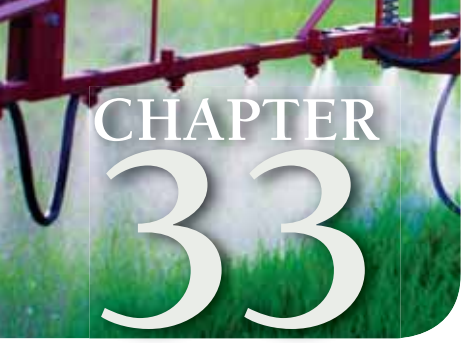

CHAPTER 33

Pesticide Management and Safety

Chapter Outcomes

After studying this chapter, you will be able to:

- List types and formulations of pesticides.
- Explain how to read a pesticide label.
- Describe methods of safe pesticide application.
- Identify pesticide toxicities, poisoning, and first-aid treatment for poisoned persons.
- Explain how to store and to dispose of a pesticide safely.
- List careers related to pesticide management and safety.

Words to Know

active ingredient
acute toxicity
agricultural pest
algaecide
biochemical pesticide
biopesticide
chronic toxicity
contact pesticide
EPA registration number
fungicide
insecticide
LC_{50}
LD_{50}
miticide
molluscicide
nematicide
pesticide formulation
restricted entry interval (REI)
rodenticide
signal word
systemic pesticide

Before You Read

Before you read the chapter, read all of the table and photo captions. What do you know about the material covered in this chapter just from reading the captions?




While studying this chapter, look for the activity icon to:

- **Practice** vocabulary terms with Words to Know activities.
- **Expand** learning with identification activities.
- **Reinforce** what you learn by completing Know and Understand questions.

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In general, a pest is something that is a nuisance. However, an ***agricultural pest*** is an insect, disease, weed, or animal that attacks a crop or food source and causes damage. Pests should be controlled using a strategic plan called integrated pest management (IPM). IPM is an approach to managing pests that uses commonsense, economical practices and results in the least possible hazard to people, property, and the environment.

Sometimes, when all other methods of IPM have been exhausted, pesticides (chemicals) are used to control pests that damage or attack plants, animals, and other organisms. Pesticides destroy pests that attack plants, animals, and other organisms, **Figure 33-1**. Before using a pesticide as part of the IPM program, the applicator must identify the pest being targeted and the best pesticide to use. The applicator should also know how to safely apply, store, and dispose of the pesticide in a manner that will ensure the safety of people, animals, plants, and the environment.

Ron Rowan Photography/Shutterstock.com

Figure 33-1. Various insects, such as adult Japanese beetles, can cause damage to plants, including holes in the leaves. A large infestation will leave plants entirely defoliated.

Types of Pesticides

Pesticides may be synthetic or organic. Synthetic pesticides are created with manufactured chemicals. Organic pesticides are derived from natural ingredients and do not contain manufactured chemicals. Both types of pesticides are toxic to the targeted pest(s), and may have detrimental effects on the environment and human beings when improperly applied or overused.

Pesticides (synthetic and organic) are divided into the following categories: insecticides, miticides, herbicides, fungicides, nematicidies, molluscicides, biopesticides, rodenticides, and algaecides. The pesticides in each of these categories are used to control specific problems.

Insecticides

An ***insecticide*** is a chemical used to prevent, control, or decimate insect populations. Insecticides are categorized by the method in which they are taken in by pests.

- ***Contact pesticides*** are insecticides that kill insects through touch, or by entering the insect's system through ingestion. Contact pesticides are attached to the plant surface that is consumed by the pest. Contact pesticides mainly target insects with chewing mouthparts. Poisons that are ingested are known as stomach poisons.
- ***Systemic pesticides*** are translocated through the plant's vascular system. Insects with piercing and sucking mouthparts will take in the insecticide when they feed on the sap. Systemic poisons target insects with piercing sucking mouthparts.

Corner Question

Q Are ticks a pest to plants?

STEM Connection

Chemicals from Flowers

A powerful chemical used to control many different insects can be pyrethrin, or a pyrethroid. Pyrethrins are a chemical derived from chrysanthemum flowers. Chemists, however, have synthetically made a chemical called a pyrethroid. The synthetic form of pyrethrin combats insects in the same manner as the naturally occurring pyrethrin. An organic pesticide can contain pyrethrins but not pyrethroids (since they are a synthetic chemical).

val lawless/Shutterstock.com

Corner Question

What famous herbicide was used as a method of combat during the Vietnam War?

