common names of the chemical you are using, and be familiar with the product's active ingredients. Signal words and symbols help the applicator recognize how toxic (i.e., dangerous) the pesticide is. These signal words are often accompanied by precautionary statements that further explain how the pesticide may cause injury and what to do to prevent it (e.g., routes of entry statements, specific action statements, protective clothing and equipment statements). Other parts of the label let the applicator know how, when, where, and on what target pest the pesticide may be applied (e.g., directions for use, mixing and loading instructions). Still other parts of the label inform users what to do should an accident occur and what precautions to take to avoid harming themselves, other persons, the environment, or non-target organisms (e.g., practical treatment statements, environmental hazards, storage and disposal, physical or chemical hazards). All parts of the pesticide label must be carefully read and followed. The label, however, may not provide all of the information needed to avoid harmful effects of pesticides. It is a good practice to take even further precautions such as using additional protective clothing and equipment beyond what the pesticide label recommends.

Pesticide labels in combination with SDS provide a wealth of information on the hazards associated with each pesticide. Carefully review these documents before applying any pesticide. Applicators are better prepared to avoid any harmful effects if they understand the properties of the pesticide more thoroughly. Remember, it is the applicator's responsibility to ensure that pesticides are applied effectively and as safely as possible.

Test Your Knowledge

Q: What is needed to apply a pesticide legally when a pest problem arises for which a food or feed commodity is not on the registered pesticide label or a tolerance has not been established?
A. An emergency exemption
B. A restricted use pesticide
C. A minimum-risk pesticide classification
D. Section 3
A: A

Q: The active ingredient in Lorsban 75WG is listed as chlorpyrifos: 0,0-diethyl 0-(3,5,6-trichloro 2 pyridinyl) phosphorothioate. What does the term "chlorpyrifos" represent?
A. The brand name
B. The chemical name
C. The common name
D. The trade name
A: C

Q: Which statement about pesticide label names and ingredients is true?
A. The active and inert ingredients must be listed by chemical name.
B. Various manufacturers use different trade names, even though the products contain the same active ingredient.
C. The common names are those accepted officially by the manufacturer.
D. Inert ingredients are responsible for the pesticidal activity.
A: B

Q: What is the purpose of the signal word?
A. To give the user an indication of the relative acute toxicity of the product to humans and animals.
B. Informs the user of what type of PPE to wear.
C. Informs the user of how toxic the pesticide is to wildlife and the environment.
D. Tells the user what type of first-aid treatment to seek in case of exposure.
A: A

Q: The route of entry statement on a label "Extremely hazardous by skin contact – rapidly absorbed through the skin" would most likely appear with which signal word?
A. DANGER
B. WARNING
C. CAUTION
D. No signal word required
A: A

Q: The statement "Do not breathe vapors or spray mist" is an example of:
A. A specific action statement
B. A statement of practical treatment
C. A route of entry statement
D. A protective clothing statement
A: C

Q: Which is true about statements of practical treatment?
A. They are not associated with signal words.
B. It is not important to have the pesticide label in case of a poisoning emergency.
C. Statements about inducing vomiting are not found on the label.
D. All DANGER labels contain a note to physicians describing appropriate medical procedures.
A: D

Q: Directions for mixing and loading a pesticide are usually found under:
A. The Agricultural Use Requirements
B. The Directions for Use
C. Environmental Hazards
D. Precautionary statements
A: B

Q: Who is responsible for developing SDSs on specific chemicals and providing them on request?
A. The EPA
B. The USDA
C. OSHA
D. The product manufacturer
A: D

Table 3.2 Example SDS.

Section 1: Identification
This section identifies the chemical on the SDS as well as the recommended uses. It also provides the essential contact information of the supplier. The required information consists of: • Product identifier used on the label and any other common names or synonyms by which the substance is known. • Name, address, phone number of the manufacturer, importer, or other responsible party, and emergency phone number. • Recommended use of the chemical (e.g., a brief description of what it actually does, such as flame retardant) and any restrictions on use (including recommendations given by the supplier).
Section 2: Hazard(s) Identification
This section identifies the hazards of the chemical presented on the SDS and the appropriate warning information associated with those hazards. The required information consists of: • The hazard classification of the chemical (e.g., flammable liquid). • Signal word. • Hazard statement(s). • Pictograms (the pictograms or hazard symbols may be presented as graphical reproductions of the symbols in black and white or be a description of the name of the symbol (e.g., skull and crossbones, flame). • Precautionary statement(s). • Description of any hazards not otherwise classified. • For a mixture that contains an ingredient(s) with unknown toxicity, a statement describing how much (percentage) of the mixture consists of ingredient(s) with unknown acute toxicity. Please note that this is a total percentage of the mixture and not tied to the individual ingredient(s).
Section 3: Composition/Information on Ingredients
This section identifies the ingredient(s) contained in the product indicated on the SDS, including impurities and stabilizing additives. This section includes information on substances, mixtures, and all chemicals where a trade secret is claimed. The required information consists of: **Substances** • Chemical name. • Common name and synonyms. • Chemical Abstracts Service (CAS) number and other unique identifiers. • Impurities and stabilizing additives, which are themselves classified and which contribute to the classification of the chemical. **Mixtures** • Same information required for substances. • The chemical name and concentration (i.e., exact percentage) of all ingredients which are classified as health hazards and are: ° Present above their cut-off/concentration limits or ° Present a health risk below the cut-off/concentration limits. • The concentration (exact percentages) of each ingredient must be specified except concentration ranges may be used in the following situations: ° A trade secret claim is made, ° There is batch-to-batch variation, or ° The SDS is used for a group of substantially similar mixtures. **Chemicals where a trade secret is claimed** • A statement that the specific chemical identity and/or exact percentage (concentration) of composition has been withheld as a trade secret is required.
Section 4: First-Aid Measures
This section describes the initial care that should be given by untrained responders to an individual who has been exposed to the chemical. The required information consists of: • Necessary first-aid instructions by relevant routes of exposure (inhalation, skin and eye contact, and ingestion). • Description of the most important symptoms or effects, and any symptoms that are acute or delayed. • Recommendations for immediate medical care and special treatment needed, when necessary.

Section 5: Fire-Fighting Measures

This section provides recommendations for fighting a fire caused by the chemical. The required information consists of:

- Recommendations of suitable extinguishing equipment, and information about extinguishing equipment that is not appropriate for a particular situation.
- Advice on specific hazards that develop from the chemical during the fire, such as any hazardous combustion products created when the chemical burns.
- Recommendations on special protective equipment or precautions for firefighters.

Section 6: Accidental Release Measures

This section provides recommendations on the appropriate response to spills, leaks, or releases, including containment and cleanup practices to prevent or minimize exposure to people, properties, or the environment. It may also include recommendations distinguishing between responses for large and small spills where the spill volume has a significant impact on the hazard. The required information may consist of recommendations for:

- Use of personal precautions (such as removal of ignition sources or providing sufficient ventilation) and protective equipment to prevent the contamination of skin, eyes, and clothing.
- Emergency procedures, including instructions for evacuations, consulting experts when needed, and appropriate protective clothing.
- Methods and materials used for containment (e.g., covering the drains and capping procedures).
- Cleanup procedures (e.g., appropriate techniques for neutralization, decontamination, cleaning or vacuuming; adsorbent materials; and/or equipment required for containment/clean up).

Section 7: Handling and Storage

This section provides guidance on the safe handling practices and conditions for safe storage of chemicals. The required information consists of:

- Precautions for safe handling, including recommendations for handling incompatible chemicals, minimizing the release of the chemical into the environment, and providing advice on general hygiene practices (e.g., eating, drinking, and smoking in work areas is prohibited).
- Recommendations on the conditions for safe storage, including any incompatibilities. Provide advice on specific storage requirements (e.g., ventilation requirements).

Section 8: Exposure Controls/Personal Protection

This section indicates the exposure limits, engineering controls, and personal protective measures that can be used to minimize worker exposure. The required information consists of:

- OSHA Permissible Exposure Limits (PELs), American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Values (TLVs), and any other exposure limit used or recommended by the chemical manufacturer, importer, or employer preparing the safety data sheet, where available.
- Appropriate engineering controls (e.g., use local exhaust ventilation, or use only in an enclosed system).
- Recommendations for personal protective measures to prevent illness or injury from exposure to chemicals, such as personal protective equipment (PPE) (e.g., appropriate types of eye, face, skin or respiratory protection needed based on hazards and potential exposure).
- Any special requirements for PPE, protective clothing or respirators (e.g., type of glove material, such as PVC or nitrile rubber gloves; and breakthrough time of the glove material).

Section 9: Physical and Chemical Properties

This section identifies physical and chemical properties associated with the substance or mixture. The minimum required information consists of:

- Appearance (physical state, color, etc.);
- Upper/lower flammability or explosive limits;
- Odor;
- Vapor pressure;
- Odor threshold;
- Vapor density;
- pH;
- Relative density;
- Melting point/freezing point;
- Solubility(ies);
- Initial boiling point and boiling range;
- Partition coefficient: n-octanol/water;
- Flash point;
- Auto-ignition temperature;
- Evaporation rate;
- Decomposition temperature;
- Flammability (solid, gas); and
- Viscosity.

The SDS may not contain every item on the above list because information may not be relevant or is not available. When this occurs, a notation to that effect must be made for that chemical property. Manufacturers may also add other relevant properties, such as the dust deflagration index (Kst) for combustible dust, used to evaluate a dust's explosive potential.

Section 10: Stability and Reactivity

This section describes the reactivity hazards of the chemical and the chemical stability information. This section is broken into three parts: reactivity, chemical stability, and other. The required information consists of:

Reactivity

- Description of the specific test data for the chemical(s). This data can be for a class or family of the chemical if such data adequately represent the anticipated hazard of the chemical(s), where available.

Chemical stability

- Indication of whether the chemical is stable or unstable under normal ambient temperature and conditions while in storage and being handled.
- Description of any stabilizers that may be needed to maintain chemical stability.
- Indication of any safety issues that may arise should the product change in physical appearance.

Other

- Indication of the possibility of hazardous reactions, including a statement whether the chemical will react or polymerize, which could release excess pressure or heat, or create other hazardous conditions. Also, a description of the conditions under which hazardous reactions may occur.
- List of all conditions that should be avoided (e.g., static discharge, shock, vibrations, or environmental conditions that may lead to hazardous conditions).
- List of all classes of incompatible materials (e.g., classes of chemicals or specific substances) with which the chemical could react to produce a hazardous situation.
- List of any known or anticipated hazardous decomposition products that could be produced because of use, storage, or heating. (Hazardous combustion products should also be included in Section 5 (Fire-Fighting Measures) of the SDS.)

Section 11: Toxicological Information

This section identifies toxicological and health effects information or indicates that such data are not available. The required information consists of:

- Information on the likely routes of exposure (inhalation, ingestion, skin and eye contact). The SDS should indicate if the information is unknown.
- Description of the delayed, immediate, or chronic effects from short- and long-term exposure.
- The numerical measures of toxicity (e.g., acute toxicity estimates such as the LD50 (median lethal dose)) - the estimated amount [of a substance] expected to kill 50% of test animals in a single dose.
- Description of the symptoms. This description includes the symptoms associated with exposure to the chemical including symptoms from the lowest to the most severe exposure.
- Indication of whether the chemical is listed in the National Toxicology Program (NTP) Report on Carcinogens (latest edition) or has been found to be a potential carcinogen in the International Agency for Research on Cancer (IARC) Monographs (latest editions) or found to be a potential carcinogen by OSHA.

Section 12: Ecological Information (non-mandatory)

This section provides information to evaluate the environmental impact of the chemical(s) if it were released to the environment. The information may include:

- Data from toxicity tests performed on aquatic and/or terrestrial organisms, where available (e.g., acute or chronic aquatic toxicity data for fish, algae, crustaceans, and other plants; toxicity data on birds, bees, plants).
- Whether there is a potential for the chemical to persist and degrade in the environment either through biodegradation or other processes, such as oxidation or hydrolysis.
- Results of tests of bioaccumulation potential, making reference to the octanol-water partition coefficient (Kow) and the bioconcentration factor (BCF), where available.
- The potential for a substance to move from the soil to the groundwater (indicate results from adsorption studies or leaching studies).
- Other adverse effects (e.g., environmental fate, ozone layer depletion potential, photochemical ozone creation potential, endocrine disrupting potential, and/or global warming potential).

Section 13: Disposal Considerations (non-mandatory)

This section provides guidance on proper disposal practices, recycling or reclamation of the chemical(s) or its container, and safe handling practices. To minimize exposure, this section should also refer the reader to Section 8 (Exposure Controls/Personal Protection) of the SDS. The information may include:

- Description of appropriate disposal containers to use.
- Recommendations of appropriate disposal methods to employ.
- Description of the physical and chemical properties that may affect disposal activities.
- Language discouraging sewage disposal.
- Any special precautions for landfills or incineration activities.

Section 14: Transport Information (non-mandatory)

This section provides guidance on classification information for shipping and transporting of hazardous chemical(s) by road, air, rail, or sea. The information may include:

- UN number (i.e., four-figure identification number of the substance).
- UN proper shipping name.
- Transport hazard class(es).
- Packing group number, if applicable, based on the degree of hazard.
- Environmental hazards (e.g., identify if it is a marine pollutant according to the International Maritime Dangerous Goods Code (IMDG Code)).
- Guidance on transport in bulk (according to Annex II of MARPOL 73/783 and the International Code for the Construction and Equipment of Ships Carrying Dangerous Chemicals in Bulk (International Bulk Chemical Code (IBC Code)).
- Any special precautions which an employee should be aware of or needs to comply with, in connection with transport or conveyance either within or outside their premises (indicate when information is not available).

Section 15: Regulatory Information (non-mandatory)
This section identifies the safety, health, and environmental regulations specific for the product that is not indicated anywhere else on the SDS. The information may include: • Any national and/or regional regulatory information of the chemical or mixtures (including any OSHA, Department of Transportation, Environmental Protection Agency, or Consumer Product Safety Commission regulations).
Section 16: Other Information
This section indicates when the SDS was prepared or when the last known revision was made. The SDS may also state where the changes have been made to the previous version. You may wish to contact the supplier for an explanation of the changes. Other useful information also may be included here.

Chapter IV

Pesticide Formulations

Chapter IV

TABLE *of* CONTENTS

Learning Objectives

After you complete your study of this chapter, you should be able to:

- Explain what a pesticide formulation is.
- Know the difference between "active" and "inert" ingredients.
- Identify advantages and disadvantages of common formulation types.
- Interpret common abbreviations used to describe formulation, such as EC, DF, WSP, G, S, and WP.
- Identify factors to consider when selecting a formulation. Explain the role of adjuvants in pesticide application.

Terms to Know

Abrasive: Capable of wearing away or grinding down another object.

Active ingredient (a.i.): The substance in a pesticide product that is intended to kill, repel, or otherwise control a target pest.

Adjuvant: Chemical that is either premixed in the pesticide formulation or added to the spray tank to improve mixing or application or to enhance pesticidal activity.

Alkaline: The opposite of acidic; having a pH greater than 7.

Carrier: The primary material used to allow a pesticide to be dispersed effectively. For example, talc in a dust formulation.

Diluent: Anything used to dilute a pesticide.

Emulsifier: Agent that helps to prevent an emulsion from separating.

Emulsion: A mixture of two or more liquids that are not soluble in one another. For example, oil droplets dispersed in water.

Formulation: A mixture of active ingredient combined during manufacture with inert ingredients.

Inert ingredients: All materials in the pesticide formulation other than the active ingredient. They are added to dilute the pesticide or to make it safer, more effective, and easier to measure, mix, apply, and handle. Some inert ingredients may be toxic or hazardous to people.

Insoluble: Does not dissolve in liquid.

Phytotoxicity: Injury to plants.

Soluble: Able to dissolve in another substance, usually a liquid.

Solvent: A liquid, such as water, kerosene, xylene, or alcohol, that will dissolve a pesticide to form a solution.

Suspension: A substance that contains undissolved particles mixed throughout a liquid.

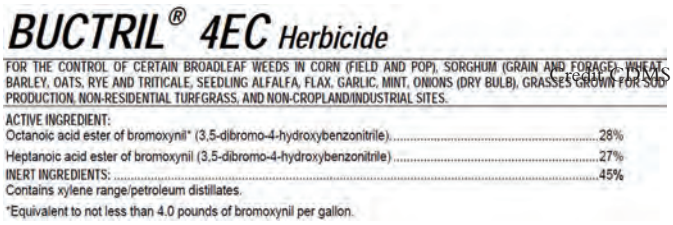
Viscous: Having a cohesive and sticky, fluid consistency.

Volatile: Evaporating rapidly; turning easily into a gas or vapor.

Introduction

Pesticide chemicals in their "raw" or unformulated state are not usually suitable for pest control. These concentrated chemicals, active ingredients, may not mix well with water, may be chemically unstable, and may be difficult to handle and transport. For these reasons, manufacturers add inert substances such as clays and solvents to improve application effectiveness, safety, handling, and storage. Inert ingredients do not possess pesticidal activity and are added to serve as a carrier for the active ingredient. Manufacturers will list the percentage of inert ingredients in the formulation or designate them as "other ingredients" on their labels. There are several inert substances, such as petroleum distillates and xylene, which will have a specific statement identifying their presence in the formulation (Figure 4.1). The mixture of active and inert ingredients is called a pesticide formulation. This formulation may consist of:

- The pesticide active ingredient that controls the target pest.
- The carrier, such as an organic solvent or mineral clay.
- Adjuvants, such as stickers and spreaders.
- Other ingredients, such as stabilizers, dyes, and chemicals that improve or enhance pesticidal activity.


BUCTRIL® 4EC Herbicide

FOR THE CONTROL OF CERTAIN BROADLEAF WEEDS IN CORN (FIELD AND POP), SORGHUM (GRAIN AND FORAGE), WHEAT, BARLEY, OATS, RYE AND TRITICALE, SEEDLING ALFALFA, FLAX, GARLIC, MINT, ONIONS (DRY BULB), GRASSES GROWN FOR SOD PRODUCTION, NON-RESIDENTIAL TURFGRASS, AND NON-CROPLAND/INDUSTRIAL SITES.

ACTIVE INGREDIENT:	
Octanoic acid ester of bromoxynil* (3,5-dibromo-4-hydroxybenzonitrile)	28%
Heptanoic acid ester of bromoxynil (3,5-dibromo-4-hydroxybenzonitrile)	27%
INERT INGREDIENTS:	45%

Contains xylene range/petroleum distillates.

*Equivalent to not less than 4.0 pounds of bromoxynil per gallon.

Figure 4.1 Some inert ingredients are specifically identified in the label ingredient statement.

Usually you need to mix a formulated product with water or oil for final application. Baits, granules, gels, and dusts, however, are ready for use without additional dilution. Manufacturers package many specialized pesticides, such as products for households, in ready-to-use formulations (Figure 4.2).

A single active ingredient often is sold in several kinds of formulations. Abbreviations are often used to describe the formulation (e.g., WP for wettable powders); how the pesticide is used (e.g., TC for termiticide concentrate); or the characteristics of the formulation (e.g., LO for a low-odor formulation). Common abbreviations and their interpretations are listed in Table 4.1. The amount of active ingredient (a.i.) and the kind of formulation are listed on the product

label. For example, an 80 percent SP contains 80 percent by weight of active ingredient and is a soluble powder. If it is in a 10-pound bag, it contains 8 pounds of a.i. and 2 pounds of inert ingredient. Liquid formulations indicate the amount of a.i. in pounds per gallon. For example, 1E means 1 pound and 4E means 4 pounds of the a.i. per gallon in an emulsifiable concentrate formulation (Figure 4.3).

Figure 4.2 Ready-to-use formulation.

If you find that more than one formulation is available for your pest control situation, you should choose the best one for the job. Before you make the choice, ask yourself several questions about each formulation. For example:

- Do I have the necessary application equipment?
- Can the formulation be applied appropriately under the conditions in the application area?
- Will the formulation reach your target and stay in place long enough to control the pest?
- Is the formulation likely to damage the surface to which you will apply it?
- Could I choose a less hazardous formulation that would still be as effective?

To answer these kinds of questions, you need to know something about the characteristics of different types of formulations and the general advantages and disadvantages of each type.

Figure 4.3 Emulsifiable concentrate formulation (4 pounds a.i. per gallon).

Liquid Formulations

Liquid formulations are generally mixed with water, but in some instances labels may permit the use of crop oil, diesel fuel, kerosene, or some other light oil as a carrier. This section will present more detailed information about the common liquid pesticide formulations.

Abbreviation	Interpretation	Abbreviation	Interpretation
A	Aerosol	MTF	Multiple temperature formulation
AF	Aqueous flowable	OL	Oil-soluble liquid
AS	Aqueous solution or aqueous suspension	P or PS	Pellets
B	Bait	RTU	Ready-to-use
C	Concentrate	S	Solution
CM	Concentrate mixture	SD	Soluble dust
CG	Concentrate granules	SG	Sand granule
D	Dust	SL	Slurry
DF	Dry flowable, also water-dispersible granule	SP	Soluble powder or soluble packet
DS	Soluble dust	TC	Termiticide concentrate
E, EC, or EW	Emulsifiable concentrate	ULV	Ultra low volume
F or FL	Flowable (liquid)	W or WP	Wettable powder
G	Granules	WDG	Water-dispersible granules
GL	Gel	WS	Water soluble
L	Liquid (flowable)	WSG	Water-soluble granules, also dry flowable
LC	Liquid concentrate or low concentrate	WSL	Water-soluble liquid
M or ME	Microencapsulated	WSB or WSP	Water-soluble bag, water-soluble powder or water-soluble packet

Table 4.1 Abbreviations for formulations.

Emulsifiable Concentrates (EC or E)

An emulsifiable concentrate formulation usually contains a liquid active ingredient, one or more petroleum-based solvents (which give EC formulations their strong odor), and an agent, known as an emulsifier, that allows the formulation to be mixed with water to form an emulsion. Upon mixing with water, they take on a "milky" appearance (Figure 4.4).

Most ECs contain between 25 and 75 percent (2 to 8 pounds) active ingredient per gallon. ECs are among the most versatile formulations. They are used against agricultural, ornamental and turf, forestry, structural, food processing, livestock, and public health pests. They are adaptable to many types of application equipment, from small, portable sprayers to hydraulic sprayers, low-volume ground sprayers, mist blowers, and low-volume aircraft sprayers.

Figure 4.4 Undiluted (l) and diluted (r) emulsifiable concentrate formulations.

Advantages of emulsifiable concentrates include:

- Relatively easy to handle, transport, and store
- Little agitation required - will not settle out or separate when equipment is running
- Not abrasive
- Will not plug screens or nozzles
- Little visible residue on treated surfaces

Disadvantages of emulsifiable concentrates include:

- High a.i. concentration makes it easy to overdose or underdose through mixing or calibration errors
- May cause damage to desirable plants (phytotoxicity)
- Easily absorbed through skin of humans or animals
- Solvents may cause rubber or plastic hoses, gaskets, and pump parts and surfaces to deteriorate
- May cause pitting or discoloration of painted finishes
- Flammable - should be used and stored away from heat or open flame
- May be corrosive

Solutions (S)

Some pesticide active ingredients dissolve readily in a liquid carrier such as water or a petroleum-based solvent. When mixed with the carrier, they form a solution that does not settle out or separate (Figure 4.5). Formulations of these pesticides usually contain the active ingredient, the carrier, and one or more other ingredients. Solutions may be used in any type of sprayer, indoors or outdoors.

Figure 4.5 Undiluted (l) and diluted (r) solution formulations.

Ready-to-Use Low-Concentration Solutions (RTU)

Low-concentrate formulations are ready to use and require no further dilution before application. They consist of a small amount of active ingredient (often 1 percent or less per unit volume) dissolved in an organic solvent. They usually do not stain fabrics nor have unpleasant odors. They are especially useful for structural and institutional pests and for household use. Major disadvantages of low-concentrate formulations include limited availability and high cost per unit of active ingredient. Many organic solvents are harmful to foliage, so they often cannot be used as plant sprays.

Ultra-Low Volume (ULV)

These concentrates may approach 100 percent active ingredient. They are designed to be used as is or to be diluted with only small quantities of a specified carrier and are used at rates of no more than ½ gallon per acre. These special purpose formulations are used mostly in outdoor applications, such as in agricultural, forestry, ornamental, and mosquito control programs.

Advantages of ultra-low volume formulations include:

- Relatively easy to transport, and store
- Remain in solution; little agitation required
- Not abrasive to equipment
- Will not plug screens and nozzles
- Leave little visible residue on treated surfaces

Disadvantages of ultra-low volume formulations include:

- Difficult to keep pesticide on target—high drift hazard
- Specialized equipment required
- Easily absorbed through skin of humans or animals
- Solvents may cause rubber or plastic hoses, gaskets, and pump parts and surfaces to deteriorate
- Calibration and application must be done very carefully because of the high concentration of active ingredient

Invert Emulsions

An invert emulsion contains a water-soluble pesticide dispersed in an oil carrier. Invert emulsions require a special kind of emulsifier that allows the pesticide to be mixed with a large volume of petroleum-based carrier, usually fuel oil.

Invert emulsions aid in reducing drift. With other formulations, some spray drift results when water droplets begin to evaporate before reaching target surfaces; as a result, the droplets become very small and light. Because oil evaporates more slowly than water, invert emulsion droplets shrink less; therefore, more pesticide reaches the target. The oil helps to reduce runoff and improves rain resistance. It also serves as a sticker-spreader by improving surface coverage and absorption. Because droplets are relatively large and heavy, it is difficult to get thorough coverage on the undersides of foliage. Invert emulsions are most commonly used along rights-of-way where drift to susceptible non-target plants or sensitive areas can be a problem (Figure 4.6).

Photo UF/IFAS Agronomy Department

Figure 4.6 Invert emulsion formulations are useful for drift control along rights-of-way.

Flowables (F)/Liquids (L)

A flowable or liquid formulation combines many of the characteristics of emulsifiable concentrates and wettable powders. Manufacturers use these formulations when the active ingredient is a solid that does not dissolve in either water or oil. The active ingredient, impregnated on a substance such as clay, is ground to a very fine powder. The powder is then suspended in a small amount of liquid. The resulting liquid product is quite thick (Figure 4.7). Flowables and liquids share many of the features of emulsifiable concentrates, and they have similar disadvantages. They require moderate agitation to keep them in suspension and leave visible residues, similar to those of wettable powders. Flowables/liquids are easy to handle and apply. Because they are liquids, they are subject to spilling and splashing. They contain solid particles, so they contribute to abrasive wear of nozzles and pumps. Flowable and liquid suspensions settle out in their containers. Always shake them thoroughly before pouring and mixing. Because flowable and liquid formulations tend to settle, manufacturers package them in containers of 5 gallons or less to make remixing easier.

Figure 4.7 Undiluted (l) and diluted (r) flowable/liquid formulations.

Aerosols (A)

These formulations contain one or more active ingredients and a solvent. Most aerosols contain a low percentage of active ingredients. There are two types of aerosol formulations: the ready-to-use type commonly available in pressurized sealed containers, and those products used in electrical- or gasoline-powered aerosol generators that release the formulation as a "smoke" or "fog."

Ready-to-use aerosols are usually small, self-contained units that release the pesticide when the nozzle valve is triggered (Figure 4.8). The pesticide is driven through a fine opening by an inert gas under pressure, creating fine droplets. These products are used in greenhouses, in small areas inside buildings, or in localized outdoor areas. Commercial models, which hold 5 to 10 pounds of pesticide, are usually refillable.

The advantages of ready-to-use aerosols include:

- Ready to use
- Portable
- Easily stored
- Convenient way to buy a small amount of a pesticide
- Retain potency over fairly long time

Disadvantages include:

- Practical for only very limited uses
- Risk of inhalation injury
- Hazardous if punctured, overheated, or used near an open flame
- Difficult to confine to target site or pest

Formulations for smoke or fog generators are aerosol formulations, but not under pressure. They are used in machines that break the liquid formulation into a fine mist or fog (aerosol) using a rapidly whirling disk or heated surface. These

formulations are used mainly for insect control in structures such as greenhouses and warehouses and for mosquito and biting fly control outdoors.

The advantages of smoke or fog generators include:

- Easy way to fill entire enclosed space with pesticide

Disadvantages include:

- Highly specialized use and associated equipment
- Difficult to confine to target site or pest
- May require respiratory protection to prevent risk of inhalation injury

Figure 4.8 Ready-to-use aerosol insecticide.

Liquid Baits

An increasing number of insecticides and rodenticides are being formulated as liquid baits. Liquid rodenticides are mixed with water and placed in bait stations designed for these products. They have two major benefits. Liquid rodenticides are effective in controlling rodents, especially rats, in areas where they cannot find water. They are also effective in areas of poor sanitation where ready availability of food renders traditional baits ineffective.

Liquid insecticide baits are used primarily by the structural pest control industry for controlling ants and, to a lesser extent, cockroaches. They are packaged as ready-to-use, sugar-based liquids placed inside bait stations. Liquid insecticide ant baits have a number of advantages. They are very effective against certain species of sugar-feeding ants. These ants typically accept and transfer liquid baits into the ant colonies. However, some ants will not feed on liquid baits. Liquid baits also must be replaced often.

Dry or Solid Formulations

Dry formulations can be divided into two types: ready-to-use and concentrates that must be mixed with water to be applied as a spray. This section will present more detailed information about the common dry or solid pesticide formulations.

Dusts (D)

Most dust formulations are ready to use and contain a low percentage of active ingredients (usually 10 percent or less by weight), plus a very fine, dry inert carrier made from talc, chalk, clay, nut hulls, or volcanic ash. The size of individual dust particles varies.

A few dust formulations are concentrates and contain a high percentage of active ingredients. These concentrates are mixed with dry inert carriers before applying.

Dusts are always used dry and can easily drift to non-target sites. They are widely used as seed treatments and sometimes for agricultural applications. In structures, dust formulations are used in cracks and crevices and for spot treatments to control insects such as cockroaches. Insects ingest poisonous dusts during grooming or absorb the dusts through their outer body covering. Dusts also are used to control lice, fleas, and other parasites on pets and livestock.

Advantages of dust formulations include:

- Most are ready to use, with no mixing
- Effective where moisture from a spray might cause damage
- Require simple equipment
- Effective in hard-to-reach indoor areas

Disadvantages include:

- Easily drift off target during application
- Residue easily moved off target by air movement or water
- May irritate eyes, nose, throat, and skin
- Will not stick to surfaces as well as liquids
- Dampness can cause clogging and lumping
- Difficult to get an even distribution of particles on surfaces

Special dusts known as tracking powders are used for rodent and insect monitoring and control. For rodent control, the tracking powder consists of finely ground dust combined with a stomach poison. Rodents walk through the dust, pick it up on their feet and fur, and ingest it when they clean themselves. Tracking powders are useful when bait acceptance is poor because of an abundant, readily available food supply. Non-toxic powders, such as talc or flour, often are used to monitor and track the activity of rodents in buildings.

Baits (B)

A bait formulation is an active ingredient mixed with food or another attractive substance. The bait either attracts the pests or is placed where the pests will find it. Pests are killed by eating the bait that contains the pesticide. The amount of active ingredient in most bait formulations is quite low, usually less than 5 percent.

Baits are used inside buildings to control ants, roaches, flies, other insects, and rodents. Outdoors they sometimes are used to control snails, slugs, and insects such as ants and termites. Their main use is for control of vertebrate pests such as rodents, other mammals, and birds (Figure 4.9).

Photo UF/IFAS EDIS publication SS-WEC-120

Figure 4.9 Bait station targeting roof rats.

Advantages of baits include:

- Ready to use
- Entire area need not be covered because pest goes to bait
- Control pests that move in and out of an area

Disadvantages include:

- Can be attractive to children and pets
- May kill domestic animals and non-target wildlife outdoors
- Pest may prefer the crop or other food to the bait
- Dead vertebrate pests may cause odor problem
- Other animals may be poisoned as a result of feeding on the poisoned pests
- If baits are not removed when the pesticide becomes ineffective, they may serve as a food supply for the target pest or other pests
- Laws require outdoor above-ground placement of certain rodenticide bait products be contained in tamper-resistant bait stations

Pastes and gels are mainly used in the pest control industry for ants and cockroaches. Insecticides formulated as pastes and gels are now the primary formulations used in cockroach control. They are designed to be injected or placed as either a bead or dot inside small cracks and crevices of building elements where insects tend to hide or travel. Two basic types of tools are used to apply pastes and gels – syringes and bait guns. The applicator forces the bait out of the tip of the device by applying pressure to a plunger or trigger.

Granules (G)

Granular formulations are similar to dust formulations except granular particles are larger and heavier (Figure 4.10). The coarse particles are made from materials such as clay, corncobs, or walnut shells. The active ingredient either coats the outside of the granules or is absorbed into them. The amount of active ingredient is relatively low, usually ranging from less than 1 to 15 percent by weight.

Granular pesticides are most often used to apply chemicals to the soil to control weeds, nematodes, and insects living in the soil, or for absorption into plants through the roots (Figure 4.11). Granular formulations are sometimes applied by airplane or helicopter to minimize drift or to penetrate dense vegetation. Once applied, granules release the active ingredient slowly. Some granules require soil moisture to release the active ingredient. Granular formulations also are used to control larval mosquitoes and other aquatic pests. Granules are used in

agricultural, structural, ornamental, turf, aquatic, right-of-way, and public health (biting insect) pest control operations.

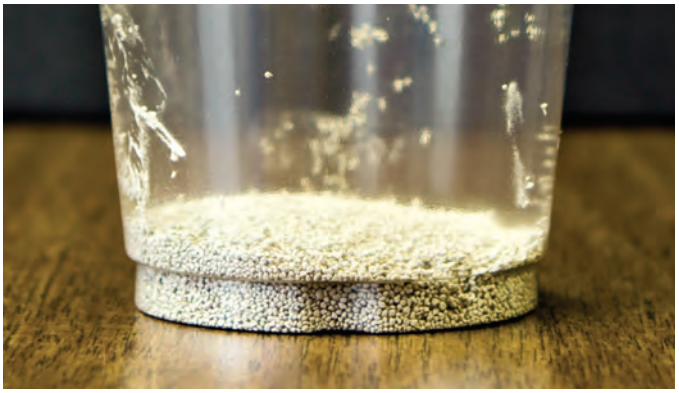


Figure 4.10 Granular formulation.

Figure 4.11 Granular formulations are often applied to the soil.