Miticides

Tiny, spider-like organisms are known as mites, **Figure 33-2**. Mites are also closely related to ticks. ***Miticides*** kill insects on contact or through the mite's ingestion of the poison. For example, a flea (insect) and tick control that is applied to a dog or cat enters the animal's bloodstream. When the flea or tick feeds on the animal, it takes up the poison and is killed. This method of delivering the poison is systemic.

D. Kucharski K. Kucharska/Shutterstock.com

Figure 33-2. Mites, such as these spider mites, have a piercing sucking mouthpart and can damage plants.

Herbicides

An herbicide is a weed killer. A weed is a plant that grows in a place where it is unwanted, **Figure 33-3**. Nonselective herbicides kill all plants. Selective herbicides target specific types or spectrums of weeds. Pre-emergent herbicides are applied to a site to create a chemical barrier at the soil level before seeds germinate. New weed seedlings are killed by this chemical as the seeds germinate. A post-emergent herbicide controls weeds after they are growing.

Bildagentur Zoonar GmbH/Shutterstock.com

Figure 33-3. Weeds, such as this chickweed, are controlled by several chemicals used in herbicides.

Fungicides

Fungicides, the most widely used and applied type of pesticide, control or prevent fungal growth. Fungicides come in contact with the fungus that feeds on the plant material.

Art Phaneuf Photography/Shutterstock.com

Figure 33-4. Various fungi, such as mildews found on this squash plant, can be prevented and sometimes treated with fungicides.

Fungal pathogens cause various diseases, **Figure 33-4**. Fungicides are usually sprayed preventively rather than to control a fungus that is actively growing (showing signs and symptoms of disease).

Nematicides

Microscopic, multicellular worm-like organisms that inhabit soil and water are known as nematodes. Nematodes often feed on the roots of plants. A ***nematicide*** can be applied to soils (often in the form of a gas, known as a fumigant) to control nematode populations.

Molluscicides

Molluscicides control types of mollusks. Slugs and snails are two forms of mollusks that cause extensive plant damage, **Figure 33-5**. Molluscicides are available in granular form and are applied as bait. The slugs and snails eat the bait, which is poison.

TwilightArtPictures/Shutterstock.com

Figure 33-5. A slug is a common pest that chews on the foliage of numerous horticultural crops. Slugs can be controlled with traps and molluscicides. Some gardeners use copper strips to shock these pests.

Biopesticides

Biopesticides are pesticides derived from natural products, such as plants, animals, and microorganisms. According to the Environmental Protection Agency (EPA), there are more than 195 registered biopesticides and more than 780 biopesticide products on the market today. Three types of biopesticides are microbial pesticides, plant incorporated protectants (PIPs), and biochemical pesticides.

Microbial Pesticides

Microbial pesticides include microorganisms such as bacteria and fungi. An example is a fungus that controls specific insects or weeds.

Thinking Green

Organic Controls for Slugs

Several methods can be used to control slugs that may damage garden plants.

- Diatomaceous earth—This powdery substance, made from the crushed remains (skeletons) of diatoms, contains a large amount of sharp silicon. Growers place the diatomaceous earth around the plants to create a barrier. As the slugs cross the barrier, the silicon causes cuts that lead to their dehydration and eventual death.
- Copper barrier—A copper wire or barrier can be placed into the soil and used as fencing. As the slug passes over the copper with its body, it reacts with the copper and is shocked.
- Clover—Plant a patch of sacrificial clover. The slugs will be lured from your prized plants and will feast on the clover instead.
- Beer trap—Place a small container in the ground with the lip at ground level. Fill the container with beer. Slugs are attracted to the sweet, fermented malt and will drown when they fall into the trap.
- Hand picking—Slugs can be picked off plants by hand and disposed of in a closed container. This type of removal is best done at night, when slugs are most active.