Advantages of granular formulations include:

- Ready to use – no mixing
- Drift hazard is low, and particles settle quickly
- Little hazard to applicator – no spray, little dust
- Weight carries the formulation through foliage to soil or water target
- Simple application equipment needed, such as seeders or fertilizer spreaders
- May break down more slowly than WPs or ECs because of a slow-release coating

Disadvantages include:

- Often difficult to calibrate equipment and apply uniformly
- Will not stick to foliage or other uneven surfaces
- May need to be incorporated into soil or planting medium
- May need moisture to activate pesticide
- May be hazardous to non-target species, especially waterfowl and other birds that mistakenly feed on the seed-like granules
- May not be effective under drought conditions because the active ingredient is not released in sufficient quantity to control the pest

Pellets (P or PS)

Most pellet formulations are very similar to granular formulations; the terms often are used interchangeably. In a pellet formulation, however, all the particles are the same weight and shape (Figure 4.12). The uniformity of the particles allows use with precision application equipment. A few fumigants are formulated as pellets; some may be referred to as tablets. However, these are clearly labeled as fumigants. Do not confuse them with non-fumigant pellets.

Figure 4.12 Pellet formulation.

Wettable Powders (WP or W)

Wettable powders are dry, finely ground formulations that look like dusts (Figure 4.13). They usually must be mixed with water for application as a spray. A few products, however, may be applied either as a dust or as a wettable powder – the choice is left to the applicator. Wettable powders contain 5 to 95 percent active ingredient by weight, usually 50 percent or more. The particles do not dissolve in water. They settle out quickly unless constantly agitated to keep them suspended. Wettable powders are one of the most widely used pesticide formulations. They can be used for most pest problems and in most types of spray equipment where agitation is possible. Wettable powders have excellent residual activity. Because of their physical properties, most of the pesticide remains on the surface of treated porous materials such as concrete, plaster, and untreated wood. In such cases, only the water penetrates the material.

Advantages of wettable powders include:

- Easy to store, transport, and handle
- Less likely than ECs and other petroleum-based pesticides to

cause unwanted harm to treated plants, animals, and surfaces
- Easily measured and mixed
- Less skin and eye absorption than ECs and other liquid formulations

Disadvantages include:

- Inhalation hazard to applicator while measuring and mixing the concentrated powder
- Require good and constant agitation (usually mechanical) in the spray tank and quickly settle out if the agitator is turned off
- Abrasive to many pumps and nozzles, causing them to wear out quickly
- Difficult to mix in very hard, alkaline water
- Often clog nozzles and screens
- Residues may be visible on treated surfaces

Figure 4.13 Undiluted (l) and diluted (r) wettable powder formulations. Note contents settling (r).

Soluble Powders (SP or WSP)

Soluble powder formulations look like wettable powders. However, when mixed with water, soluble powders dissolve readily and form a true solution. After they are mixed thoroughly, no additional agitation is necessary. The amount of active ingredient in soluble powders ranges from 15 to 95 percent by weight; it usually is more than 50 percent. Soluble powders have all the advantages of wettable powders and none of the disadvantages except the inhalation hazard during mixing. Few pesticides are available in this formulation because few active ingredients are readily soluble in water.

Water-Dispersible Granules (WDG) or Dry Flowables (DF)

Water-dispersible granules, also known as dry flowables, are like wettable powders except instead of being dustlike, they are formulated as small, easily measured granules (Figure 4.14). Water-dispersible granules must be mixed with water to be applied. Once in water, the granules break apart into fine particles similar to wettable powders. The formulation requires constant agitation to keep them suspended in water. The percentage of active ingredient is high, often as much as 90 percent by weight. Water-dispersible granules share many of the same advantages and disadvantages of wettable powders except:

- They are more easily measured and mixed
- Because of low dust, they cause less inhalation hazard to the applicator during handling

Figure 4.14 Undiluted (l) and diluted (r) dry flowable formulations.

Other Formulations

Other formulations include chemicals that cannot be clearly classified as liquid or as dry/solid pesticide formulations.

Microencapsulated Materials (M or ME)

Manufacturers cover liquid or dry pesticide particles in a plastic coating to produce a microencapsulated formulation. Microencapsulated pesticides are mixed with water and sprayed in the same manner as other sprayable formulations. After spraying, the plastic coating breaks down and slowly releases the active ingredient. Microencapsulated materials have several advantages:

- Highly toxic materials are safer for applicators to mix and apply.
- Delayed or slow release of the active ingredient prolongs its effectiveness, allowing for fewer and less precisely timed applications.
- The pesticide volatilizes more slowly; less is lost from the application site.
- These formulations often reduce injury to plants.

In residential, industrial, and institutional applications, microencapsulated formulations offer several advantages. These include reduced odor, release of small quantities of pesticide over a long time, and greater safety. Microencapsulated materials offer fewer hazards to the skin than ordinary formulations. Microencapsulated materials, however, pose a special hazard to bees. Foraging bees may carry micro- encapsulated materials back to their hives because they are about the same size as pollen grains. As the capsules break down, they release the pesticide, poisoning the adults and brood.

Breakdown of the microencapsulated materials to release the pesticide sometimes depends on weather conditions. Under certain conditions, the microencapsulated materials may break down more slowly than expected. This could leave higher residues of pesticide active ingredient in treated areas beyond normal restricted-entry or harvest intervals with the potential to injure fieldworkers. For this reason, regulations require long restricted-entry intervals for some microencapsulated formulations.

Water-Soluble Packets (WSB or WSP)

Water-soluble packets reduce the mixing and handling hazards of some highly toxic pesticides (Figure 4.15). Manufacturers package precise amounts of wettable powder or soluble powder formulations in a special type of plastic bag. When you drop these bags into a filled spray tank, they dissolve and release their contents to mix with the water. There are no risks of inhaling or contacting the undiluted pesticide as long as you do not open the packets. Once mixed with water, pesticides packaged in water-soluble packets are no safer than other diluted pesticides.

Attractants

Attractants include pheromones, sugar and protein syrups, yeasts, and rotting meat. Pest managers use these attractants in various types of traps (Figure 4.16). Attractants also can be combined with pesticides and sprayed onto foliage or other items in the treatment area.

Photo Virginia Tech Pesticide Programs

Figure 4.15 Water-soluble packet dissolves in the tank.

Figure 4.16 Insect cone trap containing pheromone.

Impregnated Products

Manufacturers impregnate (saturate) pet collars, livestock ear tags, adhesive tapes, plastic pest strips, and other products with pesticides (Figure 4.17). These pesticides evaporate over time, and the vapors provide control of nearby pests. Some paints and wood finishes have pesticides incorporated into them to kill insects or retard fungal growth. Fertilizers also may be impregnated with pesticides.

Repellents

Various types of insect repellents are available in aerosol and lotion formulations. People apply these to their skin or clothing or to plant foliage to repel biting and nuisance insects. You can mix other types of repellents with water and spray them onto ornamental plants and agricultural crops to prevent damage from deer, dogs, and other animals.

Figure 4.17 Cattle ear tag impregnated with insecticide.

Animal Systemics

Systemic pesticides protect animals against fleas and other external blood-feeding insects as well as against worms and other internal parasites. A systemic animal pesticide is one that is absorbed and moves within the animal. These pesticides enter the animal's tissues after being applied orally or externally. Oral applications include food additives and premeasured capsules and liquids. External applications involve pour-on liquids, liquid sprays, and dusts. Most animal systemics are used under the supervision of veterinarians.

Pesticide/Fertilizer Combinations

Pest managers frequently use insecticides, fungicides, and herbicides in combination with fertilizers. This provides a convenient way of controlling pests while fertilizing crops or lawns. Homeowners commonly use these combinations, although the unit cost of pesticide in these formulations is usually high. Dealers or growers often custom-mix pesticides with fertilizers to meet specific crop requirements.

Fumigants

Fumigants are pesticides that form poisonous gases when applied. Some active ingredients are liquids when packaged under high pressure and change to gases when they are released. Other active ingredients are volatile liquids when enclosed in an ordinary container and therefore are not formulated under pressure. Others are solids that release gases when applied under conditions of high humidity or in the presence of water vapor. Fumigants are used for structural pest control, in food and grain storage facilities, and in regulatory pest control at ports of entry and at state and national borders. In agricultural pest control, fumigants are used in soil, greenhouses, granaries, and grain bins (Figure 4.18).

Figure 4.18 Soil fumigant application.

Advantages of fumigants:

- Toxic to a wide range of pests
- Can penetrate cracks, crevices, wood, and tightly packed areas such as soil or stored grains
- Single treatment usually kills most pests in treated area

Disadvantages of fumigants:

- The target site must be enclosed or covered to prevent the gas from escaping
- Non-specific in that they are highly toxic to humans and all other living organisms
- Require the use of specialized protective equipment, including respirators specifically approved for use with fumigants
- Require the use of specialized application equipment

Adjuvants

Adjuvants are substances used with a pesticide to enhance performance. By themselves, they do not possess pesticidal activity. Adjuvants may be added to the product at the time of formulation, or by the applicator to the spray mix just prior to treatment. Adjuvants include surfactants, compatibility agents, anti-foaming agents and spray colorants (dyes), and drift control agents.

Much of the confusion surrounding adjuvants can be attributed to the lack of understanding of adjuvant terminology. For example, many people use the terms adjuvant and surfactant interchangeably. These terms can refer to the same product because all surfactants are adjuvants. However, not all adjuvants are surfactants.

Care should be taken when selecting an adjuvant. Pesticide performance can differ depending on what type of adjuvant

is used. The pesticide label will state if specific surfactants are required and the amount (%) of active ingredient it must contain.

Surfactants

Surfactants (surface-active agents) are substances that improve the emulsifying, dispersing, spreading, wetting, or other surface modifying properties of liquids. A surfactant increases the spray coverage on the foliage (Figure 4.19). This helps more of the pesticide to be taken up in the plant or increase pests' exposure to the chemical. Surfactants include extenders, compatibility agents, buffers or pH modifiers, drift retardants, defoaming agents, thickeners, emulsifying agents, wetting agents (spreaders), crop oil concentrates, and stickers.

Credit National Pesticide Applicator Certification Core Manual

Figure 4.19 Surfactants increase the ability of the pesticide to spread evenly over the surface of a leaf or fruit.

Emulsifying agents

An emulsion is a mixture of two incompletely mixed liquids, one of which is dispersed in the other. The surrounding liquid is called the continuous phase, while the dispersed liquid is known as the discontinuous phase. Emulsifying agents promote the suspension of one liquid in another.

There are two types of emulsions used in the application of pesticides. The type more commonly used is the "oil-in-water" emulsion, in which water is the continuous phase. When using this type of emulsion, the consistency of the spray mixture is usually similar to water. The second type of emulsion is the "water-in-oil" emulsion, in which the oil is the continuous phase. These emulsions, also referred to as "invert" emulsions, are normally rather viscous.

It seems that the character of the emulsifying agent is a large factor in determining the kind of emulsion that is formed. The "oil-in-water" emulsions are widely used in the formulation of pesticides to aid in getting an oil-soluble pesticide dispersed in a water mixture so that the active ingredient may be applied as a water spray. Invert emulsions are used to aid in drift control, to improve resistance of the pesticide treatment to the effects of weather (rain), to improve accuracy of delivery of the pesticide, and to enhance activity.

Wetting agents (spreaders)

Wetting agents or spreaders are added to spray mixtures to decrease the surface tension of the mixture, causing a larger portion of each spray droplet to come into contact with the surface of the vegetation. This is done to increase the coverage and thus the effectiveness of the pesticide, although in some cases it may alter pesticide selectivity.

There are four types of spreaders available: anionic, cationic, nonionic, and amphoteric. Anionic and cationic surfactants have electrical charges in water while nonionic surfactants do not have an overall electrical charge. Amphoteric may have positive or negative charges depending on the pH of the solution. Be sure that the type, if any, recommended in the pesticide label is selected. Most pesticide labels will recommend the use of a non-ionic type surfactant.

Crop Oil Concentrates

A crop oil concentrate refers to products that contain 80 to 85 percent petroleum or vegetable oil plus 15 to 20 percent surfactant and emulsifiers. An emulsifiable oil generally refers to products that contain about 98 percent oil and 1 to 2 percent emulsifiers. This group is often called nonphytotoxic oils and phytobland oils.

Silicone Surfactants

Silicone surfactants are silicone-based and provide a tremendous reduction in water surface tension at very low concentrations. Typical concentrations range from 0.10 to 0.25 percent on a volume/volume basis.

Stickers

Stickers are adjuvants that cause the pesticide to adhere to the plant foliage. They decrease:

- runoff of the spray mixture,
- wash-off during irrigation or rain,
- evaporation of the pesticide, and
- some slow down the degradation of pesticides by sunlight.

By increasing the amount of spray remaining in contact with the vegetation and increasing the contact time of the pesticide, the desired result is an increase in the effectiveness of a pesticide application.

Compatibility Agents

Certain combinations of pesticides with other pesticides or liquid fertilizers can be physically or chemically incompatible, which causes clumps and uneven distribution in the tank. These adjuvants are used to aid in the suspension of pesticides when they are combined with other pesticides or fertilizers. They are used primarily when the carrier solution is a liquid fertilizer.

You may wish to do a compatibility test in a jar to determine the stability of the mixture (see page 67). After adding the desired pesticides and fertilizer (if it is intended as part of the application) with the compatibility adjuvant to the jar, shake the mixture and then check for clumping, separation, thickening, and heat release. Any of these signs indicates an incompatibility problem.

Acidifiers and Buffers

There are water sources in Florida that have pH values between 7.0 and 9.0, (from neutral to alkaline). This is the case wherever water comes from a limestone aquifer, such as the Floridan (majority of groundwater withdrawal in Florida) or Biscayne (south Florida), or from lakes or canals that cut into limestone. There is some variability in these values even if they are within the same hydrologic region of the state. Both surface and ground water pH values fluctuate over time and even seasonally. One factor that influences the pH of open water is the amount of resident plant life. In these systems, there are high concentrations of carbonate in the water. The pH of the water may rise in poorly buffered systems because carbonate leads to increases of pH. Therefore, in some Florida water bodies with high levels of healthy aquatic plants, it is possible for pH to reach a measurement of 9.0 or 10.0.

Most pesticide solutions or suspensions are stable between pH 5.5 and pH 7.0 (slightly acidic to neutral). Above pH 7.0 (alkaline or basic), the pesticide may be subject to degradation. Once a pesticide solution becomes alkaline, the risk exists that the pesticide degrades. Buffers and acidifiers are adjuvants that acidify and stabilize the water in the spray tank. Buffers must be added to the tank mix water first. The water must be neutralized or slightly acidified prior to adding pesticides and adjuvants.

Acidifiers are acids that can be added to pesticide spray mixtures if there is a need to neutralize alkaline solutions and lower the pH. Acidifiers do not have a buffering action. Buffers are capable of changing the pH of a water solution to a certain level, which will be maintained even if the pH of the solution changes.

Anti-Foaming Agents and Spray Colorants

An anti-foaming agent can eliminate the excess foam that can result when certain pesticide mixtures undergo mixing or agitation in the spray tank. This is often the result of both the type of surfactant used in the formulation and the type of spray tank agitation system. Spray colorants are dyes that can be added to the spray tank so an applicator can see the areas that have been treated.

Drift Control Agents

Drift is a function of droplet size. Small, fine drops with diameters of 100 microns or less tend to drift away from targeted areas. Drift control additives, also known as deposition aids, improve on-target placement of the pesticide spray by increasing the average droplet size. Drift reduction can be very important near sensitive sites and may well be worth the small reduction in efficacy that may result from the change in droplet size (Figure 4.20).

Selecting the Right Adjuvant

Many factors must be considered when choosing an adjuvant for use in a pest management program. Following are some guidelines:

- Use only adjuvants manufactured and marketed for agricultural or horticultural uses. Do not use industrial products or household detergents with pesticides because they may interfere with pesticide performance.

- Remember, there are no miracle adjuvants. It is generally wise to be skeptical of such claims as "keeps spray equipment clean" or "causes better root penetration" unless the manufacturer has supporting evidence to back up such claims.
- Make sure the adjuvant has been thoroughly tested and proven effective for your intended use. Test questionable products on a limited area before proceeding with full-scale use.
- Certain pesticides and application procedures require certain types of adjuvants. Determine the correct type and use only an adjuvant of that type. For example, do not substitute an anionic surfactant when a nonionic surfactant is recommended.
- A particular pesticide label may require one or more adjuvants for a certain use, yet prohibit any adjuvant for another use. Read the pesticide label carefully.
- Using an adjuvant is not always necessary. It is just as important to know when not to use an adjuvant as it is to know when to use one.

Figure 4.20 Herbicide injury to residential landscape from drift.

Combining Pesticides

Combining two or more pesticides and applying them at the same time is convenient and cost effective. Most pesticide manufacturers sell some of their products as premixes, but often you must still combine two or more pesticides at the time of application. When you combine mixtures of two or more pesticides and/or fertilizers at the time of application, you create a tank- mix. A common tank-mix involves combining fungicides with insecticides as a spray for tree fruit crops. Another involves combining two or more herbicides to increase the number of weed species controlled. Some people mix pesticides with micronutrients or fertilizers. This practice saves money by reducing the time, labor, and fuel required for multiple applications. Tank mixes reduce equipment wear and decrease labor costs. They lessen the mechanical damage done to crops and soil by heavy application equipment. Combinations may, however, affect the toxicity and the physical and chemical properties of any of the components of the tank mix increase residues, and damage or injure the target site, plant, or animal.

The pesticide label is the first step in determining if a tank-mix application may be made. Under Federal law, combining pesticides is legal unless the pesticide labeling of any of the pesticides involved instructs you not to combine them (Figure 4.21). If you mix DANGER-POISON pesticides with WARNING or CAUTION pesticides, treat the mixture as a DANGER-POISON pesticide. You must use the required safety equipment and follow all other label restrictions found on the label having the greatest restrictions.

Several precautions should be kept in mind. Label instructions and compatibility charts usually refer to only two pesticide active ingredients. They do not cover mixtures of three or more pesticides and usually give no information on the compatibility of inert ingredients such as emulsifiers and wetting agents. In addition, factors such as type or variety of crop, weather and water chemistry, especially pH, may be important.

INSECTICIDES

Severe injury or kill of rice plants may result from tank-mix combinations or separate sprays of Stam 4E and certain insecticides. Do not combine Stam 4E with carbamate insecticides such as carbaryl (Sevin, etc.) methomyl (Lannate, Nudrin, etc.) or organophosphorus insecticides such as parathion, methyl parathion, Guthion, malathion, Systox, EPN, Phosphamidon, etc. Do not apply any of the above insecticides to rice fields within 14 days before or after Stam 4E. Do not use carbamate or systemic organophosphorus insecticides on rice fields to be treated with Stam 4E.

Figure 4.21 Label instructions prohibiting tank-mixing.

Compatibility Testing

Incompatibility is a condition that prevents pesticides from mixing together properly to form a uniform solution or suspension. The formation of flakes, crystals, or oily clumps, or severe separation is unacceptable. Heat may also be generated from incompatible mixtures. Such incompatible mixtures clog application equipment and limit even distribution of the active ingredient in the spray tank. This prevents good pesticide

coverage. There can be several reasons for incompatibility to occur:

- Impurities in the spray tank or water
- The order in which pesticides are mixed into the tank
- The types of formulations being mixed
- Temperature of water in the spray tank
- Water pH
- The amount of time the mixture has been in the tank

The 2-Jar Test for Compatibility

A test of compatibility may be made by using two jars for mixing various pesticides and fertilizers by taking the following steps. First, always wear personal protective equipment (PPE) listed on the most restrictive product's label when pouring and mixing pesticides.

1. Measure 1 pint of carrier (water or liquid fertilizer) to each of two quart jars.
2. Add ¼ teaspoon of compatibility agent to one jar, but not the second jar (equivalent to 2 pints per 100 gallons of spray solution).
3. Wettable powders, water dispersible granules, and dry flowables: add 1 tablespoon for each pound per 100 gallons of final spray mixture. Shake slightly to simulate agitation.
4. Water-soluble concentrates, solutions, and flowables: add 1 teaspoon for each pint per 100 gallons of final spray mixture. Shake slightly to simulate agitation.
5. Emulsifiable concentrates: add 1 teaspoon for each pint per 100 gallons of final spray mixture. Shake slightly to simulate agitation.
6. Soluble powders: add 1 teaspoon for each pint per 100 gallons of final spray mixture. Shake slightly to simulate agitation.
7. Remaining adjuvants: add 1 teaspoon for each pint per 100 gallons of final spray mixture. Shake slightly to simulate agitation.
8. After 15 minutes of letting the jars stand, feel the sides of the jars to check for heat emission. If so, a chemical reaction may be occurring, indicating incompatibility. Let the mixture stand another 15 minutes and check again for heat.
9. After standing for 30 minutes, compare the components of the 2 jars and decide:
   a. Jar with no compatibility agent has dispersed ingredients dispersed with no flaking, layer separation, formation of gels, etc., then the mixture is compatible and no compatibility agent is necessary.
   b. Compare with jar that contains compatibility agent.
   c. If the components are not dispersed in either jar, the pesticide-carrier mixture is not compatible and should not be used.

Conclusion

A pesticide formulation consists of both active and inert ingredients. The active ingredient (a.i.) functions as the pesticide; the inert ingredient includes the carrier and adjuvants. The active ingredient includes always listed on the product label. The type of formulation may also be given. Persons handling pesticides must become familiar with the active ingredients and formulation types to better understand the nature of the products.

Adjuvants are added to pesticide formulations to improve the pesticide's ability to control pests, although the adjuvants themselves do not possess pesticidal activity. For example, surfactant type adjuvants function as wetting agents or spreaders that improve pesticide coverage over an area such as a leaf surface. The pesticide handler should know how and when to use an adjuvant. Always read the pesticide label carefully to determine whether adding an adjuvant is recommended for use with the pesticide product and other instructions regarding tank-mixing with other pesticides and fertilizers (Figure 4.22).

In summary, the pesticide user must consider several factors when selecting a pesticide formulation, such as the risks associated with the formulation type, the practicality of using the formulation on the target site or pest, and whether it will provide effective control. Having a basic understanding of formulation types before using pesticides helps the user avoid mistakes and accidents in choosing, mixing, loading, and applying the product.

Figure 4.22 The label will provide mixing and adjuvant information.

Test Your Knowledge

Q: The name "Sevin 5G" on a pesticide label indicates:
A. A granular pesticide with 5 percent inert ingredients
B. A gel pesticide with 5 percent active ingredients
C. A granular pesticide with 5 percent active ingredients
D. A gel pesticide with 5 percent inert ingredients
A: C

Q: Which is the pesticide formulation process by which solid particles are dispersed in a liquid?
A. ULV solvents
B. Solution
C. Suspension
D. Emulsion
A: C

Q: Which liquid pesticide formulation consists of a small amount of active ingredient (often 1 percent or less per unit volume) dissolved in an organic solvent?
A. Emulsifiable concentrate (EC)
B. Ready-to-use low-concentrate solutions (RTU)
C. Ultra-low volume (ULV)
D. Flowables (F)/liquids (L)
A: B

Q: Which liquid pesticide formulation may approach 100 percent active ingredient?
A. Emulsifiable concentrate (EC)
B. Ready-to-use low-concentrate solutions (RTU)
C. Ultra-low volume (ULV)
D. Aerosols (A)
A: C

Q: Which is a disadvantage of both EC and ULV formulations?
A. Solvents may cause rubber or plastic hoses, gaskets, and pump parts and surfaces to deteriorate
B. Contribute to abrasive wear of nozzles and pumps
C. Require constant agitation to keep in suspension
D. Difficult to handle, transport, and store
A: A

Q: Which dry/solid formulation is mixed in water and reduces the risk of inhalation exposure during mixing and loading?
A. Dusts (D)
B. Wettable powders (WP)
C. Soluble powders (SP)
D. Water-dispersable granules (WDG) or dry flowables (DF)
A: D

Q: Which type of dry/solid pesticide formulation consists of particles that are the same weight and shape?
A. Dusts
B. Granules
C. Pellets
D. Baits
A: C

Q: Which is an advantage of microencapsulated materials?
A. They pose few hazards to bees.
B. Delayed or slow release of the active ingredient prolongs its effectiveness.
C. Their pesticidal activity is independent of weather conditions.
D. They usually require only short restricted-entry intervals.
A: B

Q: Which type of adjuvant functions as wetting agents and spreaders (they physically alter the surface tension of spray droplets)?
A. Surfactants
B. Stickers
C. Extenders
D. Buffers
A: A

Q: Which type of adjuvant increases the viscosity of spray mixtures?
A. Stickers
B. Extenders
C. Plant penetrants
D. Thickeners
A: D

CHAPTER V

PESTICIDES AND THE ENVIRONMENT

Chapter V

TABLE *of* CONTENTS

Learning Objectives

After you complete your study of this chapter, you should be able to:

- Explain the meaning of the term, "environment."
- Know how to identify sensitive areas.
- Explain the difference between point-source and non-point-source pollution.
- Name the routes by which pesticides move offsite into the environment.
- Understand factors that affect and how to prevent or minimize:
  - Pesticide drift
  - Pesticide runoff
  - Pesticide movement on or in objects, plants, or animals
- Understand factors that affect and how to prevent:
  - Surface water contamination from pesticides,
  - Groundwater contamination from pesticides
  - Pesticide effects to nontarget organisms, including endangered species

Terms to Know

Adsorption: The process whereby a pesticide binds to soil particles.

Aquifer: The overall geologic formation from which groundwater can be drawn.

Back-siphoning: The movement of liquid pesticide mixture back through the filling hose and into the water source.

Chemical degradation: The breakdown of chemicals, including pesticides, by processes that do not involve living organisms.

Drift: The airborne movement of pesticides to nontarget areas.

Endangered species: Organism that is on the brink of extinction throughout all or a significant portion of its range.

Groundwater: Water beneath the earth's surface in soil or rock.

Hydrolysis: A chemical reaction with water.

Leaching: The downward movement of a pesticide through the soil.

Microbial action: The process by which chemicals, including pesticides, are degraded by soil microorganisms, such as fungi or bacteria.

Non-point-source pollution: Contamination that comes from a widespread area, such as a pesticide entering groundwater from a large-scale application.

Organic matter: Materials and debris that originated as living plants and animals.

Particle drift: The movement of solid particles from the target area by air – may include pesticides formulated as dust or soil particles to which pesticides are attached.

Permeability: Measurement of the ease with which water and dissolved particles can flow through porous materials, such as soil, sand, and gravel.

Persistence: The ability of a pesticide to remain present and active in its original form for an extended period before breaking down.

Photodegradation: The breakdown of chemicals, including pesticide, in reaction to sunlight.

Phytotoxicity: Injury to plants due to chemical exposure.

Point-source pollution: Contamination that comes from a specific identifiable place, such as a pesticide entering a storm sewer.

Residue: The pesticide that remains in the environment after its application or a spill.

Runoff: Surface movement of a pesticide in water from the treated site.

Secondary poisoning: Harm caused to predators from feeding on plants or animals carrying pesticide residues.

Solubility: A measure of the ability of a pesticide to dissolve in a solvent, usually water.

Spray drift: The off-target movement of small, liquid spray pesticide droplets from the application site.

Surface water: Water on top of the earth's surface, such as a lake, stream, or irrigation ditch.

Temperature inversion: Condition that exists when the air at ground level is cooler than the temperature of the air above it. Such a condition is conducive for pesticide drift.

Threatened species: Organism that is likely to become endangered in the foreseeable future.

Tolerance: The maximum amount of a pesticide that may remain on or in raw agricultural commodities.

Vapor drift: The off-target movement of pesticides as gaseous vapors from the target site.

Viscosity: The thickness of a liquid or a measurement of its resistance to flow.

Volatile: Evaporating rapidly; turning easily into a gas or vapor.

Volume median diameter (VMD): Term used to indicate the relative droplet size of a volume of spray from a nozzle.

Introduction

Governmental agencies as well as the general public are becoming increasingly concerned about the harmful effects of pesticides on the environment. Initially, hazards to humans were the primary reason for the EPA to classify a pesticide as a

restricted-use product. Today more and more pesticide labels list environmental effects such as contamination of groundwater or toxicity to birds or aquatic organisms as reasons for restriction (Figure 5.1). The EPA requires extensive environmental testing when it evaluates pesticide applications submitted by manufacturers for the registration of new pesticides. The agency also looks closely at environmental effects when it reevaluates existing pesticide registrations.

Credit CDMS

RESTRICTED USE PESTICIDE
DUE TO GROUND AND SURFACE WATER CONCERNS

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.

This product is a restricted use herbicide due to ground and surface water concerns. Users must read and follow all precautionary statements and instructions for use in order to minimize potential for atrazine to reach ground and surface water.

Figure 5.1 Restricted use pesticide classification due to ground and surface concerns.

The Environment

The environment comprises everything that is around us (Figure 5.2). It includes not only the natural elements that the word "environment" most often brings to mind but also people and the manufactured components of our world. Neither is the environment limited to the outdoors - it also includes the indoor areas in which we live and work.

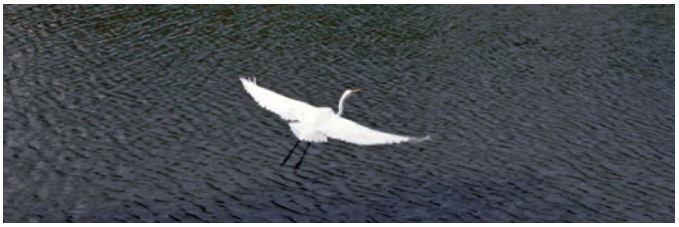


Figure 5.2 The environment is much more than our natural surroundings.

The environment is much more than the oceans and the ozone layer. It is air, soil, water, plants, animals, houses, restaurants, office buildings, and factories, and all that they contain. Anyone who uses a pesticide - indoors or outdoors, in a city or on a farm - must consider how that pesticide affects the environment. The user must ask two questions:

1. Where is the pesticide going to go in the environment after it leaves its container or application equipment?
2. What effects can this pesticide have on those non-target sites it may reach in the environment?

Sources of Contamination

When environmental contamination occurs, it is the result of either point-source or non-point-source pollution. Point-source pollution comes from a specific, identifiable place (point). A pesticide spill that moves into a storm sewer is an example of point-source pollution. Non-point-source pollution comes from a wide area. The movement of pesticides into streams after broadcast applications to large sites is an example of non-point-source pollution.

Non-point-source pollution from pesticide applications is the source that has most commonly been blamed for pesticide contamination in the outdoor environment. However, contamination also results from point sources, such as:

- Wash water and spills produced at equipment cleanup sites.
- Improper disposal of containers and water from rinsing containers.
- Pesticide storage sites where leaks and spills are not correctly cleaned up (Figure 5.3).
- Spills that occur while mixing concentrates or loading pesticides into application equipment.

Figures 5.3 Shoddy storage and disposal practices can lead to point-source pollution.

These kinds of tasks are involved with nearly every pesticide use whether the pesticide is applied outdoors or in or around an enclosed structure. Whenever you release a pesticide into the environment, whether intentionally or accidentally, consider:

- Whether there are sensitive areas in the environment at the pesticide use site that might be harmed by contact with the pesticide.
- Whether there are sensitive offsite areas near the use site that might be harmed by contact with the pesticide.
- Whether there are conditions in the environment at the pesticide use site that might cause the pesticide to move offsite.
- Whether you need to change any factors in your application or in the pesticide use site to reduce the risk of environmental contamination.

Pesticide Characteristics

To understand how pesticides move in the environment, you must first understand certain physical and chemical characteristics of pesticides and how they determine a pesticide's interaction with the environment. These characteristics are solubility, adsorption, persistence, and volatilization.

Solubility

Solubility is a measure of the ability of a pesticide to dissolve in a solvent – usually water. Pesticides highly soluble in water dissolve easily. These pesticides are more likely to move with water in surface runoff or by movement through the soil water than are less soluble pesticides.

In the MSDS, manufacturers use relative terms – such as miscible, dispersible, suspension, emulsifiable, and soluble in water – to describe their product's solubility. Some manufacturers will use a numerical value for this description, such as 2.9 mg/L (milligrams per liter) or ppm (parts per million). Pesticides with a value of 100 ppm and less are considered relatively insoluble while pesticides with values greater than 1,000 ppm are considered very soluble.

Adsorption

Adsorption is the process whereby a pesticide binds to soil particles. Adsorption occurs because of an attraction between the chemical and soil particles. Typically oil-soluble pesticides are more attracted to clay particles and organic matter in soil than are water-soluble pesticides. Also, pesticide molecules with positive charges are more tightly adsorbed to negatively charged soil particles. A pesticide that adsorbs to soil particles is less likely to move from the spray site than a chemical that does not adsorb tightly to the soil.

Persistence

Persistence is the ability of a pesticide to remain present and active in its original form for an extended period before breaking down. A chemical's persistence is described in terms of its half-life, a comparative measure of the time needed for the chemical to break down. The longer the half-life, the more persistent is the pesticide. These residues are sometimes desirable because they provide long-term pest control and reduce the need for repeated applications. However, some persistent pesticides applied to soil, plants, lumber, and other surfaces or spilled into water or on soil can later harm sensitive plants or animals, including humans. It is especially important to prevent persistent pesticides from moving off-site through improper handling, application, drift, leaching, or runoff.

In addition to presenting a hazard to people and non-target animals entering a treated area, application of persistent pesticides may lead to the presence of illegal residues on rotational food or feed crops. Check the label for statements about the persistence of the pesticide and for replanting restrictions. The rate of pesticide degradation relates to the persistence of the pesticide.

Degradation processes break down pesticide compounds into simpler and often less toxic chemicals. Some pesticides break down very rapidly – in a matter of days or even hours. Others can be detected in the environment for a year or more. Pesticides are broken down or degraded by the following processes (Figure 5.4):

- Chemical degradation: the breakdown of chemicals by processes that do not involve living organisms, most commonly by hydrolysis, a chemical reaction with water.
- Microbial action: the process in which chemicals are degraded by soil microorganisms, such as fungi or bacteria.
- Photodegradation: the breakdown of chemicals in reaction to sunlight.

Water and temperature both affect the breakdown of pesticides. Warm, wet conditions can increase the speed of pesticide breakdown; cool, dry conditions slow down the degradation process.

Volatility

Volatility is the tendency of a pesticide to turn into a gas or vapor. Some pesticides are more volatile than others. The

chance of volatilization increases as temperatures and wind increase. Volatility is also more likely under conditions of low relative humidity.

The potential for a pesticide to volatilize is measured by its vapor pressure. Pesticides that have high vapor-pressure values are more volatile. Vapors from such pesticides can move off-site and cause injury to susceptible plants. Some volatile pesticide products carry label statements that warn handlers of the product's potential for vapor movement (Figure 5.5).