Plant Incorporated Protectants (PIPs)

Plant incorporated protectants (PIPs) come from plants that produce pesticidal substances from within the plant due to transgenic modifications. For example, through the use of biotechnology, Bt corn produces a nerve toxin called *Bacillus thuringiensis* within the plant. The toxin attacks larvae (such as the European corn borer) as they try to feed on the genetically modified corn.

Biochemical Pesticides

A nontoxic, naturally occurring mechanism used to control pests is known as a ***biochemical pesticide***. An example is using pest pheromones to attract and capture pests in pheromone traps, **Figure 33-6**. Pheromone traps have proven to be effective in controlling pests such as the Japanese beetle.

Dale Spurgeon/USDA ARS

Figure 33-6. Pheromone traps, such as this boll weevil trap, can be used to help lure and capture insects to limit crop damage.

Rodenticides

Not only are mice and rats a problem in homes and businesses, they are also a problem in greenhouses, gardens, storage facilities, and farms. Additional rodent pests common in agricultural settings include gophers, woodchucks (also known as groundhogs), moles, and voles, **Figure 33-7**. Applications of ***rodenticides***, (chemicals used to control rodents) are often in the form of poisonous bait pellets, packs, or blocks.

Peter Trimming/Flickr

Figure 33-7. A vole is a type of rodent that lives in underground burrows. Voles create runways and burrows that destroy lawns and eat the roots of plants. These organisms can be controlled with rodenticides.

Algaecides

Algaecides control algae that can grow anywhere there is water. An evaporative cooling pad or a concrete floor in a greenhouse is the perfect environment for algae growth. Algaecide forms and application methods vary.

Pesticide Formulations

Pesticides must be formulated to be effective at controlling pests. A ***pesticide formulation*** is a stable mixture of active and inert ingredients used to create a product that controls pests. The formulation makes the final product easier and safer to use, and more effective in combatting a target pest.

Corner Question

Can algae be farmed?

Ingredients

A pesticide formulation may consist of:

- ***Active ingredients***—the chemicals that control the target pest population.
- Carriers—something to help deliver or carry the active ingredients.
- Surfactants—surface-active ingredients that help ingredients adhere or spread to the targeted area.
- Adjuvants—other ingredients such as dyes, stabilizers, or other substances to enhance the effectiveness of the pesticide.

Pesticide manufacturing companies provide pesticides in different formulations to make products safer and easier to apply, and more effective at controlling pests. Using certain formulations of pesticides can also help prevent contamination of the environment. Formulations for pesticides include aerosol sprays, dust, wettable powders, granular pellets, liquid concentrates, and emulsifiable concentrates.

Robert Rozbora/Shutterstock.com

Figure 33-8. Pesticides are available in spray cans that are useful for smaller applications. Gloves should be worn when handling and applying aerosol pesticides.

Aerosol Sprays

Aerosol sprays are applied through a spray can device, **Figure 33-8**. This formulation is convenient and easy to apply because all the applicator must do is press a tab to spray the pesticide. There is no mixing because the product is already formulated for release. This method of delivery is very efficient. Aerosols are expensive and are best used only for small areas. Aerosol formulations are identified on the SDS and pesticide label by the letter A.

Dust

Dust formulations are very fine particles that are applied by shaking the dust from a canister or a duster. A duster is an application device that forces the dust through a tube for dispersal. Clay, or another fine powder, may be used to bind to the active ingredient of the pesticide to create the dust. However, some pesticides may be purely made of the active chemical. Spreading the dust and getting even coverage can be a challenge with this type of product. Dust formulations are identified on the SDS and pesticide label by the letter D.

Safety Note

Aerosol Cans Are Explosive

Never use an aerosol can near an open flame, and never try to puncture a can of aerosol spray. These canisters are highly pressurized. They can explode and cause serious damage if punctured or heated by fire or another heat source. *Always read and follow the label when using aerosol can pesticides.*

Wettable Powders

Wettable powders are dust-like formulations that are mixed with water or oil and sprayed through a sprayer. Wettable powders are economical and solve the application problems that are characteristic of dust formulations. Wettable powders provide even coverage and delivery of the pesticide. Wettable powder formulations are identified on the SDS and pesticide label by the letters WP.

Granular Pellets

Dry, coarse pellets that are applied using a spreading device (broadcast or drop-type spreader) are known as granular formulations. Baits and turf products are often granular formulations. Granular formulations are identified on the SDS and pesticide label by the letters GR.

Liquid Concentrates

Liquid concentrates are diluted with water and applied through a spraying device, **Figure 33-9**. Liquid concentrates are economical and generally easy to apply. However, mixing the product and using a sprayer require manual labor. Home gardeners may use a small, portable sprayer. Growers use large sprayers placed in a truck bed or behind a tractor to treat large areas. Liquid concentrations are identified on the SDS and pesticide label by the letters LC.

l i g h t p o e t/Shutterstock.com

Figure 33-9. Applicators must always wear the appropriate PPE, regardless of the size or location being treated.

Emulsifiable Concentrates

Emulsifiable concentrates are pesticide solutions with emulsifying agents in a water-insoluble organic solvent. The pesticide solution is suspended in the emulsifying agent, much in the same way oil and vinegar do not mix in a salad dressing. When added to water, this formulation has a milky appearance. Emulsifiable concentrates are identified on the SDS and pesticide label by the letters EC.

Pesticide Labels

The pesticide label is a lengthy document created by scientists, the government, and lawyers. The pesticide label's objective is to ensure maximum benefits to users while reducing safety and environmental risks. When you are considering the application of a pesticide, it is very important that you read the label to understand how, when, and where to apply the pesticide. Before you buy a pesticide, read the label to make sure this product is appropriate for the particular pest you wish to control. Read the label for each step of use to ensure the safest and most effective use of the pesticide. Read the label before you purchase, mix, apply, store, and dispose of the pesticide.

Corner Question

What is FIFRA?

Not following the label is dangerous for several reasons, including environmental risks, safety risks, and legal implications. Failure to follow the label instructions may also result in less effective pest control with the product.

A Legal Document

The pesticide label is a legal and binding agreement between the applicator and the pesticide manufacturer. Pesticide manufacturers are under strict laws governed by the Environmental Protection Agency (EPA). The chemical undergoes years of research and testing before it is released to the public. The label contains explicit instructions and information based on this research and testing. Failure to comply with the directions of the label can have legal repercussions. If someone knowingly does not follow the directions of the pesticide label, he or she can be criminally prosecuted.

Sections of a Pesticide Label

The information found on a pesticide label is very detailed and meant to cover many issues associated with its application. Some of the most important information on the pesticide label includes:

- EPA registration number.
- Active ingredients list.
- Signal words.
- Precautionary statements.
- Environmental hazards section.
- First-aid instructions.
- Storage and disposal information.

EPA Registration Number

The ***EPA registration number*** is a number assigned to a pesticide after it has been reviewed and verified by the EPA. The number provides certification that all information and data found on the label has been reviewed by the EPA. It also indicates the product has been reviewed, and has been determined to have minimal or low risk when the label's directions are followed. The EPA registration number does not mean that the EPA supports the product, or guarantees it to be effective. The label simply indicates that the EPA has reviewed the product.

STEM Connection — Insecticides and Bumblebees

What pesticide misuse resulted in the death of more than 25,000 bumblebees? In 2013, in a parking lot in Wilsonville, Oregon, more than 25,000 bumblebees and other pollinators were found dead or dying. A local landscape company had not followed the label directions of an insecticide called Safari. They sprayed the insecticide on linden trees while they were blooming. Because the trees were blooming, pollinators were working and collecting pollen that was laced with the poison. The misuse of the pesticide resulted in a loss of at least 150 colonies of bees in the local ecosystem.

Sergey Lavrentev/Shutterstock.com

History Connection Skull and Crossbones

The symbol of the skull and crossbones originates with the medieval *Danse Macabre* (Dance of Death) symbol. The symbol took on its current form by the fifteenth century and accompanied war ships, military flags, and other insignia expressing recklessness and ferocity. In the eighteenth century, this symbol came to signify piracy. The symbol was used to mark the entrances of Spanish cemeteries. Since the nineteenth century, the skull and crossbones has been used as a symbol of warning on containers, such as those filled with poison.

Jess Kraft/Shutterstock.com

Active Ingredients

The active ingredients are those that provide control against the target pest. An active ingredient can be a synthetic or natural chemical.