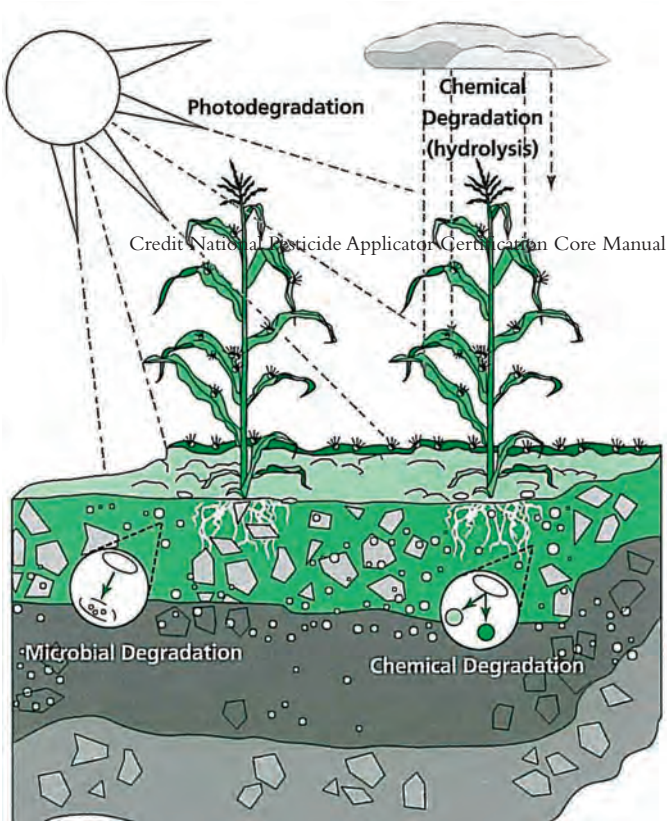


Figure 5.4 Pesticide degradation processes.

SPECIAL PRECAUTION

Off-site movement of spray drift or vapors of Command® 3ME herbicide can cause foliar whitening or yellowing of some plants. Prior to making applications, read and strictly follow all precautions and instructions in the GENERAL APPLICATION PRECAUTIONS, SPRAY DRIFT PRECAUTIONS and SPRAY DRIFT MANAGEMENT sections.

Figure 5.5 Precautionary label statement regarding vapor movement.

Movement of Pesticides in the Environment

Pesticides that move away from the targeted application site, either indoors or outdoors, may cause environmental contamination. Pesticides move in several ways: in water, in air, attached to soil particles, and on or in objects. The following sections will address these concerns in greater detail.

Movement on or in Objects, Plants, or Animals

Pesticides can move away from the application site when they are on or in objects or organisms that move (or are moved) off-site. When pesticide handlers bring home contaminated personal protective equipment, work clothing, or other items, residues can rub off on carpeting, furniture, and laundry items, and onto pets and other people.

Pesticide residue is the pesticide that remains in the environment after an application or a spill. Pesticide residues may be on treated crops, feed products, or livestock. The breakdown time ranges from less than a day to many years, depending mostly on the chemical structure of the pesticide's active ingredient. Acceptable levels of residues for any pesticide are known as its tolerance and are set by government agencies. The tolerance is the maximum amount of a pesticide that may remain on or in raw agricultural commodities.

Pesticide Drift

Drift can be defined simply as the airborne movement of pesticides to non- target areas. In Florida, drift can also have legal meaning, as there are penalties for damage caused to sensitive crops by certain types of herbicides. Off-target movement can be in the form of:

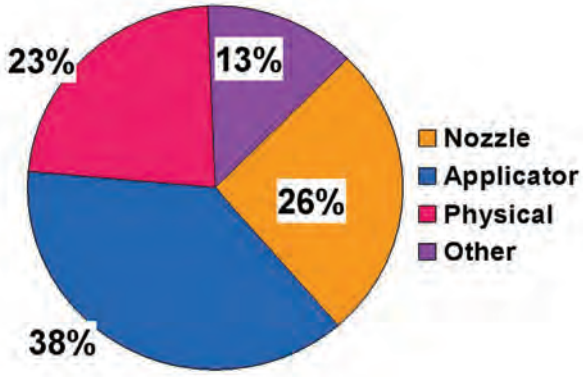
- Spray droplet drift,
- Vapor drift, or
- Particle (dust) drift

Studies have shown that a significant percentage of pesticides may never reach the intended target site because of drift. It is impossible to eliminate drift totally, but it is possible to reduce it to a tolerable level.

Where significant drift does occur, it can damage or contaminate sensitive crops, poison bees, pose health risks to humans and animals, and contaminate soil and water in adjacent areas (Figure 5.6). Applicators are legally responsible for the damages resulting from the off-target movement of pesticides. All people and animals should be removed from the area where pesticides are being applied.

Why does drift occur? Surveys during the 1990s by insurance companies investigating damage claims determined that the most common reason was applicator error (Figure 5.7).

Figure 5.6 Sensitive plant showing injury from drift.



Source Farmland Insurance (1996)

Figure 5.7 Factors contributing to pesticide drift.

Spray Drift

Spray drift refers to the off-target movement of a pesticide during a liquid application. This is the result of small spray droplets being carried off-site by air movement. Spray drift occurs more frequently than the other two types of drift because almost all spray applications result in some off-target movement.

Avoid most problems associated with spray drift by paying close attention to spray droplet size and wind direction and speed. Larger spray droplets are less likely to drift than smaller ones. Nozzle selection affects practically every aspect of spray drift. Typically, larger nozzle orifices and lower pressures produce larger droplets (Table 5.1). However, some nozzles, such as the venturi or air-induction nozzles, produce larger droplets when used at higher pressures (above 40 psi). To help applicators select nozzles according to droplet size, spray equipment manufacturers are including drop size charts with their respective catalogs and websites. These charts classify the droplet size from a given nozzle at various pressure levels according to a standard set up by the American Society of Agricultural and Biological Engineers. The standard rates droplets as extremely fine, very fine, fine, medium, coarse, very coarse, extremely coarse, and ultra coarse. Droplet size categories in their literature are color-coded as shown in Table 5.1.

Ideally, nozzles should produce only a narrow range of droplet sizes. However, in addition to droplets about the right size for good coverage of a particular application, nozzles generally produce a few larger droplets and many smaller droplets that are prone to drift. The term volume median diameter (VMD) is used to indicate the relative droplet size of a volume of spray from a nozzle. Droplet size is measured in microns. A micron is one millionth of a meter. Without magnification, particles less than 100 microns in diameter are practically invisible.

A VMD of 400 microns means that half the volume of spray will be droplets that have a diameter of less than 400 microns and the other half of the volume of spray will be droplets larger than 400 microns. Because smaller droplets have much less volume than larger droplets, most of the droplets will be smaller than the VMD (Figure 5.8).

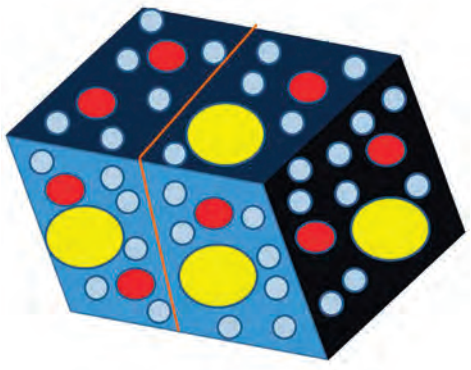


Figure 5.8 VMD shown by red droplets.

Table 5.1 Characteristics of spray droplets.

ASABE[1] standard		Relative size	
Category (symbol)	**Approx. VMD[2] (microns)**		
Extremely fine (XF)	50	Point of needle	Fog
Very fine (VF)	<136		
Fine (F)	136 – 177	Human hair Sewing thread	Fine mist Drizzle
Medium (M)	177 - 218		
Coarse (C)	218 - 349	Staple	Light rain
Very coarse (VC)	349 – 428		
Extremely coarse (XC)	428 - 622	#2 Pencil lead	Thunderstorm
Ultra coarse (UC)	>622		

[1]American Society of Agricultural and Biological Engineers; [2]Volume Median Diameter

The viscosity (thickness) of the liquid affects droplet size. The viscosity of a liquid is a measure of its resistance to flow. For example, mayonnaise is more viscous than water. As the viscosity of the liquid increases, so does the droplet size, thus reducing the potential for off- target movement. Formulations such as invert emulsions have a thick consistency that aids in reducing drift. Other formulations produce some spray drift when water droplets begin to evaporate before reaching the intended target. As a result, these droplets become very small and light and may move from the target site. Thus, invert emulsions have less water loss and more of the pesticide reaches the target. Several drift control additives can help reduce the potential for drift. The number of large droplets can be increased by using certain additives and thickeners. Remember:

- Always follow the label directions about using any spray adjuvant intended for minimizing drift.
- No drift control agent will eliminate drift in high winds.

Air movement is the most important environmental factor influencing the drift of pesticides from target areas. The movement of air is influenced by the temperature at ground level and the temperature of the air above it. Warm air at the soil surface is expected to occur more often when the sun is higher in the sky and shining on the soil.

Inversion conditions result when warmer air above traps cooler air located near the surface of the ground; this can be readily visible if dust or smoke rises little from its source and fails to dissipate (Figure 5.9). These conditions are more likely to occur in the early morning or evening. Applications made under low-wind conditions can sometimes result in more extensive drift than those made under high winds. Drift that occurs over long distances (over a mile) is most often the result of applications made under stable atmospheric conditions such as temperature inversions.

Figure 5.9 Temperature inversion evidenced by smoke not dissipating.

Except in the case of temperature inversions, the early morning and evening are often the best times to apply pesticides because windy conditions are more likely to occur around midday when the temperature warms near the ground. This causes hot air to rise quickly and mix rapidly with the cooler air above it, favoring drift. The best time to spray is when the spray droplets move slowly upwards in the absence of windy or inversion conditions.

Low relative humidity and/or high temperatures also can increase the potential for spray drift. Under these conditions, the evaporation rate of water increases, resulting in smaller spray droplets that drift more easily. Avoid spraying during these times.

Reduce outdoor drift problems by spraying when the wind speed is low, by leaving an untreated border or buffer area in the downwind target area, and by spraying downwind from sensitive areas such as residential properties, schools, crops, waterways, or beehives. For reducing drift indoors, pest control operators must consider the air circulation patterns inside of buildings. Turn fans and air conditioners off and close vents where necessary to prevent pesticides from drifting to other

areas of the structure. Using low-volatile or non-volatile pesticides and using only low-pressure treatments can reduce indoor pesticide drift problems.

Vapor Drift

Vapor drift refers to the movement of pesticides as gaseous vapors from the target area. Some pesticides are volatile and can change readily from a solid or liquid form into a gas under the right conditions. This most often occurs with high air temperatures. Pesticides that have volatilized into a vapor or gas may drift farther and for a longer time than they would have as spray droplets. Only those pesticides that are able to volatilize are susceptible to vapor drift. As air temperatures increase, the likelihood that these pesticides will volatilize and drift also increases.

Whenever possible, choose a pesticide formulated as a low-volatility product (Figure 5.10). Avoid applying volatile pesticides on hot days. Some products can even volatilize several hours after application, so beware if high temperatures are predicted for later in the day. Many products carry precautions against applying these products when temperatures are above 85 degrees F or expected to reach 85 degrees. Remember to check label precautions for product-specific concerns about vapor drift.

Figure 5.10 Low-volatile herbicide formulation.

Particle Drift

Particle drift refers to the movement of solid particles from the target area by air during or just after an application. These solid particles may include pesticides formulated as dust or soil particles to which pesticides are attached. Some pesticides can remain active on soil particles for long periods after they are applied. If particles are blown off the target area, contamination or damage to sensitive areas can occur. Be sure to close all windows and vents and turn off all circulating fans, forced-air heating systems, and air conditioning units to prevent particle drift from nearby outdoor pesticide applications from entering a building.

For indoor applications of pesticides, reduce particle drift by turning off fans, forced-air heating systems, and other air-circulating equipment. Check pesticide labels for statements related to these concerns.

Drift Mitigation Measures

Drift can be controlled by maximizing droplet size and minimizing the time that droplets are in the air. The following are specific strategies for achieving those goals.

- *Make applications in accordance with label directions.* If there are specific conditions spelled out on a product label in regards to drift, they should be the first concern.
- *Keep in mind Florida law.* Florida strictly regulates organo-auxin herbicides. If they will be applied, remember that type of equipment used for the application, wind speeds, set-back distances, and type of crop are all interrelated factors that must be considered.
- *Spray only when conditions are right.* Do not spray when wind speeds are as high as 10 mph. Use caution when winds are light and variable, especially when applications are to be made near susceptible vegetation. Also use special caution when relative humidity is below 50 percent and when temperatures are high. Drift is much more likely during the hottest part of the day.
- *Select boom configuration for maximum performance.* Keep the boom close to the target (soil surface or canopy) by using wide-angle nozzles. Relatively large nozzle spacing (not greater than 30 inches) allows the use of large orifice sizes, which produce larger droplets.
- *Select a reasonable application speed.* Site conditions will ultimately determine this but a speed that can be maintained without pushing the pressure limits of the nozzle and which doesn't cause the boom to bounce. Higher speeds are not only harder on equipment and difficult to maintain, but result in enough air movement to cause some drift.
- *Select the best nozzle type and size for each type of application you make and use drift reduction nozzles.* Remind yourself that nozzles are cheap compared to the cost of materials and cheap compared to the yield losses or litigation costs that can result from a poor application. Most improved nozzle designs really do have superior droplet size characteristics.
- *Calibrate the sprayer and replace worn nozzles.* Worn nozzles produce spray patterns and poor droplet distributions that result in poor coverage, increased drift, or both.
- *Use higher carrier rates.* Although some product labels require low volumes, there are others where you may select a higher

volume that allows the use of larger nozzles, which produce larger, less drift-prone droplets when operated at the correct pressure.
- *Use low-volatile formulations.* You don't always have a choice, but some products are formulated so that vapor drift risks are reduced.
- *Use drift-reduction agents*. Follow their directions – more is not better. Drift-reduction agents are not regulated, so use caution and take the time to determine which products have a good performance record. Your local dealer should have a list of drift reduction agents that they recommend. Use these lists as a guide for selecting drift control additives. No drift-control agent will eliminate drift in high winds.

Pesticide Contamination of Surface Water

Surface water is often a source of drinking water. In Florida, recent estimates report that surface water accounts for approximately 38 percent of the state's fresh water withdrawals. Therefore, pesticide contamination of surface water (ditches, streams, rivers, ponds, and lakes) is a health concern. Pesticides that move in runoff water or with eroded sediment may contaminate plants and animals located downslope and may reach sources of surface water.

Factors affecting runoff and erosion rates include slope, vegetative cover, soil characteristics, volume and rate of water moving downslope, temperature, and rainfall amount and intensity. These factors influence how much water runs off and how much moves into the soil (infiltration).

Runoff may be a problem for most outdoor application sites. In areas treated with any type of pesticide, it is critical that runoff does not carry the pesticide into water sources or other vulnerable areas.

Pesticide Contamination of Groundwater

Groundwater provides 62 percent of Florida's water withdrawals and is the drinking water source for approximately 90 percent of its citizens. Like surface water, groundwater needs to be protected from contamination. Once groundwater is contaminated, correcting the problem is difficult or even impossible.

Most people are more familiar with surface water than groundwater. Surface water bodies such as lakes, streams and oceans can be seen all around, but not groundwater bodies. Many people may think that groundwater occurs in vast underground lakes, rivers, or streams. However, groundwater is found underground in cracks in the bedrock and in the spaces between soil particles, gravel, and rocks, and is the source of water for wells and springs.

The layer of soil, sand, gravel, or fractured bedrock in which all available spaces are filled with water is the saturated zone. The boundary between the saturated zone and the overlying unsaturated rock and soil is known as the water table. The overall geologic formation from which groundwater can be drawn is called an aquifer.

Florida has several prolific aquifers that yield large quantities of water to wells, streams, lakes, and some of the world's largest springs. The principal source of groundwater for most of Florida is the Floridan Aquifer (Figure 5.11). The upper Floridan aquifer is the principal source of water supply in most of north and central Florida. It also yields water to thousands of domestic, industrial, and irrigation wells throughout the state.

Credit Adapted from Florida Department of Environmental Protection

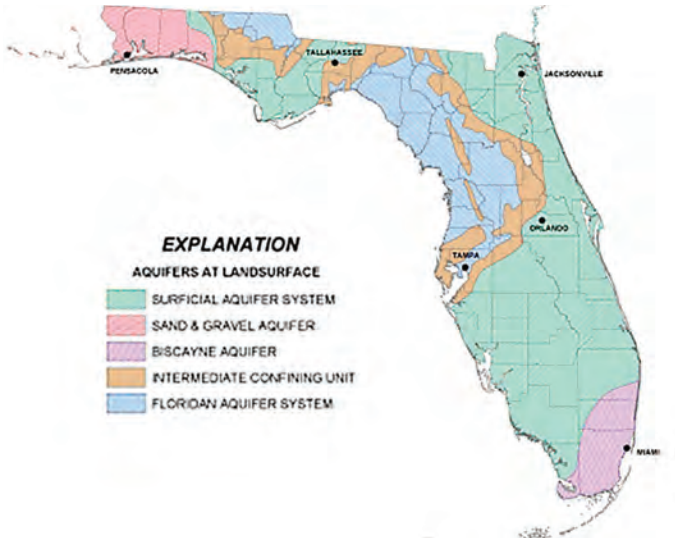


Figure 5.11 Florida's aquifers.

Leaching

Some pesticides reach groundwater by moving through the soil in a process called *leaching*. For a pesticide to leach into groundwater, it must move down through the soil in water and resist binding to soil particles and breaking down into non-toxic compounds. A pesticide's chemical and physical characteristics influence its ability to leach into groundwater. A pesticide soluble in water can move in water into surface water or groundwater. Persistent pesticides are likely to leach and contaminate groundwater. Pesticides having high solubility low adsorption, and/or persistence typically have a label statement

informing the applicator of leaching concerns. A pesticide that adsorbs or binds itself strongly to soil particles will not leach as easily. In addition to the characteristics of the pesticide, soil properties and environmental conditions also affect the likelihood and extent that a pesticide will leach.

Soil Properties

Four soil properties influence a pesticide's potential for leaching: 1) texture and structure, 2) organic matter, 3) depth to groundwater, and 4) geology.

Texture and structure. Soil texture is a term commonly used to designate the proportionate distribution of the different sizes of mineral particles in a soil. It is the relative proportions of sand, silt, and clay-sized particles. Percolating water moves faster in sandy soils, and fewer binding sites are available for the adsorption of dissolved chemicals when compared to clay or silt soils. Though sandy soils are more prone to pesticide movement, leaching may also occur in clay or silt soils.

Soil structure is the shape or arrangement of soil particles. It plays a big role in determining the size and shape of the pores through which water moves. Small amounts of pesticides may also move through soil cracks, worm holes, and root channels. These features are referred to as macropores.

Organic matter. Organic matter consists of decaying plant material. The higher the soil organic matter content, the greater the soil's ability to hold both water and adsorbed pesticides. Pesticides held in the root zone are less likely to leach into groundwater and may be taken up by plants.

Many of Florida's sandy soils were formed directly from sandy marine sediments which were transported and deposited by ocean currents as sea levels fluctuated. Florida's organic soils developed from decaying freshwater swamp and marsh plants where flooded conditions prevented the complete decomposition of organic matter to carbon dioxide. Clay soils of the panhandle and upland ridges were formed from materials that were eroded from the Appalachian Mountains and the southern coastal plain. These materials were transported southward by the action of rivers. Some soils form directly from the rocks beneath them as they break down over time. This scenario is not common in Florida, with the exception of some calcareous soils in Miami-Dade County.

There is a relationship between soil texture and organic matter content that affects the potential for and rate at which pesticides leach. The greatest potential for leaching and groundwater contamination would occur on sandy soils with low organic matter content. The concept is illustrated in Table 5.2.

Texture (particle diameter, mm)	**Organic matter content**	**Permeability**
Coarsest: gravel (> 2.00)	Lowest	**Fastest**
Coarse sand (1.00 – 0.50)		
Medium sand (0.50 – 0.25)		
Fine sand (0.25 – 0.10)		
Very fine sand (0.10 – 0.05)		
Silt (0.05 – 0.002)		
Finest: clay (< 0.002)	Highest	**Slowest**

Table 5.2 Speed of movement relative to soil properties.

Depth to Groundwater. Areas with a shallow water table have a greater chance for groundwater contamination because less soil is available to act as a filter, resulting in fewer opportunities for the pesticide to be degraded or adsorbed. When you must use pesticides in areas where the groundwater is close to the surface, select a pesticide having a low leaching potential and take extra precautions during mixing, application, and cleanup.

Geology. The permeability of the geologic layers lying between the surface of the soil and the groundwater is also an important factor. Highly permeable materials such as gravel deposits allow water and dissolved pesticides to move downward to groundwater freely. Layers of clay, which are much less permeable, can inhibit and slow the downward movement of water.

Preventing Surface Water and Groundwater Contamination

Because cleanup of water contaminated with one or more pesticides is complicated, time-consuming, expensive and usually not feasible, prevention is the best solution for water pollution. The following management practices will help to retain pesticides in target areas and keep pesticides out of water resources.

Consider the Vulnerability of the Site. Determine the

susceptibility of the soil to leaching. Soil texture, organic-matter content, soil moisture and permeability all affect pesticide movement. Some pesticides readily move through soils that are well drained, sandy, or low in organic matter. For example, many of the common soils used for citrus production in Florida have a content of well over 90 percent sand (Figure 5.12).

Figure 5.12 Many of Florida's soils have a content of over 90 percent sand.

Determine, to the extent possible, the depth of the water table and the relative permeability of the geologic layers between the soil surface and the groundwater. If sinkholes are present, surface-water runoff can quickly reach groundwater with little natural soil filtering. The slope of the field and the relative location of lakes, ponds, streams, canals, or wetlands to the application site also determine the vulnerability of these surface-water bodies to contamination from pesticides.

Construct a berm or bank between the application site and surface-water bodies to prevent or reduce the amount of water running off the field into the surface water following a heavy rainfall. Develop a buffer zone, such as a grass border, between the field or the site used for pesticide mixing and loading and surface-water-sensitive areas (Figure 5.13). Water should pass through a grass "filter" strip when draining off fields into canals or other water conveyances.

Evaluate the Pesticide/Follow the Label. Select pesticides that are less likely to leach. Pesticides that have the greatest potential to leach to groundwater are highly water soluble, relatively persistent and do not adsorb to soil. Some pesticides are classified as restricted use and have label statements because of concerns over water contamination. Read the label before you purchase, use, or dispose of a pesticide. You are required by law to follow label directions. Be aware that there are several Florida-specific laws that place soil-type limitations on use of certain pesticides, including aldicarb and bromacil. Label language will alert users of such limitations. The Cooperative Extension Service can assist you in selecting the appropriate pesticide.

Figure 5.13 Grass and weeds provide a filter strip between a grove and mixing site and canal.

Evaluate Location of Water Sources. Pesticide contamination of water frequently is associated with pesticide-handling practices in the vicinity of wells and other water sources. Pesticide spills near wells can move directly and quickly into groundwater. Wells should be properly cased, capped, and grouted.

Unprotected wells act as conduits for surface contaminants to the aquifer. Open wells near sites used for mixing or loading pesticides are particularly vulnerable to contamination. Slope the grade around the wellhead to direct runoff away from the well. Close abandoned wells and never dispose of wastes in unused wells. Avoid mixing, storing, or disposing of pesticides within 100 feet of a well. Some pesticide labels may recommend specific distances that pesticides should not be mixed and loaded within various surface-water bodies, such as intermittent streams and rivers, natural or impounded lakes, and reservoirs.

Use Integrated Pest Management (IPM). The practice of IPM combines chemical, cultural, and biological control into one program to manage pest populations. Fields must be scouted to identify pests, their population levels, and extent of damage. Make pesticide applications only when necessary, using the lowest rate required for adequate control. Reduction in the amount of pesticide used lowers potential movement of pesticides to sources of water, protects the natural environment and reduces costs. For more information on IPM programs and practices contact your IFAS Cooperative Extension Service county office.

Consider Weather and Irrigation. Delay the pesticide application if heavy or sustained rain is anticipated. Pesticide runoff and leaching are favored by rainfall soon after application. Do not apply pesticides before scheduled irrigations unless the product must be activated by moisture. Control the quantity of irrigation water to minimize leaching and runoff (Figure 5.14).

Figure 5.14 Control irrigation to minimize leaching and runoff.

Measure Pesticides Carefully. Accurately calculate the amount of pesticide needed to treat the site to assure you are staying within the label rate. Careful calculations help eliminate disposal problems associated with excess spray mix.

Calibrate Sprayer. Calibrate application equipment frequently to assure the desired amount of pesticide is being applied (Figure 5.15). Check the equipment for leaks and malfunctions.

Figure 5.15 Calibrate to check application output.

Mix and Load Carefully. Repeated pesticide spills at mixing and loading sites may exceed the capacity of the soil to adsorb or degrade the chemical, increasing the likelihood of groundwater contamination. If spills occur, follow containment and cleanup procedures. Consult the label for cleanup procedures.

If possible, mix and load on a permanent or portable containment pad to avoid saturating the soil with pesticide. If the water source (well, canal or pond) used for filling a spray tank is not protected by a concrete pad, berm or wall to prevent runoff into the source, fill the spray tank as far as possible from the water source or fill the tank in the field from a nurse tank. Nurse tanks are used to transport clean water for mixing and loading. Add the pesticide concentrate to the sprayer in the field.

Use a check valve (anti-siphon device) or an air gap between the end of the water supply hose and the highest water level in the spray tank to prevent back-siphoning from the spray tank into the water supply (Figure 5.16). Anti-siphon devices are required for chemigation equipment in Florida. Do not leave the spray tank unattended when filling. Do not allow tanks to drain at mixing and loading sites. Close the tank opening to prevent spills when transporting the sprayer to the field.

Figure 5.16 Never place a hose into a tank while filling; always leave an air gap to prevent back-siphoning.

Store Pesticides Safely. Store pesticides in a facility with restricted access and away from all water resources. Use a facility with a concrete floor that has been sealed to facilitate clean-up in the event of a spill or leak. Inspect containers regularly for leaks and corrosion. Bulk pesticide storage tanks should be placed on concrete pads with dikes built around the tanks to prevent movement of pesticide should a spill or leak occur (Figure 5.17).

Figure 5.17 Bulk storage tanks on diked-concrete pad.

Dispose of Wastes Carefully. Follow the label when disposing of pesticides. Triple or pressure rinse empty pesticide containers and add the rinse to the spray tank. Apply excess spray mix and rinse water from equipment cleaning to crops or

sites listed on the label. Don't drain the excess on the ground. Mount a tank of fresh water on the sprayer to rinse the tank and sprayer. Where practical, excess spray mix or rinses can be held in a tank for use in a later spray mix (Figure 5.18).

Figure 5.18 Bulk storage tanks holding spray mix and rinse for later use.

Take empty, rinsed plastic pesticide containers to pesticide container recycling facilities or to sanitary landfills. Excess pesticide concentrates can be given to another qualified user, safely stored for hazardous-waste-collection days, or disposed of by a firm licensed to dispose of hazardous waste.

Sensitive Areas, Non-Target Organisms, and Endangered Species

To prevent adverse effects on the environment, pesticide users must be aware of sensitive areas, non-target plants and animals, especially endangered species, and harmful effects on habitat.

Sensitive Areas

In addition to water sources, sensitive areas include sites where living things could easily be injured by a pesticide. Outdoor sensitive areas include (Figures 5.19):

- Schools, playgrounds, recreational areas, hospitals, and similar institutions
- Habitats of endangered species
- Apiaries (honeybee sites), wildlife refuges, and parks
- Areas where domestic animals and livestock are kept
- Ornamental plantings, public gardens, and sensitive food or feed crops

Figure 5.19 Sensitive outdoor areas – playgrounds, apiaries, cattle feeding facilities.

Sensitive areas indoors include:

- Where people live, work, shop, or are cared for
- Where food or feed is processed, prepared, stored, or served
- Where domestic or confined animals live, eat, or are otherwise cared for

Where ornamental or other sensitive plants are grown or

maintained, such as in malls and buildings

Sometimes pesticides must be deliberately applied to a sensitive area to control a pest. Only applicators who are competent in handling pesticides should perform these applications.

At other times, the sensitive area may be part of a larger target site. Whenever possible, take special precautions to avoid application to the sensitive area. Leaving an untreated buffer zone around a sensitive area is a practical way to avoid contaminating it.

In still other instances, the sensitive area may be near a site used for mixing and loading, storage, disposal, or equipment washing. The pesticide user must take precautions to avoid accidental contamination of the sensitive area. Check the label for statements that alert you to special restrictions around sensitive areas.

Figure 5.20 Sensitive indoor area – dairy milking facility.

Nontarget Organisms

Pesticides may affect non target organisms, directly causing immediate injury or may produce long-term consequences through environmental pollution. Pesticides may be able to accumulate in the bodies of animals or in the soil. If you use the same mixing and loading site or equipment cleaning site over a long period, pesticides are likely to accumulate in the soil. When this occurs, plants and animals that come into contact with the soil may be harmed. The following sections discuss the effects of pesticides on nontarget plants, bees and other beneficial insects, and fish, wildlife, and livestock.

Nontarget Plants

Nearly all pesticides can cause plant injury due to chemical exposure (phytotoxicity), particularly if they are applied at too high a rate, at the wrong time, or under unfavorable environmental conditions. Phytotoxicity can occur on any part of a plant – roots, stems, leaves, flowers, or fruits. Most phytotoxic injury is due to herbicides. Damage to crops or other plants in adjacent areas is primarily caused by drift, though it may sometimes be a consequence of surface runoff.

Bees and other Beneficial Insects

Bees pollinate many fruit, seed, vegetable, and field crops (Figure 5.21). Applicators must be aware of bee activity when planning pesticide applications. Preventing bee loss is the joint responsibility of the applicator, the grower, and the beekeeper. Minimize losses of bees to insecticide poisoning by following a few basic principles:

- **Notify beekeepers.** If beekeepers are notified in advance of application, colonies can be moved or loosely covered with burlap or coarse cloth to confine the bees and yet allow them to cluster outside the hive under the cloth. Repeated sprinkling each hour with water prevents overheating. Never screen or seal up colonies and do not cover with plastic sheeting. This can result in overheating, leading to bee suffocation and death. Florida law requires every apiary or bee yard to be plainly marked with the owner's name, address and telephone number.
- **Use pesticides only when needed.** Foraging honey bees, other pollinators, and insect predators are a natural resource and their intrinsic value must be taken into consideration. Vegetable, fruit, and seed crop yields in nearby fields can be adversely affected by reducing the population of pollinating insects and beneficial insect predators. It is always a good idea to check the field to be treated for populations of both harmful and beneficial insects.
- **Do not apply pesticides while crops are in bloom.** Insecticide should be applied only while target plants are in the bud stage or just after the petals have dropped.
- **Apply pesticide when bees are not flying.** Bees fly when the air temperature is above 55-60 degrees F and are most active from 8 a.m. to 5 p.m. Always check a field for bee activity immediately before application. Pesticides hazardous to honey bees must be applied to blooming plants when bees are not working, preferably in the early evening. Evening application allows time for these chemicals to partially or totally decompose during the night.
- **Do not contaminate water.** Bees require water to cool the hive and feed the brood. Never contaminate standing water with pesticides or drain spray tank contents onto the ground, creating puddles.
- **Use less toxic compounds.** Some pest control situations allow the grower-applicator a choice of compounds to use. Those hazardous to honey bees must state so on the label.
- **Use less toxic formulations.** Not all insecticides have

the same effects when prepared in different formulations. Research and experience indicate:
  – Microencapsulated insecticides are much more toxic to honey bees than any formulation so far developed. Because of their size, these capsules are carried back to the colony and they can remain poisonous for long periods. These insecticides should never be used if there is any chance bees might collect the microcapsules. Always consider using another formulation first.
  – Dusts are more hazardous than liquid formulations.
  – Emulsifiable concentrates are less hazardous than wettable powders.
  – Ultra-low-volume (ULV) formulations are usually more hazardous than other liquid formulations.
- **Identify attractive blooms.** Before treating a field with pesticides, it is a good idea to check for the presence of other blooming plants and weeds which might attract bees. In many instances bees have been killed even though the crop being sprayed was not in bloom. Many times these attractive blooms can be mowed or otherwise removed, although mowing can result in destroying other beneficial insect habitat or force destructive insects into the crop being cultivated.

Pesticides can harm other beneficial insects in addition to bees. Often these beneficial insects are valuable allies in keeping pest populations below damaging levels (Figure 5.22). A pesticide application often harms the beneficial insect population as much as the target pest, so do not spray when beneficial insects are in the target area except when absolutely necessary.

Photo Joseph Berger, Bugwood.org

Figure 5.21 Bees are important pollinators.

Top, middle: UF/IFAS Department of Entomology & Nematology
Bottom: Scott Bauer, USDA Research Services, Bugwood.org

Figure 5.22 Beneficial insects – lady beetles, green lacewing, parasitic wasp.

Fish, Wildlife, and Livestock

Pesticides can be harmful to all kinds of animals (Figure 5.23). Most injuries occur from the direct effects of acute poisoning. Fish kills often result from water pollution by a pesticide. Fish kills are most likely to be caused by insecticides, especially when small ponds or streams are under conditions of low water flow or volume.

Bird kills resulting from pesticide exposure can occur in a number of ways. Birds may ingest pesticide granules, baits, or treated seeds; they may be exposed directly to sprays; they may consume treated crops or drink contaminated water; or they may feed on pesticide-contaminated insects and other prey. Granular or pelleted formulations are a particular concern because birds and other animals often mistake them for food. Other formulations (liquid) may be safer when birds and other wildlife are in or near the treated area. Place baits properly so they are inaccessible to pets, birds, and other wildlife.

Animals can also be harmed when they feed on plants or animals carrying pesticide residues. Predatory birds or mammals feeding on animals killed by pesticides are a special concern. Pesticide residues remaining on or in the bodies of the dead animal may harm predators. This is called secondary poisoning. Check the pesticide label for statements about secondary poisoning.

The less obvious effects that occur from long-term exposure to pesticides are a major concern. For example, certain pesticides have been banned because of fish and bird kills and reproductive failures of several bird species.

The most important source of livestock poisoning by pesticides has been introduced to contaminated feed, forage, and drinking water. Contamination often occurs as a result of improper or careless transportation, storage, handling, application, or disposal of pesticides.

Figure 5.23 Pesticides can harm all kinds of animals.

Endangered Species

Certain plants and animals have been identified as endangered or threatened species. Make every effort to avoid causing harm to these populations. Because all living things are part of a complex, delicately balanced network, the removal of a single species can set off a chain reaction that affects many others. The full significance of an extinction is not always readily apparent, and the long-term effects are often difficult to predict.

An endangered species is one on the brink of extinction throughout all or a significant portion of its range. A threatened species is one likely to become endangered in the foreseeable future. The reasons for a species' decline are usually complex, and thus recovery is difficult. A major problem for most wildlife is the destruction of habitat, usually the result of industrial, agricultural, residential, or recreational development.

Each state is responsible for implementing the federal Endangered Species Protection Program in cooperation with the EPA to protect endangered and threatened species from the harmful effects of pesticides. It is largely voluntary at the present time and relies on cooperation between the US Fish and Wildlife Service, EPA regions, states, and pesticide users.