Signal Words

Signal words are language on a pesticide label used to call attention to potential threats to human health. The words *caution*, *warning*, and *danger* are the signal words indicated by the EPA. The signal words have specific meanings:

- Caution—these pesticides are the least harmful to human health.
- Warning—this is a more dangerous pesticide and has more potential to negatively impact human health.
- Danger—this is the most dangerous type of pesticide. A pesticide with the word *danger* is only available for use by licensed, or certified pesticide applicators. A label with the word *danger* will also have an illustration of a skull and crossbones.

Precautionary Statements

Precautionary statements describe the personal protective equipment (PPE) that should be worn by the applicator, protection for children and pets, and requirements for a treated area. PPE can include goggles, masks, respirators, gloves, shoes, socks, long sleeves, pants, and other protective gear for the applicator.

Environmental Hazards

The environmental hazards section outlines potential environmental damage that may result from using the product. The label will discuss the possible outcomes to wildlife, aquatic life, plants, animals, and water resources.

Safety Note

Agricultural Worker Protection Standard

The EPA's Agricultural Worker Protection Standard (WPS) was published in 1992 and is a regulation intended to protect agricultural workers from injury and poisoning associated with pesticides. The WPS offers protection to more than 2 million workers and pesticide handlers that work at more than 600,000 agricultural work sites. The WPS requires employers to provide workers with proper education, safety, and notification, and to provide mitigation when exposure does occur.

mrfiza/Shutterstock.com

Figure 33-10. A health worker is using a fog in a tropical region to control insects that spread dengue virus. This same application may not be labeled for use inside a building.

The directions for use help the applicator understand the purpose of the product and what pests it is designed to control, **Figure 33-10**. The product label will describe where it can be applied (nursery, greenhouse, outdoors, or indoors) and what pests it controls. The pesticide cannot be used against a non-targeted pest or in a location that is not described in the directions for use section of the label.

First-Aid Instructions

In case someone is poisoned, the first-aid instructions define how to handle the situation. The *Statement of Practical Treatment* outlines first-aid protocol specific to that pesticide or poison. In case of poisoning, call 911 or a poison control center with the name of the pesticide. Administer the first-aid treatment that is described. Take the pesticide container or label to the hospital.

Storage and Disposal

Safe storage and disposal of a pesticide is equally as important as safe application. Products must always remain in their original container and away from children and pets. Pesticides should not be stored at extreme temperatures. All pesticides should be kept in a locked cabinet or storage facility.

Pesticide Application

Several factors should be considered in applying pesticides safely. These factors include:

- Gaining applicator certification.
- Selecting personal protective equipment.
- Determining the correct amount to use.
- Mixing properly.
- Applying correctly.
- Enforcing restricted entry intervals.

Pesticide Applicator Certification

Only trained and certified applicators may apply restricted pesticides. In accordance with national standards determined by the EPA and USDA,

states, territories, and tribes are permitted to provide pesticide applicator certification and training programs. Certified applicators must undergo training, pass an exam, pay annual certification fees, and periodically renew their certification through education and/or testing.

Funding for Safety Programs

The EPA provides funding to review the competency of restricted-use pesticide applicators through the pesticide safety education program (PSEP). Since 1975, the EPA has had an interagency agreement (IAG) with the USDA to distribute funds to the state cooperative extension services for the purpose of training restricted use pesticide applicators. The joint efforts of the EPA, USDA, and cooperative extension services have helped educate individuals who work with these powerful pesticides. The applicators learn about appropriate use, storage, disposal, and safety for people and the environment.

Selecting Personal Protective Equipment

Whether an applicator uses personal protective equipment (PPE) is not a choice. The label describes whatever necessary PPE must be worn during pesticide application. Personal protective equipment that should be worn during pesticide application includes long-sleeved shirts, goggles, long pants, shoes, socks, and nonpermeable gloves, **Figure 33-11**. When working with and applying pesticides, it is best to cover as much bare skin as possible. The less skin that is exposed, the less likely an applicator is to be poisoned through skin contact. It is also necessary to cover your head with a hat or hood as well.

wellphoto/Shutterstock.com

Figure 33-11. Read the pesticide label to understand which type of personal protective equipment must be worn.