This particular program is one of several targeted to protect endangered species, but is unique from other state or federal programs with the same ultimate goals. This EPA program has two goals:

- To provide the best protection for endangered species from the use of pesticides.
- To minimize the impact of the EPA program on pesticide applicators.

The unique features of the EPA program are that it does not target the entire United States or Florida, but certain counties within Florida, and only specific areas of those counties. It is also very specific in the pesticides included in its scope. Not all pesticides are in the program, but only those that are considered a risk to certain endangered species. Product labels will have statements to alert the user to consult informational bulletins for details. Precautionary measures are also included in the bulletins, and may include buffer strips, reduced application rates or timing restrictions, or an applicator may be prohibited from using the pesticide within the identified habitat.

At the time of this publication, there are no counties affected by this program in the state. Affected areas in other states may be searched using the EPA database, "Bulletins Live!" at http://137.227.233.155/espp_front/view.jsp.

Conclusion

Regulation is necessary in the use and classification of pesticides because of their potential hazard to humans and the environment. An important part of using pesticides responsibly is considering where the pesticide is going once it leaves the container and whether there might be any adverse effects on nontarget sites, plants, or animals. The user must understand the characteristics of the pesticide – its solubility, volatility, adsorption, and persistence and how the pesticide might move in the environment, as in the air by drift or through water

by leaching and runoff – to know how to prevent unwanted effects.

If pesticides are applied correctly at the right time, in the right location, and with the proper application technique, the user can do a lot to prevent drift, runoff, and leaching. You can reduce or prevent drift by considering the method of application, the spray droplet size, and the speed and direction of the wind. In general, applying pesticides closer to the ground and using larger droplets reduces drift potential. Other factors to consider for preventing drift include the physical properties of the liquid, air stability, humidity, and temperature, and the volatility of the pesticide formulation.

Pesticides that enter groundwater and surface water through runoff and leaching present a hazard to aquatic organisms, plants, and wildlife, and they may enter drinking water. Factors affecting runoff include slope, vegetative cover, soil characteristics, volume and rate of water moving downslope, temperature, and rainfall amount and intensity. Some of these factors also affect leaching of pesticides as do soil properties: texture and structure, organic matter content, the depth to groundwater, and the geology of the area. Consider these factors before applying pesticides in an area. Several techniques or "best management practices" can prevent groundwater and surface water contamination from pesticides, such as identifying vulnerable areas, not mixing or loading near water, keeping pesticides away from wells, and avoiding back- siphoning.

Other important environmental considerations arise in sensitive areas. These are areas where pesticides present a greater risk of injury, such as to schools, playgrounds, endangered species habitats, and ornamental plantings. If it is necessary to make an application in these areas, make sure the pesticide applicator is well trained and knows how to apply the pesticide properly to reduce risk to people, plants, or animals in the area. Nontarget organisms include plants, bees and other beneficial insects, fish, wildlife, and livestock. To avoid exposing nontarget organisms to pesticides, applicators must know when and how exposures might occur and adjust their application practices accordingly. To prevent harmful effects on habitats, pesticide handlers also must avoid the buildup of pesticides at a site. For example, using the same mixing, loading, and cleanup site over a long time will result in the accumulation of pesticides in the soil. Pesticide handlers need to alternate locations for these activities or use some kind of containment system such as a mixing and loading pad to prevent pesticide buildup.

Pesticide handlers must be aware of any endangered or threatened species inhabiting the area to be treated. Always check the label for statements on endangered and threatened species. It may be necessary to consult a county bulletin that details the procedures for protecting them. It is the pesticide handler's responsibility not only to follow label directions but also to use the best management practices that present the least risk to the environment while achieving effective pest control.

Test Your Knowledge

Q: Which property of a pesticide would make it more likely to move with water in surface water?
A. High solubility
B. High adsorption
C. High volatility
D. A tendency to evaporate quickly

A: A

Q: Which statement is true about groundwater or surface water contamination by pesticides?
A. Pesticides cannot reach groundwater by runoff.
B. Runoff and erosion are sources of surface water contamination by pesticides.
C. Pesticide-contaminated surface water will not reach groundwater.
D. Groundwater or surface water contamination risk is low when a heavy rain immediately follows a pesticide application.

A: B

Q: Which is an example of non-point source contamination of groundwater?
A. Back-siphoning of pesticide spills at a wellhead
B. Leaching from a pesticide mixing area
C. Pesticides that dissolve and leach through soil after it rains
D. Dumping leftover pesticide products down a well

A: C

Q: Under what soil conditions are pesticides more likely to leach through soil?
A. Clay soil, low organic matter
B. Clay soil, high organic matter
C. Sandy soil, high in organic matter
D. Sandy soil, low in organic matter

A: D

Q: Which is a recommended best management practice for preventing contamination of surface and ground water by pesticides?
A. Use pesticides that are highly water soluble.
B. Use terrace and conservation tillage practices.
C. Clean sprayers near a canal.
D. Use persistent pesticides.

A: B

Q: What two things should pesticide applicators be most aware of to avoid spray drift?
A. Droplet size and wind direction and speed
B. Air stability and temperature
C. Viscosity of liquid pesticides and air turbulence
D. Temperature and pesticide volatility

A: A

Q: What two things should pesticide applicators be most aware of to avoid vapor drift?
A. Droplet size and wind direction and speed
B. Air stability and temperature
C. Viscosity of liquid pesticides and air turbulence
D. Temperature and pesticide volatility

A: D

Q: Which statement about sensitive areas is true?
A. Never treat a sensitive area to control a pest for any reason.
B. Do not treat a larger target site if it contains a sensitive area.
C. Pesticide labels may contain statements that list special precautions around sensitive areas.
D. Endangered species habitats are not considered sensitive areas.

A: C

Q: Which statement is true about protecting honeybees from pesticide injury?
A. Microencapsulated formulations are the safest.
B. It is best to spray crops while they are in bloom.
C. Treat sites that have lots of blooming weeds around them.
D. Applying pesticides in the early morning or evening is recommended.

A: D

Chapter VI

Harmful Effects and Emergency Response

Chapter VI

TABLE *of* CONTENTS

Learning Objectives

After you complete your study of this chapter, you should be able to:

- Know how to identify and differentiate between types of harmful effects associated with pesticide application:
  - Acute
  - Delayed
  - Allergic
  - Chronic
- Understand the hazard level classification system for pesticides, including the associated signal words.
- Know how to identify common exposure routes for various pesticides and application methods.
- Know how to recognize typical symptoms of pesticide exposure in humans and be aware of the appropriate first-aid response.
- Know how to identify heat stress that may occur during pesticide application and know when to give first aid.
- Know how to implement emergency response procedures as necessary and to execute an emergency response plan:
  - Contact agencies
  - Administer first aid
  - Clean up spills
- Know how unintended pesticide spills and fires can have harmful effects on humans and the environment.
- Understand how to use emergency response equipment properly.
- Understand how to plan and implement cleanup activities or procedures to mitigate environmental impact.
- Know how to dispose of contaminated materials from a spill according to regulations.
- Identify components of emergency response equipment: spill cleanup kit, first-aid kit, and personal protective equipment.
- Know how to restrict access to authorized personnel only.

Terms to Know

Acute toxicity: The measure of harm caused by a single, one-time exposure event.

Carcinogenesis: The production of malignant tumors.

Cholinesterase: A chemical enzyme found in humans and many other animals that regulates the activity of nerve impulses.

Chronic toxicity: The harmful effects that may occur from small, repeated doses of a substance over time.

Exposure: Entry of a pesticide into the body through the skin, by inhalation, by swallowing, or by eye contact.

Hazard: The potential or probability for harm to occur because of product toxicity and human exposure.

LC_{50}: The concentration of a substance in air or water required to kill 50 percent of the population of test animals under a standard set of conditions.

LD_{50}: The dose of a toxicant required to kill 50 percent of the population of test animals under a standard set of conditions.

Mutagenesis: The production of changes in genetic structure.

Oncogenesis: The production of tumors which may or may not be carcinogenic.

Oxidizer: A substance that readily transfers oxygen atoms or gains electrons in a chemical reaction, especially one that supports the combustion of fuel.

Poison: Substance that has potential to kill humans at very low exposures (less than a teaspoon).

Sensitization: The initial exposure of an individual to a substance, resulting in an immune response; subsequent exposure results in an allergic response.

Teratogenesis: The production of birth defects.

Toxicity: The ability of a pesticide to cause short-term (acute) or long-term (chronic) injury.

Introduction

Pesticides are designed to be toxic to living organisms so that control of unwanted pests can be achieved. Though pesticides are also toxic to humans, they vary significantly in the hazards they present. In many respects, living organisms are not all that different from one another, and something that is toxic to one species may also be toxic to other organisms. This is especially true if the organisms are related. For example, insects, rodents, and humans are all animals and have similarities in their nervous, circulatory, and respiratory systems. These similarities are the reasons that pesticides can affect people.

Pesticides can cause both short-term and long-term effects in humans. Refer to the signal word on the product label and the information contained in the "Hazards to Humans and Domestic Animals" section included in the "Precautionary Statements" section of the label to learn more about human toxicity concerns. Products also can pose physical and chemical risks by being explosive and combustible. If the product presents either a physical or a chemical hazard, this information is included under the "Precautionary Statements." Refer also to the material safety data sheet (MSDS) for a pesticide for more information on toxicity and precautions.

How Pesticides Enter the Body (Exposure)

Exposure occurs when a pesticide is taken into the body. Pesticides can enter the body orally (through the mouth and digestive system), through the eyes (ocular), dermally (through the skin) or by inhalation (through the nose and respiratory system).

Oral Exposure

Oral exposure may occur because of an accident, but is more likely to occur as the result of carelessness, such as blowing out a plugged nozzle with your mouth, smoking or eating without washing your hands after using a pesticide, splashing concentrate while mixing, or eating fruit that has been recently sprayed with a pesticide containing residues above the tolerance set for the commodity by the Environmental Protection Agency (Figure 6.1). The seriousness of the exposure depends upon the oral toxicity of the material and the amount swallowed.

Figure 6.1 Carelessness is the primary reason for oral exposures.

Accidental oral exposure occurs frequently when children have access to rodent baits or other improperly stored pesticides in the home or 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 of these mishaps. Mark all pesticide measuring cups and containers to ensure that no one uses them for water, drink, or food. Never store pesticides in beverage or other food containers.

Dermal Exposure

Dermal (skin) exposure accounts for about 97 percent of the exposure pesticide users receive from non-fumigant pesticides. It may occur any time a pesticide is mixed, applied, or handled, and it often goes undetected. Skin exposure may also result from contact with pesticide residues on treated surfaces or contaminated equipment during cleaning or repair. The seriousness of dermal exposure depends upon:

- The dermal toxicity of the pesticide.
- Rate of absorption through the skin.
- The size of the skin area contaminated.
- The length of time the material is in contact with the skin.
- The amount of pesticide on the skin.

Rates of absorption through the skin are different for different parts of the body. Using absorption through the forearm as the standard, absorption is over 11 times faster in the lower groin area than on the forearm (Table 6.1). Absorption through the skin in the genital area is rapid enough to approximate the effect of injecting the pesticide directly into the bloodstream.

Absorption continues to take place on all of the affected skin area as long as the pesticide is in contact with the skin. The seriousness of the exposure is increased if the contaminated area is large or if the material remains on the skin for a period of time.

Body region	Percent relative absorption
Forearm	8.6
Palm of hands	11.8
Ball of foot	13.5
Abdomen	18.4
Scalp	32.1
Forehead	36.3
Ear canal	46.5
Genitalia	100

Table 6.1 Parathion absorption rates through the skin on various bodily regions.

Pesticide formulations vary in their ability to penetrate skin. In general, water-soluble liquids or powders, wettable powders, dusts, and granular pesticides do not penetrate skin very easily. However, oil- or solvent-based liquid formulations such as

emulsifiable concentrates are readily absorbed, and wettable powder and emulsifiable concentrate products have a higher concentration of active ingredient than dusts and granules.

Application techniques can also affect exposure levels for applicators. Making overhead applications, using blower application equipment for mists and dusts, using animal pour-ons or dipping livestock and pets are all application methods that tend to have high dermal exposure levels (Figure 6.2). Contaminated hands or gloves can transfer pesticides to other body parts. A reminder on personal hygiene – be sure to wash your hands and gloves after each pesticide handling event.

Figure 6.2 Overhead applications tend to have high dermal exposure levels.

Inhalation Exposure

Inhalation exposure results from breathing pesticide vapors, dust, or spray particles. Like oral and dermal exposure, inhalation exposure is more serious with some pesticides than with others, particularly fumigant pesticides, which form gases (Figure 6. 3).

Photo FDACS

Figure 6.3 Fumigants pose a severe inhalation hazard.

Inhalation exposure can occur by breathing smoke from burning containers, breathing fumes from pesticides while applying them without protective equipment, and inhaling fumes while mixing and pouring pesticides. Some pesticides will have statements on their labels requiring the use of a specified respirator. Another means of inhalation exposure is smoking tobacco products containing pesticide residues. Once breathed into the lungs, pesticides can enter the bloodstream very rapidly and completely, eventually resulting in damage to other body organs.

Ocular Exposure

The tissues of the eye are extremely absorbent. Blood vessels are very close to the surface of the eye, so pesticides can be easily absorbed into the bloodstream. Under certain conditions and using certain pesticides, absorption through the eyes can be significant and particularly hazardous. Eyes are very sensitive to many pesticides and, for their size, are able to absorb surprisingly large amounts of chemical. In addition to systemic concerns, some products are corrosive and can cause severe eye damage or even blindness (Figure 6.4). Serious eye exposure can result from airborne dusts or particles, splashes or spills, broken hoses, spray mists, or from rubbing the eyes with contaminated hands or clothing.

Credit CDMS

Keep Out of Reach of Children

DANGER PELIGRO

Si usted not entiende la etiqueta, busque a alguien para que se la explique a usted en detalle. (If you do not understand the label, find someone to explain it to you in detail.)

Precautionary Statements

Hazards to Humans and Domestic Animals

Corrosive • Causes Skin Burns And Irreversible Eye Damage • Harmful If Swallowed Or Inhaled • Prolonged or Frequently Repeated Skin Contact May Cause Allergic Reactions in Some Individuals

Do not get in eyes, on skin or on clothing. Avoid breathing vapor or spray mist.

Figure 6.4 Label precautionary statement regarding eye damage.

Toxicity

Toxicity refers to the ability of a poison to produce adverse effects. These adverse effects may range from slight symptoms such as headaches to severe symptoms like coma, convulsions, or death. Poisons work by altering normal body functions. Most toxic effects are naturally reversible and do not cause permanent damage if prompt medical treatment is sought. Some poisons, however, cause irreversible (permanent) damage.

All new pesticides are tested to establish the type of toxicity and the dose necessary to produce a measurable toxic reaction. In order to compare the results of toxicity tests done in different labs, there are strict testing procedures. Toxicity testing is extensive (involving many phases) and therefore expensive. Humans, obviously, cannot be used as test subjects, so toxicity testing is done with animals and plants. Since different species of animals respond differently to chemicals, a new chemical is generally tested in mice, rats, rabbits, and dogs. The results of these toxicity tests are used to predict the safety of the new chemical to humans.

Toxicity tests are based on two premises. The first premise is that information about toxicity in animals can be used to predict toxicity in humans. Years of experience have shown that toxicity data obtained from a number of animal species can be useful in predicting human toxicity, while data obtained from a single species may be inaccurate. The second premise is that by exposing animals to large doses of a chemical for short periods of time, we can predict human toxicity from exposure to small doses for long periods of time. Both premises have been questioned.

Toxicity is usually divided into two types, acute or chronic, based on the number of exposures to a poison and the time it takes for toxic symptoms to develop. Acute toxicity is due to short-term exposure and happens within a relatively short period of time, whereas chronic exposure is due to repeated or long-term exposure and happens over a longer period (Table 6.2).

Type	Number of exposures	Time for symptoms to develop
Acute	Usually 1	Immediate (minutes to hours)
Chronic	More than a few	One week to years

Table 6.2. Types of toxicity.

Acute Toxicity

The acute toxicity of a chemical refers to its ability to do systemic damage as a result of a one-time exposure to relatively large amounts of the chemical. A pesticide with a high acute toxicity may be deadly if even a very small amount is absorbed. The signal words on the label (Table 6.3) are based on the acute toxicity of the pesticide (Figure 6.5). Acute toxicity may be measured as acute oral (through the mouth), acute dermal (through the skin) and acute inhalation (through the lungs or respiratory system).

Figure 6.5 Label signal word.

The commonly used term to describe acute toxicity is LD_{50}. LD means lethal dose (deadly amount) and the subscript 50 means that the dose was acutely lethal to 50 percent of the animals to whom the chemical was administered under controlled laboratory conditions. The test animals are given specific amounts of the chemical in either one oral dose or by a single injection, and are then observed for a specified time.

The lower the LD_{50} value, the more acutely toxic the pesticide. Therefore, a pesticide with an oral LD_{50} of 500 mg/kg would be much less toxic than a pesticide with an LD_{50} of 5 mg/kg. LD_{50} values are expressed as milligrams per kilogram (mg/kg) which means milligrams of chemical per kilogram of body weight of the animal. Milligram (mg) and kilogram (kg) are metric units of weight. Milligrams per kilogram is the same as parts per million. To put these units into perspective, 1 ppm is analogous to 1 inch in 16 miles or 1 minute in 2 years.

For example, if the oral LD_{50} of the insecticide parathion is 4 mg/kg, a dose of 4 parts of parathion for every million parts of body weight would be lethal to at least half of the test animals.

LD_{50} values are generally expressed on the basis of active ingredient. If a commercial product is formulated to contain 50 percent active ingredient, it would take two parts of the material to make one part of the active ingredient. In some cases, other chemicals mixed with the active ingredient for formulating the pesticide product may cause the toxicity to differ from that of the active ingredient alone.

		Categories of acute toxicity			
		LD_{50}	LD_{50}	LC_{50}	
		Oral	Dermal	Inhale	
Categories	**Signal word**	**mg/kg**	**mg/kg**	**mg/l**	**Oral lethal dose[1]**
I Highly toxic	DANGER, POISON (skull & crossbones)	Trace to 50	Trace to 200	Trace to 0.2	A few drops to a teaspoonful
II Moderately toxic	WARNING	50 to 500	200 to 2,000	0.2 to 2.0	Over a teaspoonful to one ounce
III Slightly toxic	CAUTION	500 to 5,000	2,000 to 20,000	2.0 to 20	One ounce to one pint or one pound
IV Relatively non-toxic	CAUTION (or no signal word)	5,000+	20,000+	20+	Over one pint or one pound
[1]Probable for a 150-pound person.					

Table 6.3 Acute toxicity measures and warnings.

Acute inhalation toxicity is measured by LC_{50}. LC means lethal concentration. Concentration is used instead of dose because the amount of pesticide inhaled in the air is being measured. LC_{50} values are measured in milligrams per liter. Liters are metric units of volume similar to a quart. Like the LD_{50} value, the lower the LC_{50} value, the more poisonous the pesticide. LC_{50} can also pertain to the concentration of pesticide contained in water. This measurement most often is applicable to fish and other aquatic organisms.

Chronic Toxicity

Chronic toxicity refers to harmful effects produced by long-term exposure to pesticides. Less is known about the chronic toxicity of pesticides than is known about their acute toxicity, not because it is of less importance, but because chronic toxicity is much more complex and subtle in how it presents itself. While situations resulting in acute exposure (a single large exposure) do occur, they are nearly always the result of an accident or careless handling. On the other hand, persons may be routinely exposed to pesticides while mixing, loading, and applying pesticides or by working in fields after pesticides have been applied.

There is no standard measure like the LD_{50} for chronic toxicity. How chronic toxicity of chemicals is studied depends upon the adverse effect being studied. Chronic adverse effects may include carcinogenesis, teratogenesis, mutagenesis, blood disorders (hemotoxic effects), endocrine disruption, and reproductive toxicity.

Carcinogenesis (oncogenesis). Carcinogenesis means the production of malignant tumors. Oncogenesis is a generic term meaning the production of tumors which may or may not be carcinogenic. The terms tumor, cancer, or neoplasm are all used to mean an uncontrolled progressive growth of cells. In medical terminology, a cancer is considered a malignant (potentially lethal) neoplasm. Carcinogenic or oncogenic substances are substances which can cause the production of tumors. Examples are asbestos and cigarette smoke.

Teratogenesis. Teratogenesis is the production of birth defects. A teratogen is anything that is capable of producing changes in the structure or function of the offspring when the embryo or fetus is exposed before birth. An example of a chemical teratogen is the drug thalidomide, which caused birth defects in children. Prior to its use being banned in the US in 1962, expectant mothers used it for controlling morning sickness during their pregnancy. Measles virus infection during pregnancy has teratogenic effects.

Mutagenesis. Mutagenesis is the production of changes in genetic structure. A mutagen is a substance which causes a genetic change. Many mutagenic substances are oncogenic, meaning they also produce tumors. Many oncogenic substances are also mutagens.

Reproductive toxicity. Some chemicals have effects on the fertility or reproductive rates of animals. Males or females can be affected.

For chronic toxicity there is no comparable set of signal words like those used for acute toxicity. Instead, a statement identifying the specific chronic toxicity problem is sometimes used on the label (Figure 6.6). Chronic toxicity warning statements may be accompanied by label directions to wear certain kinds of protective clothing when handling or working with the pesticide to minimize or eliminate exposure to the pesticide.

Restricted Use Pesticide

Because pronamide has produced tumors in laboratory animals, this product is 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.

Figure 6.6 Chronic toxicity warning statement.

It is important to read the label to look for signal words identifying the product's acute toxicity and for statements identifying any chronic toxicity problem. A pesticide may be low in acute toxicity (signal word caution), but it may have a label statement identifying potential chronic toxicity.

Delayed Effects

Delayed effects are illnesses or injuries that do not appear immediately (within 24 hours) after exposure to a pesticide. They may be delayed for weeks, months or even years. Whether or not you experience delayed effects depends on the pesticide, the extent and route of exposure(s), and how often you were exposed. Under "Precautionary Statements," the label states any delayed effects that the pesticide might cause and how to avoid exposures leading to them. Wearing extra protective gear and taking additional precautions may be necessary to reduce the risk of delayed effects. Delayed effects may be caused by either an acute exposure or chronic exposure to a pesticide.

Allergic Effects

Allergic effects are harmful effects that some people develop in reaction to substances that do not cause the same reaction in most other people, such as poison ivy causing skin rash. Allergic reactions are not thought to occur during a person's first exposure to a substance. The first exposure causes the body to develop repelling response chemicals to that substance. A later (the second, third, or more) exposure results in the allergic response. This process is called sensitization, and substances that cause people to become allergic to them are known as sensitizers.

Some people are sensitized to certain pesticides. After being exposed once or a few times without effect, they develop a severe allergy-like response upon later exposures. These allergy effects include:

- Systemic effects, such as asthma or even life-threatening shock
- Skin irritation, such as rash, blisters, or open sores
- Eye and nose irritation, such as itchy, watery eyes, and sneezing

Unfortunately, there is no way to tell which people may develop allergies to which pesticides. However, certain people seem to be more chemically sensitive than others. They develop an allergic response to many types of chemicals in their environment. These persons may be likely to develop allergies to pesticides.

Hazard

Hazard, or risk, is a function of the toxicity of a pesticide and the potential for exposure to it. We do not have control of the toxicity of a pesticide since toxicity is a given characteristic of a particular pesticide; however, we can have control over our exposure to pesticides. This is done by following several safety practices including the use of protective clothing and equipment (PPE).

Hazard (Risk) = Toxicity x Exposure

All pesticides are hazardous if misused, no matter what their toxicity. All pesticides can be handled safely by using safety practices that minimize or eliminate exposure to them.

Federal laws regulating pesticides have placed the burden of proving safety of pesticide usage on the manufacturer. Hazard evaluation studies are generally done by scientific laboratories maintained by the manufacturer or through outside contract laboratories (Figure 6.7). Few products are subjected to such extensive and vigorous testing as are pesticides prior to marketing. Many promising pesticide products are not marketed because they do not pass the extensive toxicology testing. Older pesticide products that were registered before the current toxicology testing standards were established are being re-evaluated on a continuing basis under current standards. Precautions and other safety information found on the product's label are based on information from these tests.

By reading and following the directions on the label, users can minimize or eliminate hazards due to use of the pesticide to themselves and others.

Figure 6.7 Potential pesticides are extensively tested.

Common Pesticide Poisonings: Recognizing the Symptoms

The pesticides most often implicated in poisonings, injuries, and illnesses, according to 2010 data from the American Association of Poison Control Center's Toxic Exposure Surveillance System, are listed in Table 6.4. The list is based on symptomatic cases classified as minor, moderate, major, or fatal outcome for unintentional cases involving a single product. Numbers of cases are reported for both children under five years of age and for adults and older children. Suicide/homicide (intentional) cases have been excluded. Cases listed as organophosphates (and the other categories as well) may also include other insecticides such as carbamates and organochlorines in a single product.

Approximately 90 percent of symptomatic cases involve only minor symptoms of the type that could typically be treated at home with dilution or just observation. However, according to the American Association of Poison Control Centers, seven of the top ten categories listed in the table (organophosphates, pyrethrins/pyrethroids, disinfectants, carbamates, organochlorines, herbicides, and rodenticides) are much more likely to require medical attention.

This list can't be considered representative of all symptomatic poisonings because it only shows cases reported to Poison Control Centers. However, it does give a sense of the relative frequency and risk of poisoning from various agents or classes of agents. The relative frequency of cases generally reflects how widely a product is used in the environment. For example, a number of disinfectants occur in the top ten partly because they are far more commonly found in the home and work environment than other pesticides. The main purpose for maintaining such a list is to give physicians a sense of what types of cases they are most likely to see in their practice.

Symptoms can be correlated with certain groups of pesticides. For example, borates (insecticides) tend to be irritating to the skin, nose, and respiratory system, while some fungicides are irritants to the skin, eyes, and mucous membranes of the respiratory system. Anticoagulant-type rodenticides may cause bloody noses and bleeding gums. Organophosphate and carbamate insecticides may cause all of the systemic symptoms listed that could ultimately result in respiratory failure and death (Table 6.5). These two insecticide groups are discussed in further detail in the following section of this chapter. Symptoms associated with synthetic pyrethroid insecticides include nausea, dizziness, weakness, nervousness, eye and skin irritation. 2,4-D and some other related herbicides (dicamba, MCPA, and MCPP) are irritating to the skin and mucous membranes, and they can also cause vomiting, headaches, diarrhea and confusion.

Because symptoms of pesticide poisoning or exposure can vary widely, physicians need training to recognize this variability and treat appropriately. A manual entitled *Recognition and Management of Pesticide Poisonings* provides treatment guidelines for physicians to follow in the case of pesticide poisonings (Figure 6.8). This manual can be obtained through the EPA Office of Pesticide Programs or from the EPA Web site.

Pesticides and Cholinesterase

Cholinesterase, or, more properly, acetylcholinesterase, is an enzyme essential for normal functioning of the nervous system of humans, other vertebrates, birds, and insects. In the body, acetylcholinesterase inactivates the chemical messenger acetylcholine, which is normally active at the junctions between nerves and muscles, between many nerves and glands, and at the synapses between certain nerves in the central nervous system. When cholinesterase levels are low because of excessive inhibition, the nervous system can malfunction, which can lead to death.

Rank	Pesticide or pesticide class	Child <5 years	6-12 years	13-19 years	>20 years	Unknown age	Total
1	Pyrethrins and pyrethroids	7,717	1,672	1,222	14,800	2,706	28,117
2	Disinfectants	12,018	1,182	1,270	7,906	1,892	24,268
3	Rodenticides	10,961	293	162	1,046	408	12,870
4	Insect repellents	6,372	1,013	381	2,272	680	10,718
5	Herbicides	2,019	362	246	4,593	817	8,037
6	Borates and boric acids	4,270	92	62	466	110	5,000
7	Organophosphates	880	218	156	1,826	404	3,484
8	Carbamates	804	119	83	1,027	221	2,254
9	Fungicides	171	25	21	414	73	704
10	Organochlorines	182	30	15	245	58	530
11	Fumigants	48	19	14	213	56	350
All other insecticides (including unknown)		5,526	615	387	5,264	1,371	13,163
Total pesticides/disinfectants		**50,968**	**5,640**	**4,019**	**40,072**	**8,796**	**109,495**

Table. 6.4 Pesticide exposures most commonly reported to National Poison Data System (2010)[1].

Degree of severity	Symptom	
Mild poisoning	Fatigue Headache Dizziness Blurred vision	Excessive sweating/salivation Nausea and vomiting Stomach cramps and diarrhea
Moderate poisoning	Inability to walk Weakness Chest discomfort	Constriction of pupils Mild symptoms more severe
Severe poisoning	Unconsciousness Severe constriction of pupils Muscle twitching Running nose and drooling	Breathing difficulty Coma and death

Table 6.5 Symptoms associated with carbamate and organophosphate insecticide poisoning.

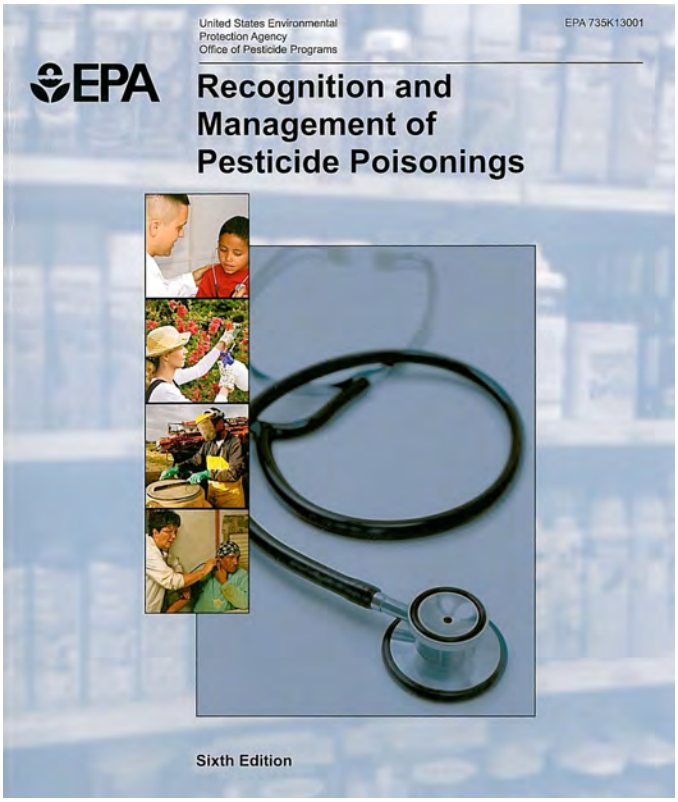


Figure 6.8 Reference manual for toxicological symptoms.

Certain chemical families of pesticides, such as organophosphates and carbamates, work primarily, but with a few exceptions, against arthropod pests by interfering with, or inhibiting cholinesterase. While the effects of cholinesterase-inhibiting products are intended for pests, these chemicals can also be poisonous – toxic to humans in some situations. Human exposure to cholinesterase-inhibiting chemicals can result from inhalation, ingestion, or eye or skin contact during the manufacture, mixing, or applications of these pesticides. Product labels will identify whether the pesticide is a cholinesterase inhibitor (Figure 6.9).

Exposure

Each person has a certain baseline level of cholinesterase enzyme that is considered normal for that individual. Exposure to carbamate and organophosphate pesticides inhibits cholinesterase, resulting in continual overexcitation of nerve-to-nerve and nerve-to-muscle communication. Extreme exposure to pesticides that inhibit cholinesterase – exposure resulting, for example, from spilling concentrates on one's self – can cause immediate illness. Lesser exposures may not cause symptoms that are immediately apparent. However, small, repeated exposures to such pesticides over several days or weeks can over time reduce the cholinesterase level in the exposed person. Such repeated exposures can ultimately trigger mild, moderate, or severe symptoms of overexposure. (Persons who only occasionally are exposed to these pesticides through residues in and around structures or landscapes or through residues on foods are not considered to be at risk.)

In human reactions to cholinesterase inhibition, it is not always obvious whether a person is showing symptoms from an acute exposure or experiencing delayed effects from repeated exposures. For example, a pesticide handler exposed to a single, large dose of a cholinesterase-inhibiting pesticide may immediately suffer acute effects. However, if, over an extended period of time, the pesticide handler is exposed to several small amounts of such pesticides, the handler's cholinesterase levels may be reduced slightly at each exposure. Eventually, a small additional exposure can cause illness. In this example, the illness may arise soon after exposure, but only following previous reductions in cholinesterase due to earlier exposures.

First Aid

Organophosphate

If swallowed: Call a poison control center or doctor immediately for treatment advice. Have person sip a glass of water if able to swallow. Do not induce vomiting unless told to do so by a poison control center or doctor. Do not give anything by mouth to an unconscious person.

If in eyes: Hold eye open and rinse slowly and gently with water for 15-20 minutes. Remove contact lenses, if present, after the first 5 minutes, then continue rinsing eye. Call a poison control center or doctor for treatment advice.

Note to Physicians: Chlorpyrifos is a cholinesterase inhibitor. Treat symptomatically. If exposed, plasma and red blood cell cholinesterase tests may indicate significance of exposure (baseline data are useful). Atropine, only by injection, is the preferable antidote. Oximes, such as 2-PAM/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.

Have the product container or label with you when calling a poison control center or doctor, or going for treatment. You may contact 1-800-992-5994 for emergency medical treatment information.

Figure 6.9 Label statement indicating the product inhibits cholinesterase.

Monitoring

Some states require employers to enroll their employees who handle such pesticides in a cholinesterase-monitoring program.

Although Florida law currently does not require employers of pesticide handlers to monitor these employees' cholinesterase levels, some employers in Florida, including the University of Florida, voluntarily enroll their employees who handle pesticides in a cholinesterase-monitoring program. Regardless of what the law requires or allows from state to state, however, any who handle carbamates and organophosphates should consult with their physician for regular cholinesterase testing.

The blood cholinesterase test measures the effect of exposure to these pesticides. Cholinesterase levels can vary considerably between individuals, so a baseline must be established for each person prior to handling such pesticides or at least 30 days from the most recent exposure to carbamates and organophosphates. Establishing an accurate baseline value often requires that two tests be performed at least 72 hours apart, but not more than 14 days apart. Handlers of carbamates and organophosphates should have their cholinesterase levels monitored periodically, so they can compare results with the previously established baseline level. A significant reduction in the cholinesterase level indicates exposure. When exposure is indicated, a physician will normally suggest that the pesticide handler be removed from further exposure until the body has had time to sufficiently build new cholinesterase. The ill effects of carbamates last for a relatively short period of time. However, it takes much longer for the body to manufacture new cholinesterase following exposure to organophosphates. Physicians will establish the frequency of testing. Those physicians who specialize in occupational and environmental medicine are most familiar with this type of testing program.