Determining the Correct Amount to Use

Many pesticide products can be purchased in a form that is ready to use; however, others must be mixed in a quantity specific to the job at hand. Mixing too much, or too little, product can cause problems. Mixing too much pesticide may mean additional storage, waste, or disposal concerns. Mixing too little pesticide means more time is required to mix another batch (losing time and money).

Safety Note

Personal Protective Equipment

Personal protective equipment (PPE) varies, depending on the job at hand. The Occupational Safety Health Association (OSHA) regulates the proper use of PPE on job sites. PPE for a landscape worker differs greatly from the PPE for someone who is applying a pesticide. Not all pieces of PPE have the same effectiveness for every job. Know what you need to wear to protect yourself, and wear the PPE even if it is uncomfortable.

Determining exactly how much pesticide product is needed to treat the targeted pest for the specified area is critical. The pesticide label will include ratios you can use to determine how much pesticide you will need. Good measurements and careful calculations result in precise and responsible pesticide applications. Follow these steps to determine the amount of pesticide needed for an application:

- Determine the size of the area to be treated: length × width = area.
- Calculate how much pesticide is needed for the target area: X ounces of pesticide per 1000 ft^2 (304.8 m^2).
- Calculate dilutions of the pesticide product if the formula is not ready-to-use: X ounces of pesticide per gallon of water.
- Example:
  Area is 100′ (30.48 m) × 20′ (6.1 m)= 2000 ft^2 (609.6 m^2)
  Pesticide needed is 1 ounce of pesticide per 1000′ square (304.8 m). Thus, 2 ounces of pesticide is needed. The pesticide must be diluted to 0.5 ounces per 1 gallon of water. Thus, if 2 ounces are needed, then 4 gallons of water would be needed for the 2000 ft^2 (609.6 m^2).

Mixing a Pesticide

If pesticides must be mixed to create the appropriate concentration, the applicator must use the appropriate measurements and follow safety protocols when mixing. Some safety protocols include:

- Never eat or drink when mixing pesticides.
- Wear appropriate PPE, including goggles, gloves, long sleeves, long pants, socks, and shoes.
- Mix in a well-ventilated area, preferably outdoors in adequate light.
- Mix only the amount that was calculated at the concentration recommended. Doubling the strength of a pesticide will not make it more effective, and may make it more dangerous. Do not make more than you need.
- Never use measuring equipment (teaspoons, cups, or jars) that will be used for anything other than pesticide measurement and mixing.
- Keep children, pets, and any other sensitive materials away from the area where mixing occurs.
- If mixing a concentrate, add water first and add the pesticide second. This will prevent splashing of the pesticide, or possible exposure by adding water to the pesticide.
- Keep pesticides in their original containers. Use clearly marked containers to hold mixed pesticides. The mixed pesticide should be used immediately.
- If a spill occurs, clean it up immediately. Sprinkle the spill with vermiculite, sawdust, or cat litter (refer to the cleanup section of the label). Sweep the pesticide-soaked material into a garbage bag, and dispose of it according to the pesticide storage and disposal section of the label.

Applying Pesticides

It is important to assess the surrounding environment before application of a pesticide begins. Thoroughly read to label to understand how, when, and where the pesticide should be applied. Keep the following general guidelines in mind when preparing to apply pesticides:

- Check the surrounding area for water, people, pets, livestock, and other elements or organisms that are in the targeted site and may be affected by the pesticide.
- Check the weather forecast to see if rain or wind may be an issue. Pesticides should never be applied on windy or rainy days. The pesticide may have restrictions regarding how soon a pesticide may be applied before rain is expected.
- Check the label for the appropriate temperature at which a pesticide may be applied. Extreme high or low temperatures should be avoided.
- Use coarse droplets from spray equipment to prevent pesticide from drifting off target.
- Apply pesticides in the garden around dusk. This is after pollinators, such as honeybees, will not be pollinating.
- Never apply pesticides near a well or other water source.
- Use pesticides indoors only when absolutely necessary (interiorscapes). Ventilate the area and remove all food sources from the site before application.
- Triple-rinse all spraying equipment once application is completed.
- Store and dispose of all pesticide material according to the pesticide label.
- Properly remove, wash, or dispose of PPE. Follow proper washing techniques for PPE that can be reused.