First Aid for Pesticide Poisoning

Get medical advice immediately if you or any of your fellow workers have unusual or unexplained symptoms that develop within 24 hours of a pesticide exposure (Figure 6.10). Be alert for the early symptoms of pesticide poisoning and contact effects in yourself and others. Recognizing symptoms early and providing an immediate first-aid response may save a life or prevent permanent injury. Do not wait until you or someone else gets dangerously ill before calling a physician or going to a hospital. It is better to be too cautious than to act too late. Take the pesticide label with you, either a duplicate copy or the one attached to the container (or at a minimum, the EPA registration number of the product). To avoid contamination and exposure, do not carry pesticides in the passenger space of the vehicle.

Figure 6.10 Get medical advice immediately if you have unexplained symptoms that develop within 24 hours of a pesticide exposure.

The attending physician needs to know the pesticide ingredients to determine the proper course of treatment. It is a good idea to print off extra copies of the label from the Internet and place one copy in your service vehicle and one in your office for use during medical emergencies.

Remember, certain symptoms are not always the result of pesticide exposure. Common illnesses such as the flu, heat exhaustion or heat stroke, pneumonia, asthma, respiratory or intestinal infections, and even a hangover can cause similar symptoms. Contact with certain plants such as poison oak or poison ivy can also produce skin effects like those resulting from pesticide exposure. However, when symptoms appear after contact with pesticides, always seek medical attention immediately.

General First Aid

First aid is the initial effort to help a victim while medical help is on the way (Figure 6.11). If you are alone with the victim, make sure he/she is breathing and is not being further exposed to the pesticide before you call for emergency assistance. Protect yourself from pesticide exposure prior to and while giving assistance. Make sure you wear the appropriate personal protective equipment (PPE), including a respirator, before assisting someone in an enclosed area. Apply artificial respiration if the victim is not breathing and is not vomiting.

Immediate action can indeed be a life-or-death matter in a pesticide poisoning. The product label is the primary source of information. Follow the label's specific first aid instructions carefully (Figure 6.12). In addition, call a physician. First aid is only the first response and is not a substitute for professional medical help. It is very important to get the victim to a hospital without delay. The following are a few key points to remember when administering first aid during a pesticide emergency:

- If oral or dermal exposure has occurred, the first objective is usually to dilute the pesticide and prevent absorption.
- Always have a source of clean water available. In an extreme emergency, even water from a farm pond, irrigation system, or watering trough could be used to dilute the pesticide.
- Never try to give anything by mouth to an unconscious person.
- If inhalation exposure occurs, get the victim to fresh air immediately.
- Become familiar with the proper techniques of artificial respiration; it may be necessary if a person's breathing has stopped or becomes impaired.
- If there is a likelihood of first responders being directly exposed to a pesticide, be sure they wear appropriate PPE.

Figure 6.11 First aid is the initial effort to help a victim.

Figure 6.12 Follow the label's specific first aid instructions carefully.

Pesticide on the Skin

Proper hygiene helps to protect the skin from pesticide exposure. Always have an adequate water supply with you anytime that skin exposure is possible.

- Remove all contaminated clothing immediately.
- Wash the affected area, including the hair, with water and soap, then rinse well. Use of a shower is best. Avoid harsh scrubbing, which enhances pesticide absorption.
- Gently dry the affected area and wrap it in loose cloth or a blanket, if necessary.
- If the skin has chemical burns, cover the area loosely with a clean, soft cloth. Avoid using ointments, greases, powders, and other medications unless instructed to do so by a medical authority

Clothing contaminated by pesticides regulated as solid waste (most pesticides) can be disposed of as solid waste (trash). Clothing contaminated by pesticides regulated as hazardous waste must be disposed of as hazardous waste, if it is contaminated as a result of a spill or leak. If the clothing is contaminated as a result of a normal, legal application of the pesticide, then the clothing can be handled as normal solid waste.

Pesticide in the Eye

Because the eyes readily absorb material that gets into them, fast action is required.

- Hold the eyelid open and immediately begin gently washing the eye with dripping clean water. Do not use chemicals or drugs in the wash-water unless instructed to do so by a physician or a poison control center.
- Drip the water across the eye, not directly into the eye, or use an eyewash dispenser.
- Continuously rinse the eye for 15 minutes. If only one eye is involved, be careful not to contaminate the other eye.
- Flush under the eyelids with water to remove debris.
- Cover the eye with a clean piece of cloth and seek medical attention immediately.

Inhaled Pesticide

The basic first aid procedure for someone who has inhaled a pesticide is to get the exposed person to fresh air.

- Immediately carry the victim to fresh air (do not allow the victim to walk).
- Do not attempt to rescue someone who is in an enclosed, contaminated area unless you are wearing appropriate PPE.
- If other people are in the area, warn them of the danger.
- Have the victim lie down and loosen clothing.
- Keep the victim warm and quiet. Do not allow him/her to become chilled or overheated.
- If the victim is convulsing, protect the victim's head and

watch that breathing continues.
- Keep the person's chin up to ensure that air passages are open for breathing.
- If breathing stops or is irregular, give artificial respiration.

Pesticide in the Mouth or Swallowed

If pesticide has gotten in the mouth but has not been swallowed, rinse the mouth with plenty of water. After the mouth has been thoroughly rinsed, give the victim large amounts (up to 1 quart) of milk or water to drink. If the pesticide is swallowed, one of the most critical first-aid decisions is whether to induce vomiting. Induce vomiting only if the label instructs to do so. Several pesticides cause more harm when vomited than if they remain in the stomach. To provide first aid for a swallowed pesticide, you must know the appropriate treatment. The decision to induce vomiting must be made quickly and accurately – the victim's life may depend on it.

Never induce vomiting if the victim:

- Is unconscious or having convulsions.
- Has swallowed a corrosive poison, such as a strong alkali or acid. The material burns the throat and mouth as severely coming up as it did going down, Also, it can be aspirated into the lungs and cause more damage.
- Has swallowed an emulsifiable concentrate or oil solution product, which is dissolved in petroleum solvents. Emulsifiable concentrates and oil solutions may cause death if aspirated into the lungs during vomiting.

How to induce vomiting:

- Make sure the victim is kneeling forward or lying on his side to prevent vomit from entering the lungs and causing additional damage.
- First give the victim at least 2 glasses of water to dilute the product. Do not use carbonated beverages.
- To induce vomiting, put your finger or the blunt end of a spoon at the back of the throat. Do not use anything sharp or pointed. Do not use salt water to induce vomiting.
- Collect some of the vomitus for the doctor, who may need it for chemical analysis.

Activated charcoal is another first-aid treatment that can be administered when a pesticide has been swallowed. Give the patient 2 to 4 tablespoons of activated charcoal in at least 8 ounces of water. Activated charcoal acts as a magnet to adsorb many chemicals. Pharmaceutical grade activated charcoal is available from most drug stores. Activated charcoal prepared for cleaning up pesticide spills may be substituted in an emergency. Take the victim to a physician or hospital.

Only general first aid practices have been discussed here. Contact the Poison Control Center for further assistance in administering first aid. If necessary, get the victim to a doctor or hospital, and take the pesticide label with you.

Antidotes

Antidotes are available for only a few classes of pesticides – anticoagulant-type rodenticides and the organophosphate or carbamate insecticides. Antidotes can be extremely dangerous if misused, so they should be prescribed and administered only by a qualified physician. Antidotes should never be used to prevent poisoning.

Information sources for pesticide poisoning emergencies:

- National Pesticide Information Center: 1-800-858-7378
- Florida Poison Information Center: 1-800-222-1222

Heat Stress

Heat stress is the buildup in the body of heat generated by the muscles during work and of heat coming from warm and hot environments. Heat exhaustion and heat stroke result when the body is subjected to more heat than it can cope with.

When the body becomes overheated, less blood goes to the active muscles, the brain, and other internal organs. Workers get weaker, become tired sooner, and may be less alert, less able to use good judgment, and less able to do their jobs well. Workers may not realize that this is happening because there is no pain. Mental performance can be affected with an increase in body temperature of 2 degrees F above normal. An increase of 5 degrees F can result in serious illness or death. The most serious illness is heat stroke.

PPE worn during handling or early-entry activities can increase the risk of heat stress. The protective qualities of the PPE may restrict the evaporation of sweat, thus impeding the body's natural cooling system.

Symptoms of Heat Stress

When a pesticide handler becomes ill from working with certain pesticides, particularly carbamate and organophosphate insecticides in warm and hot environments, it can be hard to tell whether the handler is suffering from heat exhaustion or from pesticide poisoning. While these illnesses share some

similar symptoms, their treatments differ. Table 6.6 compares these symptoms.

Heat exhaustion	**Organophosphate/carbamate poisoning**
Sweating	Sweating
Headache	Headache
Fatigue	Fatigue
DRY membranes *Dry mouth* *No tears* *No spit present*	*MOIST membranes* *Salivation* *Tears* *Spit present*
FAST pulse (slow if person has fainted)	*SLOW pulse*
Nausea	*Nausea and diarrhea*
DILATED pupils	*Possible SMALL pupils*
Central nervous system depression Loss of coordination Confusion *Fainting (recovery prompt)*	Central nervous system depression
	Loss of coordination
	Confusion
	Coma (can't awaken)

Table 6.6 Comparison of symptoms of heat exhaustion and carbamate/organophosphate poisoning.

Combined problems of heat illness and pesticide poisoning may also occur. If there is any doubt about what the illness is, get medical help immediately. Both pesticide poisoning and heat stroke can be life-threatening and require prompt treatment.

Managing Heat Stress

A heat stress control program should be geared to protecting all workers at an establishment, especially those who are not in the best physical shape. Appendix A, Tables A1 – A4 provide guidelines for outlining a basic program for managing heat stress.

Pesticide Emergencies

Although accidents and emergencies involving pesticides are rare, unfortunately they do occur. Many pesticide accidents can be traced to applicator carelessness or misuse. Pesticide accidents or fires can result in water, soil, and air contamination, damage plants, injure livestock, wildlife, or pets and can endanger the health of the applicator and other people. In addition, financial losses can occur from cleanup costs, liability claims, and fines and penalties.

Manufacturers, transporters, dealers, and users of pesticides must treat all pesticide leaks, spills, and fires as emergencies and be prepared to respond to these emergencies promptly and correctly. Do all that you can to prevent accidents, but be prepared in case an emergency should occur.

Planning for Emergencies (The Contingency Plan)

A carefully thought-out emergency response or contingency plan is one of the most important tools you can have to prevent an emergency situation from becoming a catastrophic event. An emergency response plan can help protect the health and welfare of employees, the community, minimize environmental damage, and potentially reduce liability in the event of an accident. The importance of planning for emergencies cannot be overemphasized. Undertake this planning with painstaking attention.

Some emergencies require professional assistance (police, firefighters, paramedics, environmental contractors) while others may be handled by properly trained company employees. Personal injuries may range from minor cuts, treatable with a first aid kit, to major injuries from exposure to toxic chemicals, which may require hospitalization.

Small fires often can be extinguished with a portable fire extinguisher, while larger ones require trained firefighters and possibly emergency medical assistance.

Some spills can be controlled and contained and the area cleaned, using spill kits kept on-site. It is important that all employees know exactly where spill kits, fire extinguishers, and first aid kits are stored.

A large, uncontained spill from a ruptured thousand-gallon pesticide tank would likely require a trained hazardous materials response team to control the release, evacuate the area, coordinate remedial measures, contain the spill, clean and decontaminate the site and dispose of contaminated waste (Figure 6.13).

Figure 6.13 Large spills require professional help.

The objective of contingency planning is to prevent emergencies; but if they do occur, the objective becomes a matter of reacting appropriately to minimize detrimental effects. Both aspects – prevention and reaction – require a well organized effort on the part of business owners and management personnel.

A contingency plan is only as good as the information it conveys to employees and emergency responders. It is useless if the only people who comprehend its intent and how to execute it are those who wrote it. Employees must be educated to understand the purpose of the plan, and they must be trained to perform their assigned duties in an emergency situation.

It is essential that every employee and all emergency responders in the community be familiar with the plan. And it is equally important that the plan be updated on a regular basis to incorporate changes: phone numbers, new employees, new (company) emergency responders, new or reassigned position responsibilities, etc. A thorough review should be done at least annually, as should employee review and retraining.

Consider the following when developing an emergency response plan:

- Post a 24-hour number on the outside of all buildings so that emergency responders will know where to call if an emergency occurs when the business is closed and the premises vacant (Figure 6.14). Contacts should include:
  - Persons/agencies required to be notified by local, state, and federal requirements.
  - Local emergency planning committees.
  - Police and fire units.
  - Paramedics and area hospitals.
  - Appropriate chemical manufacturers and dealers.
  - Containment and hazardous waste cleanup contractors.
  - Your attorney, to protect your rights and the rights of others.

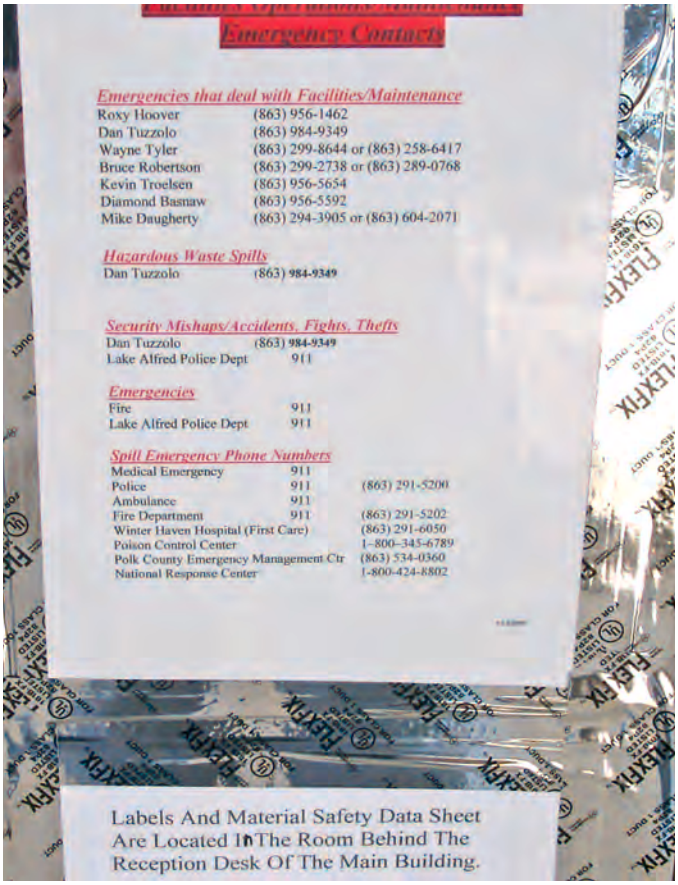


Figure 6.14 Emergency contacts posted at a storage site.

- Train all employees and document all training on:
  - The location of the written emergency response plan.
  - The purpose and objectives of the plan.
  - Implementing the plan.
  - Who to contact in an emergency.
  - Where to rendezvous following evacuation.
  - Who should deal with and talk to the media.
- Prepare a map of your facility to include with your emergency response plan. Show a layout of all chemical storage buildings and bulk storage tanks, access roads, main shutoffs for electricity, water, and gas, perimeter fencing that could hinder access to the pesticide storage facility, the location of fire alarms, firefighting equipment, protective clothing and drainage easements on the site. Provide emergency response agencies an updated copy of this map whenever changes are made at the facility (Figure 6.15).

Credit National Pesticide Applicator Certification Core Manual

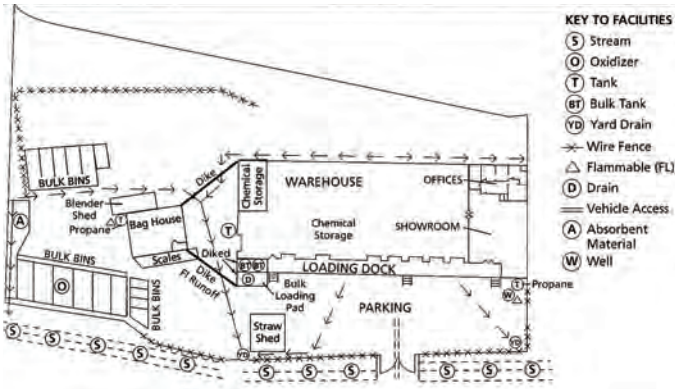


Figure 6.15 Example of a facility map.

- Keep an inventory of emergency equipment and supplies you have available on site, including:
  - Equipment that can be used for diking, trenching, pumping and vacuuming.
  - Containment and cleanup materials, such as absorbent materials and neutralizing agents.
  - Location and inventory of fire extinguishers and protective equipment.
  - Any specialized equipment, such as self-contained breathing apparatus.
- Personally deliver copies of the emergency response plan to local responders: fire departments, law enforcement agencies, emergency medical services and emergency planning committees. Review the plan with them:
  - Who to contact in an emergency.
  - Where employees are to rendezvous if evacuated.
  - Types of chemicals stored on-site.
  - Precise locations of chemical storage areas.
  - Important listings on the site map.
  - What you and your staff should and should not do in an emergency.
  - What expectations you have; for example, a let-it-burn policy when outside assistance is requested.
  - The on-site location of the written plan; that is, where emergency responders can access it.
  - Off-site locations where the plan is accessible.
- Invite emergency responders to walk through your facility. Consider incorporating videos and photographs with the written plan and ask for suggestions to make the plan better; follow up on any recommendations they offer.
- Update the emergency response plan annually and as changes occur.
- Stage a mock accident or spill annually, and critique the generated response.
- Contact hospitals to see if they can treat patients for exposure to the chemicals you handle, and ask if they have decontamination capabilities. Hospitals are often overlooked when notifying local responders.
- Use the emergency response plan in Appendix B of this publication as a model for developing your own.
- Spill recovery contractors play an essential role in follow-up operations related to a spill emergency. Select a reputable firm that you are comfortable with.

See Appendix B for examples of emergency contingency planning.

Pesticide Fires

Fires pose a special hazard in pesticide-storage facilities. In addition to the danger of the fire itself, other dangers are associated with pesticides in this situation. Pesticide products vary significantly in their flammability and the related hazard they pose in storage. Flammable pesticides typically include the following precaution in the label statement: "Do not use or store near heat or open flame (Figure 6.16)." These warnings will be found in the Physical and Chemical Hazards Statements on the product's label. Pesticides containing oils or petroleum solvents are the most flammable and are likely to have these warnings although certain dry formulations also present fire and explosion hazards.

PHYSICAL AND CHEMICAL HAZARDS

Do not use or store near heat or open flame.

Figure 6.16 Physical and Chemical Hazards label statement.

A number of potential problems may be associated with pesticide fires:

- The pesticides may be highly flammable or explosive.
- The pesticides may give off highly toxic vapors or smoke that may harm firefighters, nearby residents, animals or plants.
- Pesticide residues may be present in the debris and soil following a fire at a pesticide storage facility.
- Water runoff from the fire site may contain highly toxic chemicals.

Precautions to Reduce Fire Hazards

Emergency or contingency planning is the cornerstone of a responsible action plan. Coordinate all details on responding to a fire with local emergency-response officials and review at least annually. Proactive measures include the following:

- Locate the storage facility as far as possible from places where people and animals live.
- Carefully map a floor plan of the pesticide-storage facility and the immediate surrounding area.
- Keep the storage facility locked at all times.
- Post signs that indicate pesticides are stored in the facility (Figure 6.17).
- Store combustible pesticides away from steam lines and other heating systems.
- Do not store glass or pressurized containers in sunlight, where they can concentrate heat and possibly explode or ignite.
- Notify the local fire department of the location and contents of the storage facility.
- Develop an emergency plan and train all workers in its execution.
- Keep a written inventory of the pesticides held in storage and file the list away from the storage facility.

Figure 6.17 Post signs that indicate pesticides are stored in the facility.

If a Fire Occurs

Prompt and responsible action is essential in the event of a chemical fire. Take the following actions in the event of a chemical fire:

- Evacuate the premises.
- Notify the fire department and inform the firefighters of the nature of the pesticides involved.
- Provide emergency-response personnel with safety data sheet (SDS), which includes technical and emergency information.
- Keep people away. Establish a security perimeter to discourage onlookers.
- If significant smoke is generated, evacuate all people and animals in the vicinity, especially those downwind.
- Contain small fires with fog, foam or dry powder. If only water is available, use it as a fine spray or fog. Use only as much water as absolutely necessary. Do not use water jets because they can break bags and glass containers. If using water to fight pesticide fires, be careful not to spread the contamination to the surrounding area through water runoff.
- Make sure water and spilled chemicals are being contained. For larger fires, consider withdrawing and allowing the fire to burn out. This option is preferred over using water to fight the fire since use of water can lead to widespread environmental contamination. If runoff water cannot be avoided, build dikes to contain the contaminated water.
- Clean and dispose of equipment and all clothing. All personnel involved should shower after fighting the fire.

National Fire Protection Association (NFPA)

A hazardous rating system used to assist emergency response personnel is the NFPA Hazard Identification System. This system uses a diamond-shaped warning symbol. The top, left, and right boxes refer to flammability, health, and instability hazards, respectively, and each contains a number from 0 to 4 (Table 6.7). The bottom box is a warning against the use of water. Some pesticides and their storage sites will be marked with such a warning to alert firefighters not to use water to put out a fire (Figure 6.18).

See Appendix B for examples of emergency contingency planning, including a fire emergency response information sheet.

Section	Rating
Blue – Health hazard	4: severe hazard
	3: serious hazard
	2: moderate hazard
	1: slight hazard
	0: minimal hazard
Red – Flammability hazard	4: flammable gases; volatile liquids, pyrophoric materials
	3: ignites at ambient temperatures
	2: ignites when moderately heated
	1: must be preheated to burn
	0: will not burn
Yellow – Instability	4: capable of detonation or explosive decomposition at ambient temperatures
	3: capable of detonation or explosive decomposition with strong initiating source
	2: violent chemical change possible at elevated temperature and pressure
	1: normally stable, but becomes unstable if heated
	0: normally stable
White – Special hazard	OX: oxidizer
	~~W~~: avoid use of water

Table 6.7 NFPA's hazardous rating system.

Figure 6.18 National Fire Protection Association warning at a fumigant storage site. The strikeover on the letter "W" in the white diamond alerts firefighters not to use water to put out a fire.

Pesticide Spills

A spill is any accidental release of a pesticide. The spill may be a minor one involving only a few leaking containers, or it may be a major accident in which a piece of equipment malfunctions and releases its contents, or tank truck or rail car overturns and spills its cargo (Figures 6.19–6.20). All users of pesticides must be thoroughly familiar with the laws and guidelines governing chemical spills. The inability to respond properly to such an emergency, no matter how minor the problem, could seriously endanger public health and environmental quality.

The suggested guidelines in the event of a chemical spill are known as the three C's: CONTROL the spill, CONTAIN it, and CLEAN it up.

The 3 C's
Control
Contain
Clean up the spill

Figure 6.19 Small spill from 2.5-gallon container.

Figure 6.20 Large spill from overflowing tank.

Control the Spill

Take immediate steps to control the release of the products being spilled. If a sprayer has tipped over, if a pesticide is leaking from a damaged tank truck, or if a container on a storage shelf is leaking, do whatever you can to stop the leak or spill at once. For instance, smaller containers can be put into larger containers to prevent further release of the chemical. For larger leaks, try to plug the leak if possible. Outside assistance often is required to control large leaks.

Never expose yourself unnecessarily to leaking chemicals - always wear protective equipment when attempting to control a leak. Never charge in blindly if someone is injured; first, make sure you are properly protected.

A cellular phone must be standard equipment on every vehicle transporting pesticides. Alert the state and local police if the spill occurs on a public highway. Contact the appropriate state regulatory agency (or agencies) if the chemical is a pesticide. In certain cases, it may be necessary to alert the fire department, public health officials and/or the nearest hospital emergency room. Be sure to have the product label(s) and SDS available for emergency responders.

If the spill is large or dangerous, have someone get help. Do not leave the site unattended. Operators need radio or telephone communication available in the vehicle in case they need to call for assistance. The first contact you make in case of a spill is to your county 911 emergency number which can help coordinate the emergency response. In addition, CHEMTREC provides access to emergency response information and technical assistance from chemical industry experts. For additional information of the emergency response services available in your area, contact the telephone number listed for your county in Appendix C, Table C1 of this manual.

FL County Emergency Management Telephone numbers: See Appendix C, Table C1
CHEMTREC: 1-800-424-9300

A very important number is the emergency telephone number found on many product labels and on transportation or shipping papers. The lines are answered 24 hours per day by people who are prepared to handle pesticide emergencies involving the company's products.

Rope off the contaminated area; keep people at least 30 feet or further away from the spill. Avoid contact with any drift or fumes that may be released. Do not use road flares if you suspect the leaking material is flammable. At times it may be necessary to evacuate people from residences or businesses downwind from the spill.

Contain the Spill or Leak

At the same time the leak is being controlled, contain the spilled material in as small an area as possible. Do everything possible to keep it from spreading or getting worse. In some situations, you may need to use a shovel or power equipment to construct a dike or dam. The important thing to remember is to not let the spilled material get into any body of water, including storm sewers or drains.

If the chemical does contaminate a stream, pond, or any other waterway, immediately contact the state agency responsible for streams and fisheries and the agency for pesticide regulation. Also notify the local emergency planning coordinator if the pesticide spilled is listed as an extremely hazardous substance and exceeds the reportable quantity (see listing in Appendix D, Tables D1 and D2). Do not delay in

notifying authorities because they must alert downstream users as soon as possible to prevent accidental poisoning of livestock and to avoid contamination of irrigated crops and soil.

You can further contain liquid spills by spreading absorbent materials such as fine sand, vermiculite, clay or pet litter over the entire spill. Avoid using sawdust or sweeping compounds if the pesticide is a strong oxidizer (see label or SDS) because such a combination presents a possible fire hazard. In addition, nonspecific absorbent materials packed in pillows, tubes or pads can be placed directly on the spill or used to dike around the spill area. Waste disposal is then simplified because the contaminated pillows, tubes or pads can be placed into heavy-duty disposal bags without dust or spillage. Keep adding absorbent material to the contaminated area until all the liquid is soaked up.

In the case of dust, wettable powder, or granular spills, you can reduce spreading by lightly misting the material with water or covering the spill using some type of plastic cover. Discard the cover after use. Disposal of all hazardous wastes must be done in strict accordance with state and federal laws.

Clean Up the Spill

Once the spill has been contained, sweep it up and place it in a steel or fiber drum lined with a heavy-duty plastic bag. It may then be necessary to decontaminate or neutralize the area. Use ordinary household bleach in water (approximately 30 percent bleach), hydrated lime or a commercial decontamination preparation to help neutralize the spill area. Remember to wear protective equipment. Do not use bleach and lime together. Work this cleaning material into the spill area using a coarse broom. Then add fresh absorbent material to soak up the now contaminated cleaning solution. Sweep up this material and place it in a plastic bag or drum for disposal. It will be necessary to repeat this procedure several times to ensure that the area has been thoroughly decontaminated.

The only effective way to decontaminate soil saturated with a pesticide is to remove the top 2 to 3 inches of soil. This contaminated soil is now considered hazardous waste and must be disposed of according to state guidelines. Once the contamination has been removed, cover the area with at least 2 inches of lime, and finally, cover the lime with fresh topsoil. Soils contaminated as the result of application errors or minor spills can sometimes be cleaned up by applying activated charcoal to the contaminated surface immediately after the spill or misapplication. The charcoal may adsorb or tie up enough chemical to avoid significant plant injury and long-term contamination. However, application of activated charcoal to areas where large spills have occurred does little to reduce soil contamination and subsequent plant damage.

Clean any vehicles and equipment that were contaminated either as a result of the original accident or during the cleanup and disposal procedures. Before you begin, be sure you are properly clothed and protected to avoid contact with the chemical (Figure 6.21). Use ordinary household bleach in water (approximately 30 percent bleach) or an alkaline detergent (dishwashing soap) solution to clean your equipment. Do not mix bleach and alkaline detergent together. Equipment such as brooms, leather shoes, and cloth hats cannot be effectively decontaminated and must be discarded. Also, do not save disposable garments and gloves or badly contaminated clothing. As soon as you are finished with the spill and equipment cleanup, wash yourself thoroughly with soap and water. Wash any part of your skin that might have been exposed and always wash your face, neck, hands, and forearms.

For legal protection, it is advisable to keep records of your activities and conversations with regulatory authorities, emergency response personnel and the general public when dealing with a pesticide spill. Photographs help document any damage as well as the cleanup process.

Figure 6.21 Wear PPE when washing contaminated equipment.

Spill Kits

Most pesticide applicators are likely never to have the need for materials to be used in a pesticide spill cleanup. However, should a spill occur while handling concentrated pesticides, a cleanup kit will be well worth the small investment. Simple spill kits contain:

- Chemical-resistant gloves
- Chemical-resistant coveralls
- Chemical-resistant boots
- Chemical splash goggles
- Respirator
- Temporary hazardous material storage bag
- Absorbent pad for water- or solvent-based chemicals

- Absorbent tube sock (containment "snake")
- Bentonite/polymer mix paste for plugging leaking containers
- Floor absorbent granules
- Shovel or broom
- Dust pan
- Warning sign

More elaborate kits intended for larger facilities may also include:

- Pop-up containment pools (various holding capacities are available)
- Weatherproof, incinerable drum rated for hazardous materials.

Spill kit materials may be stored in permanent fixtures or structures (Figure 6.22), or in portable containers as simple as a 5-gallon bucket (Figure 6.23). The spill kit/location should be clearly labeled. Containers that may be mounted to the cabs of application equipment are also commercially available.

Figure 6.22 Permanent-sited spill kit cabinet.

Figure 6.23 Portable spill kit.

Conclusion

Pesticide risk can be summarized by the formula hazard=toxicity x exposure, where "toxicity" is the capacity of the pesticide to cause short-term (acute) or long-term (chronic) injury or illness and "exposure" is the means by which the pesticide gets into or onto the body.

Risk can be reduced by understanding pesticide exposure routes, ways by which pesticides can enter or contact the body: by the skin (dermal), eyes (ocular), mouth (oral), and the lungs (inhalation). Pesticide handlers can prevent exposure by following label directions, using the proper application techniques and wearing appropriate PPE.

Signal words: DANGER-POISON, DANGER, WARNING, and CAUTION help the user recognize how toxic the pesticide is and what precautions to take.

Pesticide handlers need to be aware of the symptoms of pesticide poisoning to know when to seek medical attention. Not all symptoms occur immediately following a pesticide exposure. Some symptoms are the result of chronic exposure. People who use pesticides routinely should have regular medical checkups to determine if they are experiencing any ill effects from pesticide use.

Early recognition of symptoms of pesticide poisoning is the key to preventing the potential for further injury. Victims of single, acute toxic exposures must be assisted and taken to a doctor or hospital immediately following any necessary first aid procedures. The first aid methods used depend on how the exposure occurred – to the skin, eyes, mouth, or by inhalation. The label often has important information on first-aid procedures for the particular pesticide product. Make sure a copy of the label is readily available whenever you are using pesticides, and take the label to the physician if a poisoning incident occurs.

To prepare for a pesticide emergency or incident, have a well-thought-out emergency response plan. Make sure the plan includes designating an emergency response coordinator, maintaining a list of emergency response agencies, preparing a map of the facility, keeping a product inventory of the types and quantities of stored chemicals, and knowing what emergency equipment and supplies are available. Be sure all employees at the facility are familiar with the emergency response plan and know the sequence of actions to take in a crisis.

Pesticide fires are of particular concern because of the variable nature of pesticide products in a storage facility. Actions to take in the event of a pesticide fire are a key component of any emergency response plan. Emergency response personnel must be notified of the kind of pesticides involved so they can take appropriate action to protect themselves and the

surrounding environment. In some cases it may be better to let a pesticide fire burn out rather than spreading the contamination by spraying the fire with water.

When dealing with pesticide spills, it is important to remember the three Cs: Control, Contain, and Clean up the spill. Immediate steps must be taken to control the release of products being spilled. Have emergency telephone numbers readily available in the case of a large or dangerous spill. It is important to try to contain the spilled material in as small an area as possible and to prevent the spill from entering any water source. Always keep a spill cleanup kit available wherever pesticides are handled.

Test Your Knowledge

Q: Which signal word is associated with Hazard Class I and chemicals that have severe corrosive properties but do not necessarily have very low oral LD_{50} values?
A. DANGER-POISON
B. DANGER
C. WARNING
D. CAUTION
A: B

Q: The capacity of a pesticide to cause short-term (acute) or long-term (chronic) injury is referred to as its?
A. Toxicity
B. Exposure
C. LD_{50}
D. Hazard
A: A

Q: Which statement is false about harmful effects of pesticides?
A. The most common form of pesticide injury is by inhalation.
B. Oral exposure is most likely caused by carelessness.
C. Asthma-like symptoms may be caused by allergies to pesticides.
D. Pesticides with lower LD_{50} values are more acutely toxic than pesticides with higher LD_{50} values.
A: A

Q: Which types of pesticides are most likely to lower cholinesterase levels in humans?
A. Fumigants
B. Herbicides, particularly 2,4-D
C. Insecticides, particularly carbamates and organophosphates
D. Many fungicides
A: C

Q: What is the first thing you should do for a person who has inhaled a pesticide?
A. Apply artificial respiration immediately.
B. Feed them activated charcoal.
C. Make them drink 4 shots of Jose Cuervo tequila.
D. Get them into fresh air.
A: D

Q: Which statement is false regarding pesticide storage facility fires?
A. They have potential to emit toxic vapors.
B. They should be extinguished with water.
C. Pesticide residues may be present in the debris and soil following a fire.
D. Pesticides involved may be flammable formulations.
A: B

Q: What should be the first course of action following a pesticide spill?
A. Start cleaning it up.
B. Control the source of the spill.
C. Dump water on it, then apply a torque.
D. Add activated charcoal to it.
A: B

CHAPTER VII

PERSONAL PROTECTIVE EQUIPMENT

Chapter VII

TABLE *of* CONTENTS

Learning Objectives

After you complete your study of this chapter, you should be able to:

- Describe your legal responsibility for following personal protective equipment (PPE) directions in pesticide labeling.
- Define the term, "chemical-resistant," and explain its difference from the terms, "water-resistant" and "waterproof."
- Know how to identify the minimum PPE required during pesticide handling activities to be in compliance with regulations.
- Know how to select and wear PPE according to label directions and regulations considering the length of exposure, exposure situation, and chemical to which one is exposed.
- Know how to select and properly wear PPE for protections of:
  - Skin
  - Eyes
  - Respiratory tract
- Understand the importance of selecting and fit-testing the proper respirator to match the pesticide handling situation.
- Know how to inspect for signs of wear and tear, damage, or other failures to PPE that may lead to exposure.
- Know when and how to dispose of PPE.
- Know how to clean, maintain, and store PPE according to manufacturer's recommendations.