Safety Note

Windy Days

Never apply pesticides on windy days. The small droplets can easily be swept away with the wind and treat or contaminate areas that were not meant to be exposed. This can lead to unintentional toxicities of non-targeted populations. Unintentional contamination through pesticide application is the fault of the applicator and is punishable by law.

Applying insecticides during the appropriate part of an insect's life cycle is important for the chemical to work effectively. Correctly identifying the pest and determining what part of the life cycle the pest is in (adult, nymph, pupa, larva, or egg) are critical for selecting the best chemical control, **Figure 33-12**. Knowing what type of life cycle (complete or incomplete metamorphosis) the insect has is also important.

USDA Agricultural Research Service

Figure 33-12. Some pesticides are only effective during certain life cycle stages of the targeted pest. Read the pesticide label to ensure you are using the correct pesticide at the correct stage of the targeted pest.

Restricted Entry Interval (REI)

The ***restricted entry interval (REI)*** denotes how much time must pass before a person can enter an area that has been treated with a pesticide. The pesticide label indicates the REI in hours. Depending on the pesticide's potential for toxicity, some pesticides labeled *caution* may have a REI of zero hours while others may have an REI of up to 48 hours.

TFoxFoto/Shutterstock.com

Figure 33-13. Signs to state that an area has been treated with a pesticide must be in a language that is understood by most people in the area. This sign, written in English and Spanish, is appropriate for many areas of the United States.

REIs must be posted on treated areas in a language that individuals in the area can understand. Usually, in the United States, REIs are posted in English and Spanish, **Figure 33-13**. The signs that are used for REI are very noticeable.

Toxicity

Through the EPA, the United States regulates pesticides that are considered toxic to human health and the environment. The toxicity of a pesticide is its ability to poison organisms. Poisons enter an organism through:

- Dermal contact (through skin).
- Inhalation (through respiration).
- Oral contact (through ingestion).
- Eye contact (through eye membranes).

Applicators are most likely to be affected through dermal contact or inhalation. Skin rapidly absorbs substances through cuts, the back of hands and necks, armpits, and the groin area. Inhalation of fine mists, such as aerosols or dusts, can also lead to exposure. Children, pets, and wildlife may ingest pesticides in granular forms. Thus, granular forms of pesticides, such as bait pellets, must be properly stored and applied only when pets or children will not be using the area.

Types of Toxicity

Toxicity of a poison may be described as acute or chronic. ***Acute toxicity*** is a measure of how poisonous a pesticide is after a single exposure. ***Chronic toxicity*** is a measure of how poisonous a pesticide is after repeated exposures, over a length of time. A very small amount of a toxin that is continually stored in the fat of an organism will build to toxic levels that can prove harmful or deadly.

Lethal Dose

A measurement used to determine the amount of acute oral and dermal toxicity is $\boldsymbol{LD_{50}}$. *LD* stands for lethal dose (the amount of a substance needed to cause death). The *50* signifies that 50% of a test population of animals died when exposed to this quantity. The lower the LD_{50} of a toxin, the higher the toxicity.

STEM Connection Lethal Dose

The acute LD_{50} of many pesticides is much lower than common household items that humans use in their everyday life. Numbers are expressed as milligrams (mg) of poison per kilograms (kg) of body weight.

- LD_{50} of table salt is 3000 mg/kg for rats, glyphosate (active ingredient in herbicides) is 5600 mg/kg for rats.
- LD_{50} of aspirin is 200 mg/kg for rats, malathion is 1375 mg/kg for rats.
- LD_{50} of nicotine is 10 mg/kg for rats, Sevin dust is 650 mg/kg for rats.

LD_{50} values are specified in milligrams of a substance per kilogram of a test animal's body weight.

Lethal Concentration

The measurement for acute inhalation toxicity is measured by $\boldsymbol{LC}_{50}$ values. *LC* stands for lethal concentration. The values are measured in milligrams per liter. (Liter is a volume measurement.) The lower the LC_{50} number, the more toxic the pesticide is by volume. Pets and children should be kept from areas where pesticides have been used, **Figure 33-14**.

Stibe36/Shutterstock.com

Figure 33-14. Children and pets are extremely susceptible to pesticides. Extreme caution and attention should be paid when applying pesticides near them.