Terms to Know

Acute toxicity: The measure of harm caused by a single, one-time exposure event.

Carcinogenesis: The production of malignant tumors.

Chemical-resistant: Material that withstands all measurable movement of pesticide through it during the period of use.

NIOSH: National Institute for Occupational Safety and Health. NIOSH is the federal agency responsible for testing and certifying respirators used in conjunction with pesticides.

Solvent: A liquid, such as water, kerosene, xylene, or alcohol, that will dissolve a pesticide, or other substance, to form a solution.

Waterproof (liquidproof): Material that keeps water-soluble materials out, but may not necessarily keep out oil-solvent-based products.

Water-resistant: Material that keeps a small amount of fine spray particles or small liquid splashes from penetrating through it during the period of use.

Introduction

Pesticides can pose hazards to humans. Hazard depends on the product's toxicity and length of exposure. The severity of a pesticide poisoning depends on the pesticide's chemical makeup and formulation, its path into the body, the amount that enters the body, and the length of exposure. Wearing personal protective equipment (PPE) can greatly reduce the potential for dermal, inhalation, eye, and oral exposure, and thereby significantly reduce the chances of a pesticide poisoning, but it does not necessarily eliminate it. The key to personal safety is to avoid exposure.

All pesticide handlers – applicators, mixer/loaders, flaggers, and early-entry agricultural workers – are legally required to follow all PPE instructions that appear on the product label (Figure 7.1). A pesticide label lists the minimum PPE that a person must wear while performing handling or early-entry activities (Figure 7.2). The PPE required is not necessarily the same for when applying the pesticide compared to when mixing and loading concentrates.

Figure 7.1 PPE instructions are legal requirements for pesticide handlers.

Chemical-resistant Clothing

The term chemical-resistant means that no measurable movement of the pesticide through the material occurs during the period of use. Some PPE is water resistant only. PPE that is water-resistant will prevent a small amount of fine spray particles or small liquid splashes from penetrating the clothing and reaching the skin. Waterproof (liquidproof) material keeps water-soluble materials out, but it may not necessarily keep out oil solvent-based products. Waterproof materials include items

PRECAUTIONARY STATEMENTS

HAZARDS TO HUMANS AND DOMESTIC ANIMALS

CAUTION

Harmful if swallowed, inhaled, or absorbed through the skin. Prolonged or frequently repeated skin contact may cause allergic reactions in some individuals. Avoid contact with skin, eyes, or clothing. Avoid breathing dust or spray mist.

Personal Protective Equipment
Applicators and other handlers (other than mixers and loaders) must wear:

- Long-sleeved shirt and long pants
- Chemical-resistant gloves made of waterproof material such as neoprene, butyl rubber, barrier laminate or nitrile rubber
- Shoes plus socks
- Chemical-resistant headgear for overhead exposure

Mixer and loaders must wear:

- Long-sleeved shirt and long pants
- Chemical-resistant gloves made of waterproof material such as neoprene, butyl rubber, barrier laminate or nitrile rubber
- Shoes plus socks
- Chemical-resistant headgear
- NIOSH-approved respirator with any N, R, P or HE filter

Follow manufacturer's instructions for cleaning/maintaining PPE. If no such instructions for washables, use detergent and hot water. Keep and wash PPE separately from other laundry.

Figure 7.2 Typical PPE required for handlers to wear according to label directions.

made of plastic or rubber. The chemical resistance of a material is an indication of how strongly it resists chemical penetration by pesticide products during use.

Always read the pesticide labeling to see if it states which materials are resistant to the pesticide product. In some instances, a pesticide label's PPE description lists a code letter (A-H) developed by EPA to help the user select suitable PPE (Figure 7.3). The EPA chemical resistance category selection chart is given in Table 7.1.

The chart's code letters are based on the solvents used in a pesticide product, not the pesticide's active ingredient. By referring to this chart, a pesticide handler can determine how long a given material can be expected to withstand chemical exposure by a given solvent. For example, the label directions from Figure 7.3 advise handlers to "refer to Category C on an EPA chemical resistance category selection chart." Based on the chart's recommendations, suitable materials for wearing while handling this product would be barrier laminate, butyl rubber, nitrile rubber, neoprene rubber, polyvinyl chloride, or viton.

Personal Protective Equipment (PPE)

Some materials that are chemically resistant to this product are listed below. For more options, refer to Category C on EPA chemical-resistance category selection chart.

Figure 7.3 PPE label statements based on the EPA chemical resistance category selection chart.

Protect Your Skin

According to an EPA report, most pesticide poisoning incidents occur through pesticides contacting the skin. PPE is protective only when used properly. If pesticide gets inside PPE next to the skin, the PPE will no longer protect the wearer. On the contrary, it will hold the pesticide against the skin as long as it is worn, increasing rather than decreasing the likelihood of contact injury or skin absorption and systemic injury.

Work Clothes

Ordinary shirts, pants, shoes, and other work clothes are usually not considered PPE, even though pesticide labels often indicate that specific items of work clothing should be worn during certain activities. The work clothes should be made of sturdy material and must be free of holes and tears. Shirt collars should be fastened completely to protect the lower part of the neck. The tighter the fabric weave, the better the protection. In some instances, the product label requires wearing a coverall, a chemical-resistant suit, or a chemical-resistant apron over work clothes.

Coveralls

The protection offered by chemical-resistant clothing depends on the fabric, and on design features such as flaps over zippers, elastic at the wrists and ankles, and seams that are bound and sealed. Coveralls should be made of sturdy material such as cotton, polyester, a cotton-synthetic blend, denim, or a non-woven fabric such as Tyvek® (Figure 7.4). When wearing a coverall, the opening should be closed securely so the entire body, except the feet, hands, neck, and head, is covered. With two-piece outfits, the shirt or coat should not be tucked in at the waist, rather the shirt should extend well below the waist of the pants and fit loosely around the hips. Well-designed coveralls offering protection from pesticides are tightly constructed, have sealed seams and snug, overlapping closures that do not allow gaps and do not unfasten readily. For example,

Selection category on label	Type of resistant material							
	Barrier laminate	Butyl rubber ≥ 14 mils	Nitrile rubber ≥ 14 mils	Neoprene rubber ≥ 14 mils	Natural rubber* ≥ 14 mils	Poly-ethylene	Polyvinyl chloride (PVC) ≥ 14 mils	Viton ≥ 14 mils
A Dry & water-based formulations	High	High	High	High	High	High	High	High
B	High	High	Slight	Slight	None	Slight	Slight	Slight
C	High	High	High	High	Moderate	Moderate	High	High
D	High	High	Moderate	Moderate	None	None	None	Slight
E	High	Slight	High	High	Slight	None	Moderate	High
F	High	High	High	Moderate	Slight	None	Slight	High
G	High	Slight	Slight	Slight	None	None	None	High
H	High	Slight	Slight	Slight	None	None	None	High

*Includes natural rubber blends and laminates.
High: Highly chemically resistant. Clean or replace PPE at end of each day's work period. Rinse off pesticide at breaks.
Moderate: Moderately chemically resistant. Clean or replace PPE within an hour or two of contact.
Slight: Slightly chemically resistant. Clean or replace PPE within 10 minutes of contact.
None: Not chemically resistant. Do not wear this type of material as PPE when contact is possible.

Table 7.1 EPA chemical resistance category selection chart.

many coveralls have zippers that are covered by flaps for added protection. Some coveralls, such as those made of Tyvek®, are water resistant and disposable.

Chemical-resistant Suit

Some product labels require the handler to wear a chemical-resistant suit. This usually indicates the pesticide is very hazardous because of either acute or delayed effects. Chemical-resistant suits made of rubber or plastic are sold as one-piece coveralls or as two-piece outfits consisting of a jacket worn over coveralls. Chemical-resistant suits made of coated, non-woven fabric usually are sold as one-piece coveralls. The biggest drawback to chemical-resistant suits is they make the body uncomfortably warm. In Florida's climate, heat stress becomes a major concern. If heat stress is a possible concern, it may be necessary to reduce the time spent applying pesticides.

Chemical-resistant Apron

An apron protects from splashes and spills, and it protects coveralls or other clothing. Aprons should be considered whenever pesticide concentrates are handled. The pesticide label may require wearing a chemical-resistant apron when mixing or loading a pesticide or when cleaning application equipment. Some aprons are heavily constructed, but lightweight, disposable aprons are also commercially available (Figures 7.5).

An apron can pose a safety hazard when working around equipment with moving parts. In that situation, a chemical-resistant suit would be a better choice.

Photo (top right) James H. Miller, USDA Forest Service, www.forestryimages.org

Figure 7.4 Coveralls, clockwise from top left: synthetic blend, cotton, Tyvek®.

Figure 7.5 Some labels state that a chemical-resistant apron should be worn.

Gloves

The parts of the body that get the most exposure to pesticide are the hands and forearms. Research has shown that workers mixing pesticides received 85 percent of the total exposure to hands and 13 percent to the forearms. The same study showed wearing gloves reduced exposure by at least 98 percent to applicators who had spills while mixing or applying pesticides (Table 7.2). As a result, most product labels require use of waterproof or chemical-resistant gloves during handling and mixing. Gloves should be worn any time pesticides may contact hands, such as when working around contaminated equipment or surfaces (Figure 7.6).

Polymers used for chemical-resistant gloves (Figures 7.7) include those materials listed in Table 7.1. These materials are used either individually or in various combinations in commercially available gloves. Canvas and leather gloves will not protect against exposure to pesticides because these materials absorb pesticide easily and can't be decontaminated.

Activity	**Use of rubber gloves**	
	Yes	**No**
	Concentration (ppb)	Concentration (ppb)
Spill while mixing	4.1	232.7
Spill while applying	3.6	153.6

Table 7.2 Average urinary glyphosate concentration values on the day of application according to use of rubber gloves.

Figure 7.6 Gloves should be worn while working with contaminated equipment and surfaces.

Figure 7.7 Gloves: Barrier laminate gloves, butyl rubber, nitrile rubber, neoprene rubber (l), natural rubber (r), polyvinyl chloride.

Chemical-resistant gloves are fabricated in two forms. One is that of the hand silhouette. This glove is made by die cutting a two-dimensional outline of a hand from a plastic film. Two of these flat hand forms are welded around the edges to form a glove. Most gloves made from polyethylene are constructed in this manner. The hand silhouette gloves can be ineffective because of poor fit, loss of dexterity, and difficult in keeping the gloves on the hands. The second and more common type of chemical-resistant glove is made by dip molding, that is, by dipping a hand mold into a polymer-containing liquid. Dipped gloves are right- and left-handed and are sized. These gloves provide both a better fit and improved dexterity. Some of the dipped gloves come with curved fingers, which provide additional comfort.

Glove thickness is described in units of mils (1 mil = 0.001 inch). In general, the effectiveness of the barrier and its resistance to tear and puncture increases with thickness. Commercially available gloves range in thickness from 1 to 60 mils. The most commonly used chemical-resistant gloves range from 12 to 22 mils.

Footwear

Pesticide handlers may get pesticides on their feet. Shoes and socks are often sufficient to protect your feet during many handling activities. When handling certain pesticides, however, canvas and leather shoes offer insufficient protection for the same reasons gloves made of these materials are not protective. The product labels for those pesticides require wearing waterproof or chemical-resistant footwear which could mean shoe covers (Figure 7.8) or boots.

If a pesticide is likely to get on the lower legs or feet, chemical-resistant boots that extend past the ankles and at least halfway up to the knee should be worn. Wear waterproof boots when entering or walking through recently treated areas such as lawns before the spray has dried.

Figure 7.8 Shoe covers designed for use while handling pesticides.

Properly Wearing Gloves and Footwear

Chemical-resistant gloves and footwear should not be worn when handling certain fumigants, such as methyl bromide. The

gloves and footwear can trap the fumigant gas near the skin and cause burns (Figure 7.9). Like other pesticides, fumigant labels specify the appropriate PPE required to protect the applicator from exposure.

Figure 7.9 Skin blistered by methyl bromide exposure to the foot.

If removing non-disposable gloves during a handling activity, the gloves should be thoroughly washed before removal. For jobs in which the arms are mostly lowered, the sleeves should be placed outside the gloves to prevent pesticide from running down into the gloves and onto the skin of the hands. For jobs in which the arms are mostly raised, gloves should remain outside the sleeves. Likewise, similar precautions should be observed with pant legs and boots. Pant legs should be outside of the boots to prevent pesticides from running down into the boots (Figure 7.10).

Figure 7.10 Pant legs should be outside, not inside, of the boots to prevent pesticide from running down into the boots.

Overhead Protection

For overhead exposure or exposure to airborne particles, there are several PPE options. A plastic safari hat with plastic sweatbands is a good choice in hot weather. More flexible hats and hoods are also available in chemical-resistant materials (Figure 7.11). Hats must not contain absorbent material such as cotton, leather, or straw. Many chemical-resistant jackets or coveralls can be purchased with attached protective hoods.

Figure 7.11 Flexible, lightweight chemical-resistant hat.

Protect Your Eyes

Eyes are very sensitive to the chemicals contained in some pesticide formulations, especially concentrates. Goggles, face shields, and safety glasses with shields at both the brow and sides are examples of protective eyewear (Figure 7.12).

Shielded safety glasses and full face shields are good choices in many handling situations because they are relatively comfortable, do not cause fogging or sweating, and provide good eye protection. If goggles will be worn, materials made of polycarbonate that have protected air baffles to avoid fogging are the most comfortable choice. Either goggles or shielded safety glasses can be worn with a half-face respirator (Figure 7.13).

If the Worker Protection Standard applies and if the label specifies protective eyewear, then regulations pertaining to eyewash decontamination are in effect.

Figure 7.12 Eye protection: goggles, full face shield, shielded safety glasses

Figure 7.13 Wearing goggles with a half-face respirator.

Protect Your Respiratory Tract

Respirators protect from breathing pesticide-contaminated air. Various pesticide formulations require different types of respirators. The label will provide specific instructions if required, and if so, which type (Figure 7.14).

Credit: CDMS.

Personal Protective Equipment (PPE)

Applicators and other handlers (other than Mixers and Loaders) must wear:

- Long-sleeve shirt and long pants
- Shoes plus socks
- Protective eyewear
- Chemical Resistant Gloves – Category A (e.g. barrier laminate, butyl rubber, nitrile rubber, neoprene rubber, natural rubber, polyethylene, polyvinyl chloride (PVC) or Viton®)
- A dust mist NIOSH-approved respirator with any N, R, P, or HE filter

Figure 7.14 If a respirator is required, the label will specify the type.

Respirators are the most specialized piece of personal protective equipment for working with pesticides, and proper

selection is complicated. Specific information on choosing the appropriate respirator will be supplied by pesticide labels.

The National Institute of Occupational Safety and Health (NIOSH) is the federal agency responsible for testing and certifying respirators used in conjunction with pesticides (and other non-mining respiratory protection). Approval numbers beginning with the letter TC are assigned to all respirators reviewed by the agency and must be on the box containing the facepiece. Pesticide product labels often specify the type of respirator required by listing its TC number. In addition, filters are classified on the basis of oil degradation resistance and filter efficiency. The classification levels for oil degradation resistance are N – not oil resistant; R – oil resistant; and P – oil proof. The filter efficiency for each classification level may be 95, 99, or 100 percent. The following is a list showing several types of respirators and their TC code designations under the NIOSH classification system:

- TC-84A: non-powered particulate respirators (N, P, and R filters)
- TC-21C: powered particulate respirators only (100 series filters)
- TC-23C: chemical cartridge respirators
- TC-14G: gas masks with canisters
- TC-19C: supplied-air respirators
- TC-13F: self-contained breathing apparatus

The product formulation, toxicity, and type of application influence the type of respirator needed. Manufacturers use criteria approved by the EPA to assign PPE respirator requirements on labels (Table 7.3).

EPA criteria	Label statement for respiratory protection
Solid pesticides with Toxicity Class II, III, or IV	Use a NIOSH-approved respirator with any N, R, P, or 100 series prefilter.
Liquid pesticides, Toxicity Class I	Use a NIOSH-approved respirator with an organic vapor (OV) cartridge or canister with any N, R, P, or 100 series prefilter.
Gas applied in enclosed area	Use an air-supplying respirator with NIOSH TC-19C, or use a self-contained breathing apparatus with NIOSH TC-13F.

Table 7.3 Label examples based on the EPA respiratory protection criteria.

Particulates are solid particles such as dusts and mists. Pesticide labels that specify organic vapor-removing cartridge respirators will also list which filters or pre-filters can be used with the respirator. The filters are identified by codes such as an HE, N, R or P, which indicate the level of oil resistance offered by the filter. "N" filters are not resistant to oils, but are excellent for use with dusts and granular formulations. "R" and "P" filters are either oil-resistant (R) or oil-proof (P). HE filters refer to "high efficiency" filters for powered-air purifying units, which can be used with oils. Manufacturers will designate a number that follows the HE, N, R, or P on their products, and this number is an indication of the trapping efficiency. For example, a particulate respirator or filter with the N95 designation would be expected to have 95 percent efficiency in its trapping capacity. Pesticide label recommendations generally instruct the user to have a P100 filter with the chemical cartridge respirator when handling and applying oil-based pesticides.

One of the two common types of respirators is the air-purifying respirator. Some air-purifying respirators cover the entire face; there are also less expensive half-masks that cover the nose and mouth. These respirators should be used only where there is sufficient oxygen. Air-purifying respirators have chemical cartridges or mechanical filters to remove airborne contaminants as air enters the respirator. The chemical cartridges are filled with activated carbon, which has a very high absorption capacity for gases and vapors. Each chemical cartridge is color-coded to indicate the use for which it was designed. A description of these codes is listed in Table 7.4. Mechanical filters provide protection by trapping particulate matter in the porous filter material.

Color	Protects against…
Black	Organic vapors (pesticides except fumigants unless allowed on label), paint spraying (except isocyanate-containing paints), fumigation
Green	Ammonia: anhydrous or from livestock confinement
Yellow	Acid gases, such as chlorine and other disinfectants
Olive[1]	Organic vapors, ammonia, and acid gases
Pink	Dusts and welding fumes
[1]Relatively short life against pesticides.	

Table 7.4 Chemical cartridge color codes.

Most air-purifying respirators (Figure 7.15) operate under negative pressure; that is, they rely on the power of the wearer's lungs to pull air through the filter elements. These include half-mask dust/mist respirators, half-mask dual-cartridge respirators, full-face dual-cartridge respirators, and canister-type gas masks. Dust/mist respirators (Figure 7.16) and some half-mask dual-cartridge respirators are disposable. The only air-purifying respirator that operates under positive pressure is the powered air-purifying respirator (PAPR). It has a fan that pulls air through the filters and circulates it over the wearer's face. Air-purifying respirators vary widely in price.

Figure 7.15 Air-purifying respirator.

The second basic type of respirator is the atmosphere-supplying respirator. This kind of respirator supplies an independent source of breathable air and is used in conditions where oxygen is deficient or the applicator is exposed to high concentrations of very toxic pesticides in enclosed areas. Breathable air is supplied to the wearer from an independent source through an air line, or the wearer carries oxygen in a tank. These respirators are relatively expensive and should be serviced and inspected by qualified personnel.

Figure 7.16 Dust/mist respirator.

An applicator should perform a fit test to determine correct size of a respirator face piece because a respirator that does not provide a proper seal is of little value. OSHA mandates that a fit test be performed every time a person puts on a respirator. Instructions for conducting fit tests generally accompany half-mask and full-face respirators.

Chemical cartridges should be replaced according to the manufacturer's recommendations or the pesticide label, or when the wearer notices odor or experiences irritation. Pre-filters will extend the life of chemical cartridges in dusty conditions. Mechanical filters should be replaced when breathing becomes difficult or the filter is damaged, or as specified by the manufacturer or the pesticide label. If no instructions are provided, replace cartridges and filters when the workday is over.

Maintaining Personal Protective Equipment

When a pesticide handling activity is completed, PPE should be removed right away. The outside of the gloves should be washed with detergent and water before removing the rest of the PPE. Then, the outside of the other chemical-resistant items should be washed before removing the gloves. Wash your skin after removing gloves.

Disposables

Disposable PPE items are not designed to be cleaned and reused, and should be discarded when they become contaminated with pesticides. Chemical-resistant gloves, footwear, and aprons labeled as disposable are designed to be worn only once and then thrown away. These items are made of thin vinyl, latex, or polyethylene. These inexpensive disposables may be a good choice for brief pesticide handling activities that require dexterity as long as the activity does not tear the thin plastic.

Reusables

Some PPE items, such as rubber and plastic suits, gloves, boots, aprons, capes, and headgear, are designed to be cleaned and reused several times. However, they should not continue to be worn when they no longer are able to provide adequate protection. They can be checked for rips and leaks by using the rinse water to form a "balloon" and/or holding the items up to the light. Even if there are no obvious signs of wear, reusable PPE items should be replaced regularly. The ability of a chemical-resistant material to resist pesticides decreases each time the item is worn. A good rule of thumb is to throw out gloves that have been worn for about 5 to 7 workdays. Extra-heavy-duty gloves, such as those made of butyl or nitrile rubber, may last as long as 10 to 14 days. The cost of frequently replacing gloves is a wise investment. Footwear, aprons, headgear, and protective suits may last longer than gloves because they generally receive less exposure to the pesticides and less abrasion from rough surfaces. Most protective eyewear and respirators, face pieces, and helmets are designed to be cleaned and reused. These items can last many years if they are of good quality and are maintained correctly.

Washing PPE

Pesticide-contaminated items should be washed separately from the family laundry. The following procedure can be used for washing non-chemical-resistant items such as cotton, cotton/polyester, denim, canvas, and other absorbent materials, and for most chemical-resistant items.

Procedure for Washing Contaminated PPE

1. Wash only a few items at a time so there is plenty of agitation and water for dilution.
2. Wash in a washing machine, using heavy-duty liquid detergent and hot water for the wash cycle. Set the washer to the longest wash cycle and two rinse cycles.
3. Use two entire machine cycles to wash items that are moderately to heavily contaminated. If PPE is too contaminated, bundle it in a plastic bag, label the bag, and take it to a household hazardous waste collection site.
4. Run the washer through at least one additional entire cycle without clothing, using detergent and hot water, to clean the machine before any other laundry is washed.
5. Hang the washed items to dry, if possible. It is best to let them hang for at least 24 hours in an area with plenty of fresh air.

Maintaining Eyewear and Respirators

Wash goggles, face shields, shielded safety glasses, respirator bodies, and face pieces after each day of use. Use detergent and hot water to wash them thoroughly. They should be sanitized by soaking for at least 2 minutes in a mixture of 2 tablespoons of chlorine bleach in 1 gallon of hot water, then rinsed thoroughly. Following rinsing, the items should be allowed to dry thoroughly by hanging them in a clean area. Store respirators and eyewear in an area where they are protected from dust, sunlight, extreme temperatures, excessive moisture, and pesticides or other chemicals. A sturdy plastic bag with a zip closure works well for storage (Figure 7.17).

Figure 7.17 Store respirators and cartridges in an airtight bag, or they may lose their effectiveness.

Conclusion

Proper use and selection of personal protective equipment (PPE) is essential for prevention of pesticide exposures. The PPE items selected for a particular pesticide application depend on the application procedure, the pesticide being applied, and the label requirements. Applicators must be familiar with the various types of PPE available and how well they protect against pesticide exposures.

Choose PPE items to protect the skin, eyes, and lungs from exposure. If there is a risk of pesticides penetrating clothing and contaminating skin, select items made of chemical-resistant materials such as plastics or rubber. Gloves, boots, aprons, suits, and hoods come in chemical-resistant materials such as plastics or rubber. Regular work clothes made of cotton, leather, or canvas are not chemically resistant. Pesticide labels may refer to a chemical resistance category that tells the user how long to expect protection after the pesticide contacts the PPE. Keep a copy of the EPA Chemical Resistance Category Selection Chart on hand for an explanation of how long certain materials provide protection.

In addition to being able to choose the appropriate type of PPE, pesticide users must also know how to wear, clean, and dispose of PPE properly. Wear PPE to prevent pesticides from coming into contact with skin, eyes, or clothing. Clean PPE after each use and wash separately from other clothing to prevent contamination. Dispose of PPE if it has cracks, holes, or rips, or is wearing thin in places. If PPE is contaminated by pesticides that cannot be removed by washing, dispose of it as hazardous waste.

PPE is also available to protect the eyes and lungs. The label often specifies what type of protection to use. Goggles, safety glasses, and faceshields may be worn to protect the eyes. A respirator may be worn to prevent inhalation exposure. The label often lists the type of respirator to use by its "TC" number. Whenever you use an air-purifying, tight-fitting respirator, make sure it has been fit tested specifically for you and understand how to perform the fit check each time you use it. Like other types of PPE, eyewear and respirators must also be worn, cleaned, and stored properly if they are to continue providing protection to the user. Remember, you are legally required to wear all PPE recommended by the label. In many cases, you may want to select additional PPE for added protection. Make sure you are familiar with the level of protection provided by the PPE, and know how to use and wear it properly.

Test Your Knowledge

Q: Which statement is true about PPE as required by the label?
A. You should not wear more PPE than the label requires.
B. Sometimes a label has different PPE requirements for pesticide application and mixing concentrates.
C. You are not required to wear all the PPE listed on the label.
D. Wearing the PPE listed on the label ensures that you will not be exposed to pesticides.
A: B

Q: Which statement is true about PPE chemical resistance?
A. The ability of a given material to protect an individual from a pesticide product is largely a function of the type of solvent used to formulate the pesticide product.
B. Cloth is easy to clean after it becomes contaminated with a pesticide.
C. Cotton, leather, and canvas are chemically resistant to dry formulations.
D. Gloves and boots made of rubber or plastic are the least chemically resistant.
A: A

Q: Which parts of the body are the most likely to be exposed to pesticides?
A. The hands and forearms.
B. The feet and legs.
C. The chest and stomach.
D. The eyes and lungs.
A: A

Q: What is the purpose of the fit check?
A. To select the right size respirator for the user.
B. To make sure you have a tight-fitting seal with no leakages each time you use the respirator.
C. To see if you can taste or smell any substance leaking into the mask.
D. To compare the dust concentration in the surrounding air with the dust concentration inside the respirator.
A: B

Q: Which is true about disposable PPE?
A. Inexpensive disposables may be a good choice for brief pesticide-handling activities.
B. Non-woven coveralls and hoods are usually designed to be worn for 7 workdays.
C. Dust/mist respirators can be cleaned and reused three or four times before disposing of them.
D. Chemical-resistant gloves are designed to be worn three or four times before disposing of them.
A: A

Q: Which statement is true about washing contaminated PPE?
A. Wash a full load of PPE items at a time.
B. Use cold water and one wash cycle.
C. Use only very short wash cycles.
D. After washing, run the washer through at least one cycle without clothing.
A: D

Q: Which statement is true about respirator maintenance?
A. Respirator cartridges should be stored in an air-tight bag to maintain effectiveness.
B. Inspect respirators twice each year for signs of wear and tear.
C. After use, prefilters should be stored in a zip-closable bag with canisters and cartridges.
D. Use a substitute canister or cartridge if you cannot find the replacement part for your respirator.
A: A

Chapter VIII

Transportation, Storage and Security, and Disposal of Pesticide Wastes

Chapter VIII

TABLE *of* CONTENTS

Learning Objectives

After you complete your study of this chapter, you should be able to:

- List safety precautions for transporting pesticides in a vehicle.
- Know how to identify components of a proper storage area.
- Know how to store pesticides according to label directions and regulations and how to post warning signs around storage areas.
- Know how to practice inventory control methods to prevent excess storage.
- Know how to maintain pesticide containers.
- Know how to restrict access to pesticides by unauthorized personnel.
- Know how to dispose of pesticide wastes according to label directions.

Terms to Know

Hazardous material: Substance or material which has been determined to be capable of posing an unreasonable risk to health, safety, and property when transported in commerce.

Placard: A notice for public awareness – pertains to posting with diamond-shaped signs on transport vehicles and storage sites for pesticides.

Introduction

This chapter discusses safety and security issues while pesticides are in transit or in storage, and proper disposal of pesticide wastes. Accidents involving pesticides are more likely to occur while they are being transported. Properly design and maintain storage sites to prevent damage and unauthorized access to pesticides. Pesticide safety practices include securing pesticides in the cargo area of the transport vehicle and preventing water damage in storage areas to prevent the accidental discharge of pesticides. In addition, appropriate security measures, such as locking pesticides inside cargo boxes and storage areas prevent pesticide theft and vandalism. You can reduce the potential for pesticide problems by being aware of the conditions that leave pesticides open to security risks and by initiating good safety practices.

Transportation

Pesticides are transported from manufacturers to distributors and dealers, from retailers to end users, and from storage sites and mixing locations to application sites. Accidents can happen at any point in the distribution chain, even when transport distances are short. The first line of defense is knowing how to prevent transportation mishaps. When mishaps occur, however, initiating the appropriate response could mean the difference between a minor inconvenience and a communitywide disaster.

The fact that some pesticides are highly flammable increases the danger (fire and toxic fumes) while they are in transit. Another concern is that other vehicles could scatter pesticide products that are spilled on public roads. Such events have the potential to injure bystanders and animals. In addition, transportation-related pesticide spills and leaks can contaminate the environment, endanger residential areas, and lead to financial losses and legal actions.

Transport Vehicle

Never carry pesticides in the passenger compartment of a vehicle because spilled chemicals and hazardous fumes can seriously injure the occupants. Spilled pesticides can be difficult or impossible to remove completely from the vehicle's interior, leading to long-term exposures. If pesticides must be carried in a station wagon, utility van, or similarly enclosed vehicle, ventilate the cargo and passenger compartments, and keep passengers and pets away from pesticides during transport. Remember, cargo can shift during collisions and other sudden stops. Placing a safety barrier between the passengers and the cargo area is advisable.

The cargo area must be able to securely hold containers and provide protection from tears, punctures, or impacts that could lead to container damage (Figure 8.1). Enclosed cargo boxes provide the greatest protection but are not always practical. Cargo boxes also offer the added benefit of security from curious children, careless adults, or vandals (Figure 8.2). Open truck beds are convenient for loading and unloading, but take precautions to minimize the possibility of theft or losing containers on sharp turns or bumpy roads. Never stack pesticide containers higher than the sides of the vehicle. Make sure flatbed trucks have side and tail racks, and tie-down rings, cleats or racks to simplify the job of securing the load. Before loading, inspect every cargo area for nails, stones, or sharp edges/objects that could damage containers. Steel beds are preferable to wood because they are more easily cleaned if a spill should occur.

Figure 8.1 Pesticide transport vehicles must provide protection for their cargo.

Figure 8.2 Cargo boxes offer security benefits for transporting pesticides.

Vehicle Operator

Both the owner and the operator of the transport vehicle can be held accountable for any injuries, contamination, or damage resulting from a chemical release that may occur. The vehicle operator may be the only person capable of reacting to a spill and, in some instances, may need to assist first response emergency personnel as they arrive on the scene. At a bare minimum, the vehicle operator must understand the nature and hazards of the pesticides being transported. Train the operator in basic emergency response procedures, including spill control and emergency notification procedures. Refer to Chapter VI, "Harmful Effects and Emergency Response" for specific information on how to respond to a fire, spill, or leak involving chemicals.

Special motor vehicle training and licensing, in addition to pesticide training or certification, may be required for operators of pesticide transport vehicles. If a load meets the US Department of Transportation (DOT) definition of a hazardous material or substance, then special driver training and, in some instances, commercial driver licensing is required.

Other Safety Precautions

Before departing, make sure that the technical data for all pesticide products and emergency information for spill response are in the vehicle. A shipping paper, also called a vehicle manifest, may be required for certain products regulated as hazardous materials under DOT regulations. A hazardous material is a substance or material which has been determined to be capable of posing an unreasonable risk to health, safety, and property when transported in commerce. The regulatory section of an SDS lists whether or not the pesticide product is a DOT-regulated product (Figure 8.3).

Credit CDMS

SECTION 14. TRANSPORT INFORMATION

DOT Hazardous Material Classification

Carbamate Pesticides, Solid, Toxic, 6.1, UN2757, PG II, RQ(Aldicarb)

Figure 8.3 SDS listing of a DOT-regulated product.

Product labels and Safety Data Sheets contain information about the proper storage and handling of products, including acceptable storage temperatures, human and environmental hazards, personal protective equipment, and emergency telephone numbers. Provide this information in the vehicle to help the driver or emergency personnel properly respond to a pesticide release. It is also a good idea to have a phone number in the vehicle for 24-hour emergency assistance.

A mobile phone is strongly recommended for anyone routinely involved in the transport of pesticides or working alone in remote locations. Always carry a spill kit including a shovel and broom and personal protective equipment appropriate for the pesticides in transit and know how to use these items. Be familiar with the travel route so you can anticipate and avoid problems such as construction delays. If a pesticide release occurs, a major traffic jam only further complicates cleanup.

Inspect containers before loading to be certain they are in good condition. Look for legible and attached labels, tight closures, and pesticide-free outside surfaces. Handle containers carefully during loading to avoid rips and punctures. Use packing or shipping containers to provide extra protection and secondary containment. Where practical, using a synthetic liner or tarpaulin large enough to cover the floor and sides of the cargo area (especially truck beds) can provide containment

and easier cleanup of spilled materials. Organize the load to maximize stability while at the same time maintaining access to containers for ease of unloading. The less containers are handled, the less likely they are to be damaged. Secure the load with tarps, straps, brace bars, or other appropriate devices to prevent containers from shifting (Figure 8.4). Also, stabilize anything else that could move and damage a container during transport. Also secure application equipment such as hand sprayers, backpack sprayers, spreaders, and spray tanks during transport.

Photo FDACS

Figure 8.4 Fumigant cylinder securely strapped in the vehicle's cargo area.

Protect pesticides from temperature extremes and moisture during transit. Extremely low or high temperatures (below 40 degrees F or above 110 degrees F) can alter the stability or effectiveness of some pesticide formulations. Moisture can destroy paper and cardboard pesticide containers. Placing a waterproof cover over the load can provide protection from the elements, including the hot sun.

Never allow people, pets, or livestock to ride in a cargo area loaded with pesticides. Separate food, livestock feed, seed, veterinary supplies, and plant materials from pesticides because contamination may render them unusable or result in a poisoning incident. Keep herbicides separate from other pesticides and fertilizers because of the potential for cross-contamination.

Transportation Security

Whenever possible, transport pesticides in a locked compartment or container. If you must use an open vehicle to transport pesticides, never leave it unattended. Remember, you will be held responsible if a curious child or careless adult is poisoned or if environmental contamination occurs because of your negligence. Take all appropriate steps to reduce the chance of vandalism or theft.

The DOT requires diamond-shaped signs called placards on vehicles that transport certain types and quantities of hazardous materials (Figure 8.5). Though few pesticides require placarding, it is important to ask distributors whether what you are buying requires placarding. Most distributors furnish these to you if you need to place them on your transportation vehicles. Hazardous materials include some pesticides, fertilizers such as anhydrous ammonia or ammonium nitrate, fuels such as gasoline, diesel, and propane, and explosives such as dynamite and detonators. Placards provide emergency responders with the information necessary to quickly assess an accident situation from a distance, reducing the possibility of someone approaching the accident site without wearing the proper protective clothing or equipment.

Photo FDACS

Figure 8.5 Placarding of trailer indicating it holds a hazardous material.

People, including farmers, who ship or transport materials in quantities that require placards are now required to develop and implement a transportation security plan. Vehicles must be placarded when transporting pesticides bearing a DOT poison label being transported in containers larger than 119 gallons or in quantities greater than 1,000 pounds. Therefore, all operations that transport pesticides that meet these conditions must have a security plan. The security plan must include protection against unauthorized access, a security check of employees that pick up and transport placarded hazardous materials, and a security plan for the intended travel route. For further details on the transportation security plan, contact the Hazardous Materials Information Center.

Hazardous Materials Information Center
1-800-HMR-4922
http://www.phmsa.dot.gov/hazmat/info-center

Storage

Although many pesticide handlers use existing buildings or areas within existing buildings for pesticide storage, it is always best to build a separate storage facility just for pesticides.

A well-designed and maintained pesticide storage site:

- Protects people and animals from exposure
- Reduces the chance of environmental contamination
- Prevents damage to pesticides from temperature extremes and excess moisture
- Safeguards the pesticides from theft, vandalism, and unauthorized use
- Reduces the likelihood of liability

Secure the Site

Keeping out unauthorized people, pets, and stray animals is an important function of the pesticide storage site. Whether the designated area is as small as a cabinet or closet or as large as an entire room or building, keep it securely locked. Post highly visible warning signs on doors and windows to alert people that pesticides are stored inside (Figure 8.6). In addition, post "No Smoking" warnings – many pesticides are highly flammable (Figure 8.7). Security of pesticides is covered in much more detail in a separate section of this chapter.

Figure 8.6 A well-marked pesticide storage facility.

Prevent Water Damage

Locate the pesticide storage facility where water damage is unlikely to occur. Carefully consider soil and land surface characteristics when selecting a storage site to prevent potential contamination of surface water or groundwater. Avoid locating

Figure 8.7 No smoking sign on a pesticide storage facility.

the storage facility near a stream likely to flood or where runoff water can be a potential problem, such as at the base of a slope. In extreme cases of flooding, all the pesticides from the storage site can move into surrounding areas. In certain situations, consider diking or constructing some other containment structure around the storage facility (Figure 8.8). A common recommendation is to set storage areas back at least 50 feet from a well to prevent groundwater contamination, but requirements may vary by state.

Photo FDACS

Figure 8.8 Containment dike at a pesticide storage site.

Water or excess moisture can damage pesticide containers and their contents. Moisture causes:

- Metal containers to rust (Figure 8.9)
- Paper and cardboard containers to split or crumble (Figure 8.10)
- Pesticide labeling to peel, smear, or otherwise become unreadable
- Dry pesticides to clump, degrade, or dissolve
- Slow-release products to release their active ingredients

Figure 8.9 Rusted metal pesticide container from moisture.

Figure 8.10 Paper bag split from moisture.

Control the Temperature

Choose a cool, well-ventilated room or building that is insulated or temperature-controlled. Exhaust fans directed to the outside of the building reduce temperatures and remove dust and vapors from the storage facility (Figure 8.11). Ventilation of the air from a pesticide storage area into other rooms is an unsafe practice. The pesticide labeling often specifies the temperature limits for storing a product. Temperature extremes can decrease the effectiveness of some pesticides. In addition, freezing temperatures can result in breakage of glass, metal, and plastic containers. Excessive heat can cause plastic containers to melt, some glass containers to explode, and a few pesticides to volatilize and drift from the storage site. Always store pesticide containers out of direct sunlight to prevent overheating.

Figure 8.11 Exhaust fan on a pesticide storage building.

Provide Adequate Lighting

Be sure the pesticide storage facility is well lighted. Pesticide handlers using the facility must be able to see well enough to read the pesticide label and notice whether containers are leaking or corroding (Figure 8.12). Without adequate lighting, the pesticide handler can have difficulty cleaning up spills and leaks.

Because of the volatility of some pesticide formulations, use only spark-proof lighting fixtures and switches.

Figure 8.12 Storage sites should have adequate lighting to allow for inspection.

Use Nonporous Materials

Construct the floor of the pesticide storage area using sealed cement, glazed ceramic tile, no-wax sheet flooring, or other material that is free of cracks and easy to clean and decontaminate in the event of a spill or leak. Carpeting, wood, soil, and other absorbent floors are not suitable because they are difficult or impossible to decontaminate. A floor that slopes into a containment system or recessed below the level of the doors helps to keep spilled or leaking pesticides within a confined area. For ease of cleanup, choose shelving and pallets made of non-absorbent materials such as plastic or metal (Figure 8.13).

Figure 8.13 Metal shelving is easy to clean in the event of a spill.

Maintain the Storage Site

Store only pesticide containers, pesticide equipment, and a spill cleanup kit at the storage site. Never keep food, drinks, tobacco, feed, medication, medical or veterinary supplies, seeds, clothing, or personal protective equipment (other than that necessary for emergency response) at the site (Figure 8.14). These items could become contaminated by pesticide vapors, dusts, or spills, resulting in accidental exposure to people or animals. Have water available for decontamination.

Keep Labels Legible

Store pesticide containers with the labels in plain sight (Figure 8.15). Costly errors can result if the wrong pesticide is chosen. Be sure labels are always legible. If the label is destroyed or damaged, immediately mark the container with some basic labeling information such as the trade name and

Figure 8.14 PPE and food (top shelf) should be stored separate from pesticides.

Figure 8.15 Store containers with labels in plain sight.

common name of the product, the EPA registration number, the percentage of each active ingredient, the signal word, and the use classification. Then request a replacement label from the pesticide dealer or the distributor.

Store Pesticide Containers Safely

Store pesticides only in their original containers or an acceptable service container. At a minimum, write the trade and common names, EPA registration number, and signal word on the container. Never use milk jugs, soft drink bottles, fruit

jars, medicine bottles, fuel cans, or other types of non-pesticide containers. Besides being illegal, switching containers has resulted in serious poisonings because children, as well as most adults, associate the shape, size, and color of a container with its usual contents (Figure 8.16). Never lend or borrow any pesticide product in an unmarked or unlabelled container.

One woman dies after drinking bug killer stored in wine bottle

ATLANTA (AP) — Someone decided to use an old wine bottle to store a highly toxic bug killer. One woman died and another was seriously injured when they drank it.

The fumes from the pesticide were so strong they sickened medical personnel who were treating the women.

Members of the DeKalb County Fire Department's hazardous materials team and police evacuated and decontaminated the apartment where the women ingested the substance believed to contain organic phosphate, a chemical commonly used in insecticide.

Jan Heuett, 45, of Decatur, Ga., ... from the poison, and Barbara Lowe, 42, was in serious condition today at DeKalb Medical Center. Lowe's hometown was unavailable.

Symptoms of organic phosphate poisoning include headache, dizziness and nausea.

Eleven employees at the hospital, including a doctor, began showing symptoms after the women were rushed to the emergency room vomiting and struggling to breathe yesterday afternoon, said Patricia Horton, the hospital's director of critical-care and emergency room services.

Fire officials said the women unknowingly consumed the pesticide after someone carelessly stored it in an empty wine bottle. Investigators didn't know who it was.

Neighbors at the Decatur apartment complex where one of the women lived said there had been problems with fire ants in the area.

"A lot of times people accidentally put things in their beverage bottle," said W.B. Johnson, a fire department battalion chief. "They're finished with the beverage, so they put something else in there to store it."

The medical staff who dealt with the women were treated and later returned to work, while the room was sealed off and the contaminated air was filtered out, hospital spokeswoman Linda Tierney said.

"At no time were other patients in jeopardy," she said.

Figure 8.16 Never store pesticides in non-pesticide containers.

Keep containers securely closed when not in use. Dry formulations tend to cake when wet or subjected to high humidity. Opened bags of wettable and soluble powders, dry flowables, dusts, and granules can be placed into sealable plastic bags or other suitable containers to reduce moisture absorption and to prevent a spill, should a tear or break occur.

Place large drums and heavy bags on plastic pallets (Figure 8.17). Store other pesticides on metal shelving, placing the heaviest containers and liquids on the lower shelves. Do not allow containers to extend beyond the edge of shelving, because they could easily be bumped or knocked off. Be sure the shelving is sturdy enough to handle the quantity and weight involved.

Figure 8.17 Place large drums on plastic pallets.

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

Place bulk or mini-bulk tanks on a reinforced concrete pad or other impermeable surface. Diking around a tank keeps spilled or leaking pesticides inside a restricted area and also helps prevent damage to the tanks from vehicles and equipment. Construct the area inside a dike large enough to contain the volume of the liquid in the tank, plus at least an additional 10 percent. Keep valves and pumps within the diked area. Make sure all drains within the dike connect to a holding tank. Outside, use fencing to prevent tampering or unauthorized access to any bulk tanks.

Look for Damage

Inspect pesticide containers regularly for tears, splits, breaks, leaks, rust, or corrosion. If you find a damaged container, immediately put on appropriate personal protective equipment and take immediate action to prevent the pesticide from leaking or spreading into its surroundings. If a container is already leaking, take corrective action to prevent further leaking and immediately clean up any spilled pesticide. Be especially careful if the damaged container is an aerosol can or fumigant cylinder that contains pesticides under pressure.

Depending on the specific situation, consider the following actions:

- Use the pesticide immediately at a site and at a rate allowed by the label.
- Transfer the pesticide into another pesticide container that originally held the same pesticide and has an intact label.
- Transfer the contents to an appropriate container that can be tightly closed. If possible, remove the label from the damaged container and place it on the new container. Otherwise, temporarily mark the new container with basic labeling information and get a copy of the label from the pesticide dealer or distributor as soon as possible.
- Place the entire damaged container and its contents into a suitable larger container (overpack container for subsequent disposal).

Note Shelf Life of Pesticides

Keep an inventory of all pesticides in storage and mark each container with its purchase date (Figure 8.18). Be sure to note if the product has an effective shelf life listed on its label. If you have questions about the shelf life of a product, contact the dealer or manufacturer. Signs of pesticide deterioration from age or poor storage conditions may appear during mixing.

Watch for excessive clumping, poor suspension, layering, or abnormal coloration during mixing. Other times, however, the first indication of pesticide deterioration from age or poor storage conditions may be poor pest control and/or damage to the treated crop or surface.

Figure 8.18 Mark containers with their purchase date.

To minimize storage problems, avoid storing large quantities of pesticides for long periods. Keep records of previous usage to make good estimates of future needs. Buy only as much as you need for the job or season.

Additional Safety Measures

The following safety tips help prevent pesticide accidents and exposures in storage areas and help people respond appropriately to pesticide spills and emergencies:

- Have duplicate copies of labels available in case of an emergency. Keep a safety data sheet available for every chemical in the storage facility. The Internet or the pesticide dealer is a good source for SDS and labels.
- Wear the appropriate protective clothing when handling pesticide containers.
- Label all items used for handling pesticides (measuring utensils, protective equipment, etc.) to prevent their use for other purposes.
- Have clay, pet litter, fine sand, activated charcoal, vermiculite, or similar absorbent materials readily available in case of spills or leaks. In addition, keep a shovel, broom, and heavy duty plastic bags on hand.
- Check the SDS for the types of materials that may be needed to deactivate spills.
- Treated seed is usually colored with a bright dye to serve as a warning that the seed has been treated with a pesticide. Unfortunately, the bright colors may be attractive to children. Never use treated seed for feed or mixed with untreated seed. Handle it with the same care as the pesticide itself and store in a locked storage facility away from feed, veterinary supplies, pesticides, other chemicals, equipment, pets, wildlife, and children.
- Keep clean water for decontamination, an eyewash station, personal protective equipment, a fire extinguisher rated for chemical fires, first-aid equipment, and emergency telephone numbers easily accessible at all times. In addition, keep plenty of soap, water, and paper towels available near the storage facility (Figure 8.19).
- Do not store your PPE in the same room as your pesticides.

Figure 8.19 Permanently-plumbed emergency station at a mix/load site.

Make a Checklist

Safety is the key element in proper pesticide storage. If you answer "no" to any of the statements in the table in Appendix E, you should correct your storage facility immediately.

Storage Site Security

Many farmers and managers of pesticide storage facilities had concerns about biosecurity and agroterrorism even before the Oklahoma City bombing and the September 11, 2001 terrorist attacks on our nation. Businesses that manufacture, reformulate, sell, distribute, transport, store, or apply pesticides have long known the mitigation steps for safety of their workers, customers and communities. In today's age, these efforts may not necessarily be enough.

Even though security steps appear to be routine, they are critical to the safety of a business, facility and community. Without effective security measures, a business dealing with pesticides may be vulnerable to both internal and external threats. Buildings, machinery, stored pesticides and business information are all included in these threats. Protection of mobile pesticide application equipment, particularly aerial application equipment, should be taken into account as well.

Terrorists are unlike common criminals whose prime motivation is monetary gain. Terrorists have idealistic or political goals and will attempt to accomplish their mission with no fear of being caught. Their actions are carefully planned and coordinated, and attempted by skilled, and maybe armed, individuals. Security precautions designed to deter theft will likely fail against terrorists.

Questions to ask of your establishment to assess risks:

- What is the threat (theft, sabotage, attack)?
- How might illegal activities be carried out?
- Is the threat internal or external?
- Are containers of hazardous substances easily accessible?
- Is there the potential for siphoning from large storage tanks?
- Are unauthorized people allowed on the premises?
- Are unauthorized people escorted while on the property and do they sign in and out?
- Are background checks performed on employees?
- Are employees aware of the security risks associated with the storage of pesticides and other hazardous substances?
- Is there a potential for theft of electronic information that could result in security breaches?

Recommended considerations in evaluating pesticide security:

- Securing buildings, manufacturing facilities, storage areas and surrounding property: it's fundamental, but prevention of intrusion can include elements such as fencing or other barriers, lighting, locks, detection systems, signage, alarms, cameras and trained guards.
- Securing pesticide application equipment and vehicles: consider using an authorization process for persons who have access to such equipment before their use.
- Aerial application equipment: the FBI has requested that aerial applicators be vigilant to any suspicious activity relevant to the use, training in, or acquisition of dangerous chemicals and their application. Such activity includes, but is not limited to, threats, unusual purchases, suspicious behavior and unusual contacts with the public.
- Protection of confidential information: as businesses have grown more reliant on computers and communication technology, the need to secure these systems has grown. Efforts to include contingency planning for power losses, monitoring access ports, adherence to password and backup procedures, and maintaining access for authorized personnel only should be taken into account.
- Developing procedures and policies that support security needs: even the best hardware and staffing budgets are only as effective as the procedures and policies that control their use.
- Effective hiring and labor relations are important to obtain and retain good employees who will support and follow safety precautions. For example, the hiring process should ensure that pesticide handlers have all requisite training necessary to handle pesticides safely. Background checks of staff who have access to secure areas, particularly those areas where pesticides may be stored, are also necessary.
- Inventory management policies can help limit the amount of potentially hazardous pesticides stored on site, reducing the risks of accidental or intentional release or theft.
- Effective advance emergency response procedures can be critical. Business officials and employees need to have an understanding of how to respond and who to contact in the case of an emergency.
- Establish a procedure for locking up the facility at the close of the business day.

Suspicious Individuals

Maintain awareness of anyone demonstrating suspicious behavior, including those who:

- Seem unfamiliar with agriculture, pest control, or pesticides. This can usually be determined by everyday conversation with someone who enters the business.
- Seem to be "hanging out." These could be individuals who appear to be scoping the facility out.
- Insist on paying cash only, especially for large purchases.
- Wish to purchase only the most toxic materials.
- Refuse to take delivery.
- Are unwilling to present positive identification or license credentials.

- Seem anxious or uneasy when asked questions regarding their intent.

Also, remember to:

- Ask for proof of licensure when a customer is purchasing a Restricted Use Pesticide.
- Ask for picture identification to confirm identities.
- Be aware of personal identity theft for customers and employees. Examine all forms of identification carefully.
- Keep all required documentation for RUP purchases.
- Require a signature for product deliveries and deliver them only to legitimate recipients.
- Avoid unguarded and unlit areas where the possibility of theft increases.
- Advise all customers regarding potentials for theft and use of agrichemicals as weapons of terror.

Telephone Contacts if You Suspect Suspicious Activity

Florida Department of Agriculture and Consumer Services:

- Bureau of Compliance Monitoring: (850) 617-7851
- Law Enforcement Division: 1-800-342-5869

Florida Department of Law Enforcement Security Hotline: 1-800-342-0820

FBI:
Jacksonville: (904) 248-7000
Miami: (305) 944-9101
Tampa: (813) 253-1000

Disposal of Pesticide Wastes

Proper pesticide waste disposal is an important part of responsible pesticide use. Improper disposal can lead to contamination of soil and ground and surface water, causing serious liability problems for the pesticide user, as well as a poor public image. There are five types of pesticide wastes:

- Empty containers
- Excess mixture
- Excess waste products
- Rinse water from containers and application equipment
- Material generated from cleanup of spills and leaks

Several of these waste types were addressed in chapter V. This chapter will address excess waste products and empty containers.

Isolate Waste Products

Do not accumulate outdated or cancelled pesticide products. Make every effort to use up what you purchase because leftover pesticides may become hazardous waste. All of these materials could be subject to additional Federal regulations on the storage, disposal, and reporting of hazardous materials (see SARA Title III and RCRA). Outdated products - those whose shelf life has expired - may no longer be effective. Cancelled products often have a specified period beyond which they cannot be legally used. Use time-limited products according to the label directions before the expiration date to avoid generating hazardous wastes. Follow the status of products on the verge of cancellation, and use these products before the deadline.

Superfund Amendments and Reauthorization Act of 1986 (SARA Title III)

SARA Title III is a federal right-to-know law that affects those that produce or store hazardous chemicals. Pesticide producers, distributors, retailers, and some pesticide applicators are among those that must comply with this law. It is designed to inform communities regarding hazardous chemicals located in the vicinity and addresses the need for community emergency response plans in the event of an accident.

Title III has many sections; however, the areas that affect pesticide applicators, applicator businesses, or dealers are confined to:

- Emergency planning and notification: under certain conditions, the law requires notification of state and local officials about the location and amount of hazardous chemicals at a site. EPA has designed a Threshold Planning Quantity (TPQ) for a number of active ingredients, not the formulated product. When the product in storage is at or above the TPQ, the State Emergency Response Commission (SERC) must be notified in writing. Each facility is also required to designate a coordinator to work with the Local Emergency Planning Committee (LEPC). The state will

notify the LEPC that the operation is covered under SARA. This is a one-time notification.
- Emergency release reporting: describes the safety measures when an accidental release, such as a spill of any extremely hazardous substance, occurs. If all of the following conditions occur:
  – The pesticide was spilled;
  – Is covered under SARA Title III;
  – The spill quantity was greater than the Reportable Quantity (RQ);
  – The spill created off-site exposure.

If those conditions exist, then one is required to notify the SERC, LEPC, and the National Response Center (1-800-424-8802). If a pesticide is applied according to the label, the use is exempt from emergency release reporting.

- Safety Data Sheet (SDS) reporting: employers are required to obtain and keep safety data sheets. They must submit copies of each SDS, or a listing of SDSs that must be maintained, to their local fire department, the LEPC, and the SERC. There is one exclusion: if a chemical is used solely for household, consumer, or agricultural purposes, notification is not required.
- Annual inventory reporting: all regulated facilities must submit an annual inventory to their local fire department, LEPC, and SERC. The inventory must include:
  – All hazardous chemicals stored at the facility in quantities of 10,000 pounds or more, and
  – All extremely hazardous chemicals stored in quantities of 500 pounds, or 55 gallons, or more, or in a quantity that exceeds the TPQ, whichever is less.

Agricultural producers are exempt from this section.

Resource Conservation and Recovery Act of 1976 (RCRA)

The EPA regulates wastes under the RCRA. EPA issues a list of materials that are considered hazardous. Under RCRA:

- Private applicators (agricultural commodity producers) who properly dispose of pesticide wastes, excess pesticides, and triple-rinsed empty containers on their own property are in general exempt from the requirements of this law.
- "Wastes" include unrinsed containers, excess pesticides and pesticide dilutions, and rinse and wash water that contain a listed chemical and cannot be used.
- Those who accumulate wastes of acutely toxic pesticides totaling 2.2 pounds or more per month or wastes of any RCRA-regulated pesticides totaling 2,200 pounds per month are regulated. Such users must register as a generator of hazardous waste, obtain an identification number from EPA, state, or tribe and follow certain disposal requirements.

The EPA RCRA hotline can be contacted for determining if a pesticide is listed in RCRA: 1-800-424-9346.

If you are holding pesticides or pesticide containers for disposal or recycling, store them in a special section of the storage site (Figure 8.20). Be sure to follow label directions for disposal of any excess or leftover product. Accidental use of pesticides meant for disposal can be a costly mistake. Make sure all empty containers are triple-rinsed or pressure-rinsed before storing for disposal or recycling. Clearly mark properly rinsed containers. If possible, recycle or dispose these containers and pesticides through a program supported by the Ag Container Recycling Council (Figure 8.21).

Figure 8.20 Drum holding leftover pesticides.

Photo Florida Department of Environmental Protection

Figure 8.21 Leftover pesticide collection event – Jefferson County.

Cleaning and Disposing of Pesticide Containers

There are two types of pesticide containers: rinsable and non-rinsable. Rinse empty rinsable plastic containers immediately because the residues can dry quickly and become difficult to remove. When rinsing, add the rinsate to the spray tank as part of the pesticide mixing process. Triple-rinsing or pressure-rinsing empty pesticide containers allows them to be disposed of as non-hazardous waste. Clearly mark and puncture rinsed containers and safely store them for later recycling or disposal.

Non-rinsable containers include bags and boxes of dry pesticides and aerosol cans and cylinders. Empty them as completely as possible. Some containers are designed to be returned to the pesticide dealer or manufacturer for refilling.

If empty pesticide containers cannot be refilled, reconditioned, recycled, or returned to the manufacturer, crush, break, or puncture them to make them unusable – except in the case of aerosol cans. Do not leave pesticide containers unattended at the mixing, loading, or application site - return them to a secured storage area until they can be recycled or disposed of properly. Dispose of containers in accordance with label directions and with federal, state, and local laws and regulations. Do not reuse pesticide containers or tamper with containers designed to be returned and refilled.

Container Rinsing Procedures

To triple-rinse a container, wear protective clothing and follow these steps:

1. Allow the concentrate to drain from the empty pesticide container for 30 seconds.
2. Fill approximately 20 percent of the container volume with water, replace the lid, and shake the container so all the interior surfaces are rinsed.
3. Drain the rinse water into the spray tank, allowing it to drain for at least 30 seconds.
4. Repeat the procedure two more times.

Pressure-rinsing is an effective way to make a pesticide container non-hazardous. Pressure-rinsing requires the use of a special nozzle that directs water under high pressure into the container (Figure 8.22). Check with your chemical dealer for availability of these nozzles. Studies have indicated that pressure-rinsing is as effective as triple-rinsing and it can take less time. Puncturing the container with the rinse nozzle also renders the container unusable.

Figure 8.22 Pressure-rinse nozzles.

To pressure rinse a container (Figure 8.23), wear protective clothing, especially gloves and protective eyewear, and follow these steps:

1. Allow the concentrate to drain from the empty pesticide container for 30 seconds.
2. While holding the container over the spray tank in a draining position, push the pointed pressure-rinse nozzle through the side of the pesticide container.
3. Pressure-rinse the container for at least 30 seconds, draining the rinse water directly into the spray tank.
4. Thoroughly rinse the container cap with a slower flow of water, capturing the rinse water in the spray tank.

Figure 8.23 Pressure-rinsing a container.

Conclusion

It is essential that good safety and security practices be in place for pesticides in transit and in storage. Spills and accidents are more likely to occur while transporting pesticides. The

transport vehicle must be in good mechanical condition, and the owner/operator of the vehicle must be trained in emergency and spill response procedures. It is also important to have the pesticide label and SDS for each pesticide being carried in the vehicle to assist the driver or emergency personnel should a pesticide release occur.

Design and maintain pesticide storage sites to prevent unauthorized access and damage to pesticide containers. Keeping pesticides in a cool, dry, well-ventilated room with adequate lighting protects pesticide containers and their contents from damage. Lock the storage area and post it with highly visible signs to warn others that pesticides are stored inside. Store pesticides in their original containers and out of direct sunlight. Make sure labels can be read easily. If damage to pesticide containers occurs, take appropriate steps to prevent the pesticide from leaking into surrounding areas and clean up any spill carefully. Keep an inventory of all pesticides in storage, and note if the product has an effective shelf life on its label to minimize storage and disposal problems. Follow label directions for disposing of any excess or leftover pesticide products.

Attention to pesticide site security has been on the increase. Develop security management plans for every pesticide storage facility to safeguard employees and the community. Design security plans to reduce the risk of theft, vandalism, and the deliberate misuse of pesticides to harm others or the environment. Pesticide-related businesses must train their employees in appropriate security and emergency response procedures and coordinate their effort with local police, emergency response personnel, and the FBI.

Do not accumulate outdated or cancelled pesticide products. Make every effort to use up what you purchase because leftover pesticides may become hazardous waste. Pressure- or triple-rinse rinsable containers prior to disposal, preferably disposing them through an approved recycling program. Some containers are designed to be returned to the pesticide dealer or manufacturer for refilling. Empty non-rinsable containers, such as bags and cylinders, as completely as possible.

Test Your Knowledge

Q: Which statement about transporting pesticides is true?
A. Carry hazardous pesticides in the passenger compartment of a vehicle to prevent unauthorized access.
B. Enclosed cargo boxes offer the greatest protection but are not always practical.
C. Operators of vehicles that transport hazardous materials are not required to have any special training, only a commercial driver's license.
D. The operator is not held responsible if a pesticide spill or accident occurs because the vehicle was left unattended.
A: B

Q: Which statement about pesticide storage facilities is true?
A. If pesticides are stored in a small, locked cabinet or closet, it is not necessary to post warning signs.
B. Carefully consider soil and land surface characteristics when selecting a storage site to prevent potential contamination of water sources.
C. Store pesticides in a warm, airtight environment.
D. The floor of the pesticide storage site should consist of materials such as carpeting or wood.
A: B

Q: What is the first thing you should do if you notice a damaged pesticide container?
A. Put on appropriate personal protective equipment.
B. Transfer the contents into another sturdy container that can be tightly closed.
C. Use the pesticide immediately at a site and at a rate allowed by the label.
D. Clean up any spilled chemical.
A: A

Q: Which practice for minimizing storage problems is not recommended?

A. Buy large quantities of pesticides to reduce costs and ensure that the chemicals you use are available when you need them.
B. Keep records of previous usage to make good estimates of future needs.
C. Mark each pesticide container with the purchase date, and keep an inventory of all pesticides in storage.
D. Be sure to note if the product has an effective shelf life listed on the label.

A: A

Q: What is the proper thing to do with empty rinsable pesticide containers?

A. Burn them.
B. Use them to store food and drink.
C. Bury them behind the mix/load area.
D. Triple- or pressure-rinse, puncture, and mark for recycling or disposal.

A: D

Chapter IX

Pesticide Application Procedures

Chapter IX

TABLE *of* CONTENTS

Learning Objectives

After you complete your study of this chapter, you should be able to:

- Know how to select the application procedure, equipment, and pesticide formulation appropriate to the situation.
- Know how to use appropriate safety systems.
- Understand the factors that affect calibration.
- Understand the importance of calibrating application equipment.
- Know how to determine the pesticide application rate.
- Know how to determine the amount of pesticide concentrate and diluent to use.

Terms to Know

Calibration: The process of measuring and adjusting the amount of pesticide that a piece of equipment delivers to a specific area.

Introduction

Today's pest management practices require modern equipment to apply a variety of pesticides. Pesticides may be applied as sprays, dusts, granules, gases (vapors), fogs, baits, rubs, or dips. The vast array of equipment on the market must be matched to the pesticide as well as to the size and type of the job to be done. To make an effective, safe, and efficient application, read the label first. In addition, the equipment must be properly selected, operated, calibrated, and maintained.

Application Methods

The pesticide application method you choose depends on the nature and habits of the target pest, the characteristics of the target site, the properties of the pesticide, the suitability of the application equipment, and the cost and efficiency of alternative methods. Your choice is often predetermined by one or more of these factors. Following are some common application methods:

- **Band** application involves applying a pesticide in parallel strips or bands such as between rows of crops rather than uniformly over the entire field.
- **Basal** application directs herbicides to the lower portions of brush or small trees to control vegetation (Figure 9.1).

Figure 9.1 Basal application.

- **Broadcast application** is the uniform application of a pesticide to an entire area or field.
- **Crack and crevice application** is the placement of small amounts of pesticide into cracks and crevices in buildings, such as along baseboards and in cabinets, where insects or other pests commonly hide or enter a structure.
- **Directed-spray application** specifically targets the pests to minimize pesticide contact with non-target plants and animals.
- **Foliar application** directs pesticide to the leafy portions of a plant.
- **Rope-wick or wiper treatments** release pesticides onto a device that is wiped onto weeds taller than the crop, or wiped selectively onto individual weeds in an ornamental planting bed.
- **Soil application** places pesticide directly on or in the soil rather than on a growing plant.
- **Soil incorporation** is the use of tillage, rainfall, or irrigation equipment to move the pesticide into the soil.
- **Soil injection** is the application of a pesticide under pressure beneath the soil surface (Figure 9.2).

Space treatment is the application of a pesticide in an enclosed area.

Spot treatment is the application of a pesticide to small, distinct areas.

Tree injection is the application of pesticides under the bark of trees. Similar methods are "hack and squirt," which requires the use of a small ax, machete, or hatchet to cut through the thick bark and into the sapwood, and cut stump, which the applicator places herbicide directly to a freshly cut tree stump (Figures 9.3 and 9.4).

Photo James H. Miller, USDA Forest Service, www.forestryimages.org

Figure 9.2 Soil injection.

Photo James H. Miller, USDA Forest Service, www.forestryimages.org

Figure 9.3 Hack and squirt application.

Photo James H. Miller, USDA Forest Service, www.forestryimages.org

Figure 9.4 Cut stump application.

Safety Systems

Closed systems for working with pesticides are excellent safety investments for pesticide handlers who handle large quantities of pesticides or who handle pesticides that are very hazardous to humans or to the environment.

Closed Mixing and Loading Systems

Closed mixing and loading systems are designed to prevent pesticides from coming in contact with handlers or other people during mixing and loading. Label instructions for some pesticides, usually products with a high risk of causing human health effects, may require the use of a closed mixing and loading system under certain circumstances.

There are two primary types of closed mixing and loading systems. One type uses mechanical devices to deliver the pesticide from the container to the equipment. The other type uses water-soluble packaging.

Mechanical systems typically consist of a series of interconnected equipment parts that allow for the safe removal of a pesticide from its original container (Figure 9.5). These systems minimize exposure when rinsing the empty container and also when transferring to the application equipment wash water that contains pesticide residues.

Closed systems for mixing and loading are often custom-made with components from several commercial sources. Because the openings of pesticide containers vary in size and shape, no single closed system can be used with all containers. Closed systems are available for containers as small as 2.5

gallons. Mechanical systems are available to remove the pesticide concentrate from the original container, either by gravity or by suction.

Figure 9.5 Closed mixing and loading system.

Some closed systems are available commercially for safe loading of chemicals into spray tanks (Figure 9.6). In such systems, all materials are mixed at ground level, thereby eliminating the need for operators to climb on and around machines while handling chemicals. As a result, operator exposure to slips, trips, and falls is reduced. The potential for chemical spill is also reduced, and potential for exposure of operator and environment to the pesticide is minimized.

Figure 9.6 Commercial loading system for delivering pesticide to the spray tank.

A mechanical loading system is often used with mini-bulk containers. Mini-bulk containers range in volume from 40 - 600 gallons and are adapted to closed systems. The applicator can use the closed system to attach the mini-bulk tanks to the sprayer without exposure to the chemical. Typically, pump-and-drive units deliver the product, and a meter allows accurate measuring from the mini-bulk tank to the sprayer. These meters require frequent calibration to be accurate. Mini-bulks must be returned to the dealer for refilling. This process eliminates the need to triple-rinse or pressure-rinse multiple small containers. This process also includes an environmental safety benefit: it reduces the volume of used plastic containers, which must be properly disposed. If not disposed properly, the used containers can place liability on the handler for environmental hazard.

Water-soluble bags are a simple type of closed mixing and loading system. The premeasured pesticide is contained inside a water-soluble bag or package. This pesticide bag is placed unopened into the mixing tank and dissolves in water or liquid fertilizer. Few manufacturers, however, provide water-soluble bags for small-volume applications.

Enclosed Cabs

An enclosed cab, such as a tractor cab (Figure 9.7), cockpit, or truck/vehicle cab, surrounds the occupant(s) and may prevent operator exposure to the pesticides being applied as long as any doors, hatches, or windows are kept closed at all times during the application. Enclosed cabs are considered a supplement to personal protective equipment, as required by the federal Occupational Safety and Health Administration (OSHA). Enclosed cabs are not a replacement for PPE.

Figure 9.7 Enclosed tractor cab.

While working inside the enclosed cab, operators should wear all PPE specified on the pesticide label and keep in mind that outside surfaces of the application equipment and cab are contaminated. Operators should be especially careful to

wear appropriate PPE when getting in and out of the cab and conducting maintenance.

Pesticide Containment Systems

If you often use the same location to mix and load pesticides or clean equipment, a pesticide-containment pad may be necessary. These pads are designed to contain spills, leaks, overflows, and wastewater, whether for reuse by the applicator or for disposal by a commercial waste-management contractor (Figure 9.8).

Figure 9.8 Containment pad and tank for holding wastewater.

If the spray tank contains pesticides, keep the tank on the pad. These pads make spills easier to clean up. The pads may also reduce pesticide waste by allowing the rinse water to be reused. The pads also help prevent environmental contamination.

Where large quantities of pesticides are handled or stored and where large equipment exposed to pesticide is cleaned, use a permanently installed containment pad for mixing, loading, and equipment cleaning. The containment pad must be made of an impermeable material, such as sealed concrete, glazed ceramic tile, welded steel, synthetic liners, or no-wax sheeting. Construct a concave pad or one having curbs, berms, or walls high enough to hold the largest amount of spill, leak, or equipment wash water likely to occur at the site (Figure 9.9). The permanent containment pad also must be equipped with a system for removing and recovering spilled, leaked, or otherwise released material by either an automatic pump system or a manually operated pump. Smaller, portable pads and lightweight trays made of heavy duty plastic may be used when mixing and loading at the application site.

Figure 9.9 Mixing area with a concave containment pad.

Application Equipment

The application equipment or device must apply the pesticide to the intended target at the proper rate. Information on the label specifies the legal application rate and sometimes suggests the appropriate equipment for use with the product. The application equipment can range from an aerosol can to hand equipment to power equipment, including aircraft. The equipment may be carried, towed, or self-propelled.

Sprayers

The most common type of pesticide application equipment is the sprayer – nearly 90 percent of all pesticides are formulated for spraying. A hydraulic (liquid) sprayer uses water or some other liquid carrier for the pesticide. However, in the case of ultra-low volume (ULV) spraying, the pesticide is applied directly as formulated. Hydraulic sprayers range from large agricultural sprayers with multiple-nozzle spray booms and power sprayers to small manual backpack and handheld compressed-air sprayers (Figures 9.10 and 9.11). In all cases, pressure from either a pump or compressed gas or air is used to atomize the spray mix at the nozzle.

Manual sprayers are designed for spot treatments and for areas unsuitable for larger units. They are relatively inexpensive, simple to operate, maneuverable, and easy to clean and store. Adjustable spray guns are commonly used with these units, but spray booms are available on some models.

The air-blast (or mist) sprayer uses both water and air as carriers (Figure 9.12). The pesticide is diluted with water (except in ULV spraying). Spray droplets are formed by the

nozzles and delivered to the target by an air stream. Air-blast sprayers are typically used for disease and insect control on fruit trees, vineyards, vegetables, and Christmas trees.

Figure 9.10 Hand-held compressed-air sprayer.

Figure 9.11 Shielded boom sprayer for golf course greens.

Figure 9.12 Air-blast sprayer.

Sprayer Components

Because sprayers use water or other liquids to dilute and carry a pesticide, a tank is necessary to contain the spray mix (Figure 9.13). Use a tank large enough to eliminate frequent refills but not so large that the weight of the full tank becomes a problem. Choose a tank made of or coated with a material that does not corrode and can be easily cleaned. Corrosion and dirt clog screens and nozzles and increase wear on the equipment. Large tanks require an opening in the bottom to aid in the cleaning and draining. A large top opening is useful for filling, cleaning, and inspecting the tank. The opening must have a watertight cover to prevent spillage. A tank agitator is useful for most sprayable formulations but especially for wettable powders or dry flowables. Constant mixing of a pesticide and liquid carrier produces a uniform spray mixture (suspension or solution) resulting in an even application of the chemical.

Figure 9.13 Tank for holding liquid pesticide mixtures.

Sprayers require a pump to supply the needed pressure and volume to the nozzles and agitator (Figure 9.14). The pump parts must be corrosion- and abrasion-resistant, especially when wettable powders or other abrasive formulations are used. Never operate a sprayer pump at speeds or pressures above those recommended by the manufacturer. Some pumps can be damaged if they are operated dry or with a restricted flow at the inlet or outlet. Pumps depend on the spray liquid for lubrication and to prevent overheating.

Nozzles are a very important part of a sprayer (Figure 9.15). They control the amount of material applied, the formation of the droplets and their size, and the distribution and pattern of the droplets. A nozzle's spray pattern is made up of a wide variety of spray droplet sizes, from very fine to extra coarse. Nozzles are classified on the basis of the spray pattern and the droplet size they produce. The size of the nozzle opening (orifice) affects the droplet size and flow rate. A nozzle that primarily produces coarse droplets is usually selected to

minimize off-target drift. A nozzle that mainly produces fine droplets is required to obtain maximum surface coverage of the target. Base nozzle selection on the target pest, type of application, coverage desired, and potential for drift.

Nozzles are available in various materials including brass, aluminum, plastic, stainless steel, hardened stainless steel, and ceramic. Select the nozzle material appropriate for the pesticide formulation. Never use brass or aluminum tips to apply abrasive materials such as wettable powders and dry flowables, because they wear too fast. Wear destroys the proper working of a nozzle, so replace worn nozzles. To reduce wear, use nozzle tips made of a hard, wear-resistant material such as hardened stainless steel or ceramic. Nozzles made of these materials are more expensive but last longer. Also, be sure you have the correct nozzle screen size for each nozzle.

Figure 9.14 Pumps supply the pressure for liquid pesticide sprays.

Figure 9.15 Nozzles break up the pesticide mixture into droplets during the application.

Granular Applicators

Granular applicators are available for either band or broadcast application. They may be operated as separate units but are often attached to other equipment such as planters or cultivating equipment to combine two or more operations. They usually operate by gravity feed and have an adjustable opening to regulate the flow.

Band applicators use hoses or tubes with deflectors on the bottom. Broadcast applicators use a system of tubes and deflectors or a spinner to spread the granules. The application rate is affected by the ground speed; granule size, shape, and density; field terrain; and even relative humidity and air temperature. When multiple band applicators are used, each individual unit must be calibrated with the specific material to be applied to ensure accurate application.

Rotary and drop spreaders are two common types of granular applicators. Rotary spreaders distribute the granules to the front and sides of the spreader, usually by means of a spinning disk or fan (Figure 9.16). In a drop spreader, an adjustable sliding gate opens holes in the bottom of the hopper and the granules flow out by gravity feed (Figure 9.17). Drop spreaders are preferred over rotary spreaders when more precise placement of the pesticide is desired.

Figure 9.16 Rotary applicator.

Figure 9.17 Drop spreader.

Other Application Equipment

Additional types of application equipment include:

- Rubs, walk-through sprayers, and dipping vats for controlling pests on animals
- Bait dispensers for control of rodents, insects, and predators
- Foggers for indoor pest control and for some insect control outdoors
- Chemigation systems for greenhouses, groves, and field crops
- Dusters for small-scale disease and insect control

Equipment Calibration

Calibration is the process of measuring and adjusting the amount of pesticide your equipment applies or delivers to a specific area (Figure 9.18). The purpose of calibration is to ensure your equipment is applying the correct amount of material uniformly over a given area.

Equipment is manufactured to be adjustable. Charts or tables may be provided to assist the operator in making adjustments to the settings. These recommended settings, however, are only approximate and may not be appropriate for all situations. Therefore, your equipment must be calibrated periodically. This depends on the type of equipment and the frequency of use. The application rate of the sprayer is affected by:

- Travel speed
- Nozzle size
- Sprayer pressure
- Nozzle spacing on the boom or width of spray pattern

Figure 9.18 Calibrating a backpack sprayer.

Equipment is calibrated by making a trial run on some premeasured area and measuring the output. For example, using a hand-held sprayer, spray a premeasured test area with water using the same pressure and techniques, including travel speed and equipment you would use when applying the pesticide (Figure 9.19). After spraying the test area, determine how much water was used (Figure 9.20). This volume can then be used to calculate the amount of water and pesticide needed to cover the intended application area.

Figure 9.19 Spraying a premeasured test area.

The time invested in calibrating your equipment is time well spent. Once you have calibrated your equipment, do not assume that it will continue to deliver the same rate during all future applications. Clogging, corrosion, and wear may change the delivery rate, or the settings may gradually get out of adjustment. Accurate calibration to determine the application rate under your operating conditions is important for cost, efficiency, and safety.

More detailed information on calibration and the associated calculations is provided in category study manuals. The

information presented in those manuals is relevant to the type of work and the associated equipment that is specific for the category.

Figure 9.20 Measuring output from a sprayer.

Conclusion

To choose the appropriate pesticide application method, pesticide users must be aware of the nature of the target sites, pests, and available pesticides. Pesticide users must also be able to evaluate the cost and availability of both pesticide and non-pesticide control methods. This information can help in deciding which type of pesticide application procedure, if any, provides practical and efficient control.

Pesticide users must wear all safety equipment specified on the label during mixing, loading, application, and cleanup. The use of other safety systems also helps prevent pesticide exposures, spills, and environmental contamination. These include closed mixing and loading systems (mechanical systems and water-soluble packaging), enclosed cabs, and pesticide containment systems (containment pads).

Choosing the right application equipment is also an important factor in managing pests successfully. The equipment must be able to deliver the correct amount of pesticide to the intended target. A wide variety of pesticide application equipment is available, each suitable to a particular pest control situation. For example, on a small scale, an aerosol can may be used to control household pests, while aircraft may be used to control mosquitoes over a broad geographic area.

The most common type of application equipment used in pest management is the hydraulic sprayer. These range from small handheld or backpack sprayers to large power sprayers.

Calibrate application equipment to ensure the correct amount of pesticide is being applied. Before making an application, be sure your equipment is properly calibrated and that you know how to use the label information to calculate the correct amount of pesticide.

Test Your Knowledge

Q: Which type of pesticide application procedure involves the uniform application of a pesticide to an entire area or field?
A. Broadcast application
B. Band application
C. Directed-spray application
D. Basal application

A: AWhich type of pesticide application would you use to control cockroaches inside of buildings?
A. Broadcast application
B. Band application
C. Crack and crevice application
D. Basal application

A: C

Q: True or False: An enclosed cab always provides enough protection from pesticide exposure to allow applicators to use less PPE than recommended on the label.
A. True
B. False

A: B

Q: Which statement about containment pads is true?
A. They should not be used if you mix and load frequently at the same site.
B. Pads make spill cleanup more difficult.
C. Pads should be made of permeable materials.
D. Pads should be used where large quantities of pesticides are handled or mixed.

A: D

Q: Which nozzle tips would be a poor choice for spraying abrasive materials, such as wettable powders?
A. Brass
B. Ceramic
C. Stainless steel
D. Hardened stainless steel

A: A

Q: Which statement about granular applicators is true?
A. They do not require calibration.
B. Ground speed has no effect on the application rate.
C. Rotary spreaders throw lighter granules farther than heavy ones.
D. Drop spreaders are preferred over rotary spreaders when more precise placement of the pesticide is desired.
A: D

Q: The process of measuring and adjusting the amount of pesticide your equipment applies or delivers to a specific area is known as:
A. Application coefficient
B. Calibration
C. Equipment performance ratio
D. Standard of operation
A: B

Appendixes

Appendixes

Appendix A. Managing Heat Stress

Table A1. A basic program for controlling heat stress.[1]

Step	Management tactic
1	**Assign a manager for heat stress problems.**
2	**Train workers and supervisors.** • Train workers and supervisors in the control of heat stress and the recognition, prevention, and treatment of heat illnesses. • Conduct safety meetings during heat spells.
3	**Acclimatize workers when they begin to work under hot conditions.** • Assign a lighter workload for 5 – 7 days. • Allow longer rest periods for 5 – 7 days. • Assign work in the heat for at least 100 minutes each day. • Watch workers' response to working in the heat closely for 5 – 7 days.
4	**Account for the conditions of work and of the workers.** • Check weather conditions. • Consider how heavy the work is. • Consider whether the worker is to wear protective garments and equipment. • Check if the worker is or has recently been sick or has had a sharp loss in weight. • Check whether the worker is rested, is taking any medications, or appears to have consumed alcohol that day.
5	**Manage work activities.** • Set up rest breaks. • Rotate tasks among workers. • Schedule heavy work for cooler hours. • Postpone non-essential tasks during heat spells. • Monitor environmental conditions and workers.
6	**Establish a drinking water program.**
7	**Take additional measures, as appropriate.** • Provide special cooling garments. • Select lightest weight or "breathable" protective garments and cooler respirators that give adequate protection. • Provide shade. • Use air-conditioned mobile equipment. • Modify pesticide usage and handling to reduce need for protective garments and equipment.
8	**Give first aid when workers become ill.** • Set up a first aid program. • Take heat stroke victims to the nearest medical facility. • Follow up on incidents of heat illness.

[1]Adapted from EPA Publication HW77, A Guide to Heat Stress In Agriculture, 1994.

Table A2. Approximate workload levels.[1]

Workload level	Work activity
Light	Sitting at ease
	Writing, typing
	Sorting light materials
	Inspecting crops
	Driving mobile equipment on paved roads
	Piloting spray aircraft
Moderate	Using a chain saw
	Off-road operation of mobile equipment
	Periodic handling of moderately heavy materials
	Weeding/hoeing
	Picking fruits or vegetables
	Air blast and boom spraying
	Backpack spraying on level, even ground
	Pushing or pulling light-weight carts or wheelbarrows
	Washing vehicles or aircraft
	Walking 2-3 mph
Heavy	Transferring heavy materials
	Shoveling
	Digging
	Hand mowing
	Loading sacks
	Stacking hay
	Planting seedlings
	Hand-sawing wood
	Pushing or pulling loaded hand carts or wheelbarrows
	Moving irrigation pipe
	Laying cinder blocks
	Backpack spraying on rough ground or on an incline
	Walking 4 mph

[1]Adapted from EPA Publication HW77, A Guide to Heat Stress In Agriculture, 1994.

Table A3 Directions: Account for weather conditions by adjusting the temperature reading as follows before going to the temperature column in the table:

- If there is full sun (no clouds): add 13 degrees.
- If the sky is partly cloudy/overcast: add 7 degrees.
- If no shadows are visible or work is in the shade or at night: no adjustment.

For relative humidity of:

- 10 percent: subtract 8 degrees.
- 20 percent: subtract 4 degrees.
- 30 percent: no adjustment.
- 40 percent: add 3 degrees.
- 50 percent: add 6 degrees.
- 60 percent: add 9 degrees.

Example 1: if the temperature is 91 degrees F, it is dusk, the relative humidity is 40 percent, and heavy work is to be done, such as moving heavy materials with a wheelbarrow:

Start with 91 degrees and add 3 degrees because the humidity is 40 percent (91 + 3 = 94). Go to 94 degrees in the table.

Under these conditions, it would be reasonable to follow a normal work schedule.

Example 2: if the air temperature is 85 degrees, it is midday with no clouds in the sky, the relative humidity is 50 percent, and heavy work is to be done, such as unloading a wagon of hay:

Start with 85 degrees, add 13 degrees for the additional heating effect of the sun, and add another 6 degrees because the humidity is 50 percent (85 + 13 + 6 = 104). Go to 104 degreees in the table.

Under these conditions, it might be necessary to work approximately 20 minutes and rest 40 minutes during the course of each hour that this task is done. It would be better, if circumstances permit, to shift this task to a time when it is cooler or the sun is not so strong, in order to reduce heat stress and avoid the need for longer rest periods.

Table A3. Approach for setting work/rest periods and amount of drinking water for workers wearing normal work clothing.[1]

Air temperature (°F)	Light work	Moderate work	Heavy work	Minimum water to drink†
90	Normal	Normal	Normal	½ pint every 30 minutes
91				
92				
93				
94				
95			45/15‡	
96				
97			40/20	
98			35/25	
99				
100		45/15‡	30/30	
101		40/20		
102		35/25	25/35	
103		30/30	20/40	½ pint every 15 minutes
104				
105		25/35	15/45	
106	45/15‡	20/40	Caution‡‡	
107	40/20	15/45		½ pint every 10 minutes
108	35/25	Caution‡‡		
109	30/30			
110	15/45			
111	Caution‡‡			
112				

[1]This table is based on the American Conference of Governmental Industrial Hygienists limits for heat-acclimatized adults.

Assumptions:

- Physically fit, well-rested, and fully hydrated workers under the age of 40.
- Adequate water intake.
- 30 percent relative humidity.
- Natural ventilation with very slight air movement.
- Air temperatures taken in the shade, no sunshine, or no shadows visible.

†Varies from person to person and increases with heavier work and hotter conditions. Continue water consumption after work to replace all lost body fluids.

‡45/15 minutes = 45 minutes work and 15 minutes rest each hour.

‡‡Indicates very high levels of heat stress.

Table A4 Directions:

- Read through Table A3 directions.
- Go to Table A4, find the current air temperature, and read across the column matching the workload and the amount of sunlight. Remember that these work/rest times are only part of an overall approach and that individual requirements will vary greatly.

Table A4. Approach for setting work/rest periods and amount of drinking water for workers wearing chemical-resistant suits.[1]

Air temperature (°F)	Light work			Moderate work			Heavy work			Minimum water to drink[1*]
	Full sun	Partly cloudy	No sun[†]	Full sun	Partly cloudy	No sun[†]	Full sun	Partly cloudy	No sun[†]	
75	Normal schedule	Normal schedule	Normal schedule	Normal schedule	Normal schedule	Normal schedule	35/25[‡]	Normal schedule	Normal schedule	½ pint every 30 minutes
80	30/30			20/40			10/50	40/20		1 to 1 ½ pints every 30 minutes
85	15/45	40/20		10/50	25/35		Caution[**]	15/45	40/20	1 pint or more every 15 minutes
90	Caution[**]	15/45	40/20	Caution[**]	Caution[**]	25/35	Stop work	Caution[**]	15/45	
95	Stop work	Stop work	15/45	Stop work	Stop work	Stop work	Stop work	Stop work	Stop work	

Source: Ralph F. Goldman, *Internal Report: Heat Stress Management Protocol*, Office of Research and Development, US EPA, Nov. 1989.

[1]This table is based on values for heat-acclimatized adult workers under the age of 40 who are physically fit, well-rested, and fully hydrated; with the assumptions of tyvek coveralls, gloves, boots, and a respirator being worn; adequate water intake; and air temperatures readings taken in the shade. Cooling vests may enable workers to work for longer periods. Adjustments must be made when additional protective gear is worn.

[*]Varies from person to person and increases with heavier work and hotter conditions. At higher temperatures, there are limits to how long heavier work and consumption of large amounts of water can be kept up; continue water consumption after work to replace all lost body fluids.

[†]No shadows are visible or work is in the shade or at night.

[‡]35/25 = 35 minutes work and 25 minutes rest each hour.

[**]Indicates very high levels of heat stress.

Appendix B. Developing a Facility Emergency Contingency Plan

Table B1. Facility information.

Name of Facility		
Telephone (main)	Telephone (24 hour)	Fax
Geographical Site Address Street/Road/Highway		
County	Latitude	Longitude
Global Positioning System Coordinates		
Mailing Address		
Street or P.O. Box		
City	State	Zip
Management Personnel		
Name		
Title		
Telephone (Work) (Cell phone)	(Home) (Pager)	
Street or P.O. Box		
City	State	Zip

Table B2. County map.

Geographic location of facility = X
Yellow highlight over black line ----- = most common route of access
Blue line ----- = alternate traffic route
Red line ----- = route for transporting hazardous materials
↕ Show north (N), south (S) arrow
Verbal directions for most common and alternate routes of access (during an emergency, it may become difficult to think clearly. These directions to the facility can be read easily when calling for assistance. Most common route: Alternate route:

Table B3. Facility site map.

Code	Building, storage tanks, hazardous materials, structures, vehicles, propane tanks, fire extinguishers, other facility items of importance
A	
B	
C	
D	
E	
F	
G	
H	

↕ Show north (N), south (S) arrow

Table B4. Evacuation map.

Building or other structure:
Site map code from site map:
Utilities are marked with a red star (*).
Evacuation routes = ----- Exits = →
First choice rendezvous point = ♦
Second choice rendezvous point = ●
↕ Show north (N), south (S) arrow

Table B5. Chemical inventory (pesticides).

Company name:	Date of original inventory:
Geographical address:	Dates of revision:

NOTE: The amount of each pesticide in inventory may fluctuate throughout the year, but the maximum amount of each pesticide stored will not exceed the maximum stated here. The storage location for each pesticide is identical in wording to the corresponding location on the site map (Appendix B, Table B3).

A checked box ✓ indicates a chemical reported under Community Right-to-Know.

Pesticide trade name	**CAS number**	**Storage location (building name and code)**	**Maximum amount stored**	**Month(s) of highest inventory**	**Size of container**

CHEMTREC (Chemical Transportation Emergency Center): 800 262-8200
Florida Poison Control Center: 800 222-1222
Florida Department of Environmental Protection: 850 245-2118
Florida Department of Agriculture and Consumer Services: 850 488-3022

Table B6. Chemical inventory (fertilizers).

Company name:	Date of original inventory:
Geographical address:	Dates of revision:

NOTE: The amount of each fertilizer in inventory may fluctuate throughout the year, but the maximum amount of each fertilizer stored will not exceed the maximum stated here. The storage location for each fertilizer is identical in wording to the corresponding location on the site map (Appendix B, Table B3).

A checked box ✓ indicates a chemical reported under Community Right-to-Know.

Fertilizer trade name	CAS number	Storage location (building name and code)	Maximum amount stored	Month(s) of highest inventory	Size of container

CHEMTREC (Chemical Transportation Emergency Center): 800 262-8200
Florida Poison Control Center: 800 222-1222
Florida Department of Environmental Protection: 850 245-2118
Florida Department of Agriculture and Consumer Services: 850 488-3022

Table B7. Chemical inventory (fuels).

Company name:	Date of original inventory:
Geographical address:	Dates of revision:

NOTE: The amount of each fuel in inventory may fluctuate throughout the year, but the maximum amount of each fuel stored will not exceed the maximum stated here. The storage location for each fuel is identical in wording to the corresponding location on the site map (Appendix B, Table B3).

A checked box ✓ indicates a chemical reported under Community Right-to-Know.

Fuel	CAS number	Storage location (building name and code)	Maximum amount stored	Month(s) of highest inventory	Size of container

CHEMTREC (Chemical Transportation Emergency Center): 800 262-8200
Florida Poison Control Center: 800 222-1222
Florida Department of Environmental Protection: 850 245-2118
Florida Department of Agriculture and Consumer Services: 850 488-3022

Table B8. Fire emergency response information sheet.

Facility name: **Facility fire protection district:** **Fire department telephone:** **9ll coordinates for facility:**	
Owner/Manager: 2nd contact person: 3rd contact person:	Phone: Phone: Phone:
Electric power company: Account number:	Phone: Meter number:
Is there a disconnect between the meter base and the buildings? Y N	
Natural gas company: Account number:	Phone: Meter number:
Propane company: Account number: Phone: Location and size of propane tanks (marked on the facility site map):	
Other fuels and locations (marked on the facility site map):	
Fire mitigation Fire detection equipment inspection date: Fire extinguishers re-charge date: The following should have their locations marked on the facility site map: • Fire extinguishers • Self-contained breathing apparatus • Spare compressed breathing air tanks • Earth moving equipment • Portable water pumps • Street barriers • Sand bags	
Hazardous materials Are hazardous materials stored in the facility? Y N If yes, are their locations marked on the facility site map? Y N	
Location of evacuation routes marked? Y N	
CHEMTREC (Chemical Transportation Emergency Center): 800 262-8200 **Florida Poison Control Center: 800 222-1222** **Florida Department of Environmental Protection: 850 245-2118** **Florida Department of Agriculture and Consumer Services: 850 488-3022**	

Appendix C. Florida County Emergency Management Telephone Numbers

Table C1. County listing of Emergency Management telephone numbers.

County	Telephone
Alachua	352-264-6500
Baker	904-653-HELP
Bay	850-784-4000
Bradford	904-966-6336
Brevard	321-637-6670
Broward	954-831-3900
Calhoun	850-674-8075
Charlotte	941-833-4000
Citrus	352-746-6555
Clay	902-284-7703
Collier	239-252-3600
Columbia	386-758-1125
DeSoto	863-993-4831
Dixie	352-498-1240
Duval	904-630-2472
Escambia	850-471-6400
Flagler	386-313-4200
Franklin	850-653-8977
Gadsden	850-875-8688
Gilchrist	386-935-5400
Glades	863-946-6020
Gulf	850-229-9110
Hamilton	386-792-6647
Hardee	863-773-6373
Hendry	863-675-5255
Hernando	352-754-4083

County	Telephone
Highlands	863-385-1112
Hillsborough	813-236-3800
Holmes	850-547-1119
Indian River	772-567-2154
Jackson	850-482-9678
Jefferson	850-342-0211
Lafayette	386-294-1950
Lake	352-343-9420
Lee	239-533-3622
Leon	850-488-5921
Levy	352-486-5213
Liberty	850-643-2339
Madison	850-973-3698
Manatee	941-749-3500
Marion	352-732-8181
Martin	772-287-1652
Miami-Dade	305-468-5400
Monroe	305-289-6018
Nassau	904-548-4980
Okaloosa	850-651-7150
Okeechobee	863-763-3212
Orange	407-836-9140
Osceola	407-742-9000
Palm Beach	561-712-6400
Pasco	727-847-8137
Pinellas	727-464-3800

County	Telephone
Polk	863-534-5600
Putnam	386-329-0379
Santa Rosa	850-983-4610
Sarasota	941-861-5000
Seminole	407-665-5102
Seminole Tribe	954-965-4380
St. Johns	904-824-5550
St. Lucie	772-462-8100
Sumter	352-569-6000
Suwannee	386-364-3405
Taylor	850-838-3575
Union	386-496-2501
Volusia	386-258-4088
Wakulla	850-926-0800
Walton	850-892-8065
Washington	850-638-6203

Appendix D. Hazardous Wastes

Table D1. Common pesticides regulated as toxic hazardous wastes.

Common chemical name	**Trade name**
Amitrole	Weedazol, others
Cacodylic acid	Phytar, others
Chlorobenzilate	Acaraben
Chlordane	Chlordane, others
Diallate	Avadex
DBCP	Nemagon, others
1,2-D	DD, others
1,3-D	Telone,Vorlex
2,4-D	Weedone, others
DDT	DDT
Ethylene dibromide	EDB, Soilbrom, others
Lindane	Isotox, others
Maleic hydrazide	MH-30, others
Methyl bromide	Brom-o-gas, others
Methoxychlor	Marlate, others
Pronamide	Kerb
Thiram	Tersan, others
Warfarin (3 percent or less)	Coumadene, others
Zinc phosphide (10 percent or less)	ZP, others

Table D2. Common pesticides regulated as acutely toxic hazardous wastes

Common chemical name	**Trade name**
Aldrin	Aldrex, others
Aluminum phosphide	Phostoxin
Aminopyridine	Avitrol
Dimethoate	Cygon, others
Dinoseb	Dinitro, other
Disulfoton	Di-syston
Endosulfan	Thiodan
Endothall	Aquathol, others
Famphur	Warbex
Heptachlor	Gold Crest H60, others
Methomyl	Lannate, Nudrin
Methyl parathion	Metaphos, others
Parathion	Ethyl Parathion, others
Phorate	Thimet
Toxaphene	Toxakil, others
Warfarin (more than 0.3 percent)	Coumafene
Zinc phosphate (more than 10 percent)	ZP, others

Appendix E. Pesticide Storage Checklist

Date of Inspection:		
General Information	**Yes**	**No**
Clean, neat pesticide storage site		
Current, on-site pesticide inventory		
Posted emergency phone numbers		
Labels and SDS on file		
Accurate storage inspection log maintained		
Pesticide Containers	**Yes**	**No**
Containers marked with purchase date		
Insecticides, herbicides, and fungicides segregated		
Pesticides stored in original containers		
Labels legible and attached to containers		
Container caps tightly closed		
No reused pesticide containers present		
Pesticides stored off floor and low to ground		
Dry formulations stored on pallets		
Feeds stored separately from pesticides		
Used containers rinsed and punctured		
Rinsed and unrinsed containers separated		
Spills and Disposal	**Yes**	**No**
Storage area free of spills and leaks		
Shovel and absorbent materials		
Floor drains sealed (if present)		
Safety Information	**Yes**	**No**
No smoking signs posted		
Safety equipment separated from pesticides		
Fire extinguisher in good working order		
Storage room locked		
Storage room posted: *Pesticides. Keep Out.*		
Storage site well lit and ventilated		

Appendix F. University of Florida/IFAS Extension County Offices

Alachua County
2800 NE 39th Avenue
Gainesville, FL 32609
(352) 955-2402

Baker County
1025 W Macclenny Avenue
Macclenny, FL 32063
(904) 259-3520

Bay County
2728 East 14th Street
Panama City, FL 32401
(850) 784-6105

Bradford County
2266 N Temple Avenue
Starke, FL 32091
(904) 966-6224

Brevard County
3695 Lake Drive
Cocoa, FL 32926
(321) 633-1702

Broward County
3245 College Avenue
Davie, FL 33314
(954) 370-3725

Calhoun County
20816 Central Avenue E
Suite 1
Blountstown, FL 32424
(850) 674-8323

Charlotte County
2550 Harbor View Road
Suite 3
Port Charlotte, FL 33980
(941) 764-4340

Citrus County
3650 W Sovereign Path Suite 1
Lecanto, FL 34461
(352) 527-5700

Clay County
2463 State Road 16 W
PO Box 278
Green Cove Springs, FL 32043
(904) 284-6355

Collier County
14700 Immokalee Road
Naples, FL 34120
(239) 353-4244

Columbia County
971 W Duval St Ste 170
Lake City, FL 32055-3708
(386) 752-5384

DeSoto County
2150 NE Roan Avenue
Arcadia, FL 34266
(863) 993-4846

Dixie County
99 NE 121 Street
PO Box 640
Cross City, FL 32628
(352) 498-1237

Duval County
1010 N McDuff Avenue
Jacksonville, FL 32254
(904) 255-7450

Escambia County
3740 Stefani Road
Cantonment, FL 32533
(850) 475-5230

Flagler County
150 Sawgrass Road
Bunnell, FL 32110
(386) 437-7464

Franklin County
66 4th Street
Apalachicola, FL 32320
(850) 653-9337

Gadsden County
2140 W Jefferson Street
Quincy, FL 32351
(850) 875-7255

Gilchrist County
127 E Wade Street
PO Box 157
Trenton, FL 32693
(352) 463-3174

Glades County
900 US 27 W
PO Box 549
Moore Haven, FL 33471
(863) 946-0244

Gulf County
200 E 2nd Street
PO Box 250
Wewahitchka, FL 32465
(850) 639-3200

Hamilton County
1143 US Hwy 41 NW
Jasper, FL 32052
(386) 792-1276

Hardee County
507 Civic Center Drive
Wauchula, FL 33873
(863) 773-2164

Hendry County
1085 Pratt Blvd
PO Box 68
Labelle, FL 33975
(863) 674-4092

Hernando County
1653 Blaise Drive
Brooksville, FL 34601
(352) 754-4433

Highlands County
4509 W George Boulevard
Sebring, FL 33875-5837
(863) 402-6540

Hillsborough County
5339 County Road 579 S
Seffner, FL 33584
(813) 744-5519

Holmes County
1169 E Hwy 90
Bonifay, FL 32425
(850) 547-1108

Indian River County
1028 20th Place, Suite D
Vero Beach, FL 32960
(772) 770-5030

Jackson County
2741 Pennsylvania Avenue, Suite 3
Marianna, FL 32448
(850) 482-9620

Jefferson County
2729 W Washington Street
Monticello, FL 32344
(850) 342-0187

Lafayette County
176 SW Community Circle, Suite D
Mayo, FL 32066
(386) 294-1279

Lake County
1951 Woodlea Road
Tavares, FL 32778
(352) 343-4101

Lee County
3406 Palm Beach Boulevard
Ft. Myers, FL 33916
(239) 533-4327

Leon County
615 Paul Russell Road
Tallahassee, FL 32301
(850) 606-5200

Levy County
625 N Hathaway Ave Alt 27
PO Box 219
Bronson, FL 32621
(352) 486-5131

Liberty County
10405 NW Theo Jacobs Way
PO Box 369
Bristol, FL 32321
(850) 643-2229

Madison County
184 NW College Loop
Madison, FL 32340
(850) 973-4138

Manatee County
1303 17th Street W
Palmetto, FL 34221
(941) 722-4524

Marion County
2232 NE Jacksonville Road
Ocala, FL 34470
(352) 671-8400

Martin County
2614 SE Dixie Highway
Stuart, FL 34996
(772) 288-5654

Miami-Dade County
18710 SW 288 Street
Homestead, FL 33030-2309
(305) 248-3311

Monroe County
1100 Simonton Street
Room 2-260
Key West, FL 33040
(305) 292-4501

Nassau County
543350 US Highway 1
Callahan, FL 32011
(904) 879-1019

Okaloosa County
3098 Airport Rd
Crestview, FL 32539-7124
(850) 689-5850

Okeechobee County
458 Highway 98 North
Okeechobee, FL 34972
(863) 763-6469

Orange County
6021 S Conway Road
Orlando, FL 32812
(407) 254-9200

Osceola County
Osceola Heritage Park
1921 Kissimmee Valley Lane
Suite A
Kissimmee, FL 34744
(321) 697-3000

Palm Beach County
559 N Military Trail
West Palm Beach, FL 33415
(561) 233-1700

345 S Congress Avenue
Delray Beach, FL 33445
(561) 276-1230

2976 SR 15
Belle Glade, FL 33430
(561) 996-1655

Pasco County
36702 State Road 52
Dade City, FL 33525
(352) 518-0156

Pinellas County
12520 Ulmerton Road
Largo, FL 33774
(727) 582-2100

Polk County
1702 Highway 17-98 S
Bartow, FL 33830
(863) 519-8677

Putnam County
111 Yelvington Road, Suite 1
East Palatka, FL 32131
(386) 329-0318

St. Johns County
3125 Agriculture Center Drive
St. Augustine, FL 32092
(904) 209-0430

St. Lucie County
8400 Picos Road, Suite 101
Ft. Pierce, FL 34945
(772) 462-1660

Santa Rosa County
6263 Dogwood Drive
Milton, FL 32570
(850) 623-3868

Sarasota County
Twin Lakes Park
6700 Clark Road
Sarasota, FL 34241
(941) 861-9900

Seminole County
250 West County Home Road
Sanford, FL 32773
(407) 665-5551

Seminole Tribe
Brighton Indian Reservation
15465 Reservation Road
Okeechobee, FL 34974
(863) 763-5020 ext. 115

Sumter County
7620 State Road 471, Suite 2
Bushnell, FL 33513
(352) 793-2728

Suwannee County
1302 11th Street, SW
Live Oak, FL 32064
(386) 362-2771

Taylor County
203 Forest Park Drive
Perry, FL 32348-6340
(850) 838-3508

Union County
25 NE 1st Street
Lake Butler, FL 32054
(386) 496-2321

Volusia County
3100 E New York Avenue
DeLand, FL 32724
(386) 822-5778

Wakulla County
84 Cedar Avenue
Crawfordville, FL 32327
(850) 926-3931

Walton County
732 N 9th Street, Suite B
DeFuniak Springs, FL 32433
(850) 892-8172

Washington County
1424 Jackson Avenue, Suite A
Chipley, FL 32428
(850) 638-6180

UF | IFAS Extension
UNIVERSITY of FLORIDA

An Equal Opportunity Institution. UF/IFAS Extension Service, University of Florida, Institute of Food and Agricultural Sciences, Nick T. Place, dean for UF/IFAS Extension. Information on copies for purchase is available from IFAS Extension Bookstore, University of Florida, PO Box 110011, Gainesville, FL 32611-0011 (visit our website at: ifasbooks.ufl.edu). Information about alternate formats is available from IFAS Communications, University of Florida, PO Box 110810, Gainesville, FL 32611-0810. Published September 2010 as SM 1, UF/IFAS Extension. Revised September 2014.