Toxicity Categories

The EPA has established guidelines and educational materials for handling pesticides. In addition to the toxicity categories listed below, the EPA has published guidelines for REI (restricted entry intervals). Pesticides with greater toxicity have a greater REI.

- Toxicity I chemicals—the signal word *danger*, skull and crossbones, and *danger-poison* are included on the pesticide label. When the chemical is applied, warning signs must be posted and no one may enter the treated area for 48 hours after application.
- Toxicity II chemicals—the signal word *warning* is included on the pesticide label. Warning signs must be posted in the treated area, and no one may enter the area within 24 hours after application.
- Toxicity III chemicals—the signal word *caution* is included on the pesticide label. People may enter the area as soon as the mist or dust settles.
- Toxicity IV chemicals—the signal word *caution*, or no warning, may appear on the label. People may enter the treated area immediately or work within the targeted area as the treatment is applied.

Pesticide Poisoning

Recognizing pesticide poisoning is critical in preventing serious injury or death. If poisoning occurs, immediately contact a poison control center and dial 911 for an emergency. Find the pesticide label and have that ready for professionals. Symptoms of pesticide poisoning include:

- Redness, swelling, blistering, or pimpling of skin.
- Redness, swelling, or blistering of eyes, nose, mouth, and throat.
- Shortness of breath.
- Rapidness of breath.
- Drooling.
- Nausea, vomiting, abdominal cramps, and diarrhea.
- Headache, muscle twitching, and numbness.

If someone develops symptoms of poisoning after exposure to these chemicals, seek medical attention immediately to determine if the symptoms are pesticide related. Blood or urine analysis may be needed to determine pesticide toxicity.

Corner Question

What was the largest recorded case of pesticide poisoning in the United States?

First Aid

First aid should precede, but never replace, professional medical assessments and treatment. Once first aid has been administered, call both 911 and the poison center at 1-800-222-1222. Have the pesticide label available when calling the poison center.

Spills

Keep the following guidelines in mind when taking care of someone who has spilled a pesticide on his or her skin or clothing.

- Implement first-aid practices based on the Statement of Practical Treatment when pesticide poisoning occurs.
- Remove the exposed clothing immediately.
- Wash the exposed area immediately with freshwater and soap to dilute the chemical. Dilution of the poison is imperative.
- Cover any chemical burns with a loose, clean cloth. If the situation permits, and emergency personnel are not present, take the victim an emergency treatment center.

Eye Exposure

For eye exposure, hold the eye open and flush with clean water (or saline) for a minimum of 15 minutes. Flushing the eyes will rinse and dilute the poison. Do not use drops or ointments to flush eyes. Seek professional medical help as soon as possible after flushing the eyes. The eye membrane absorbs poisons faster than any other external part of the body. Eye damage can occur in a few minutes with many types of chemicals.

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Figure 33-15. Learning and knowing CPR and other first-aid procedures can help in treating a person who has been poisoned.

Inhalation

If a person has inhaled a poison, immediately move that person to a fresh air environment, and call 911. Do *not* expose yourself! If the victim is unable to stand or unconscious, and you do not feel safe entering the area to retrieve the victim, immediately call 911. If it is safe to enter the area, retrieve the victim and help him or her to fresh air. (If you cannot move the person, open windows and doors to ventilate an enclosed space.) Keep the victim stationary, and loosen any clothing that would restrict breathing. If the victim is unresponsive, and you are trained to do so, administer artificial respiration (CPR) while waiting for emergency personnel to arrive, **Figure 33-15**.

Remain calm when helping someone, and remember to keep your health a priority. If you are exposed to the chemical in your first-aid efforts, it is important that you also receive medical attention.

Safety Note

Handling a Pesticide Emergency

You may need to help someone who has been poisoned by a pesticide. If the person is unconscious, having trouble breathing, or having convulsions, act quickly:

- Give first aid immediately.
- Call 911, or ask someone else can to do so while you begin first-aid treatment.

If the person is awake or conscious, not having labored breathing, and not having convulsions:

- Contact your local poison center (1-800-222-1222).
- Read and follow Statement of Practical Treatment on the pesticide label.
- Give first aid.

Storage and Disposal

The storage and disposal of a pesticide is as potentially harmful to human and environmental health as improper mixing or application. When considering how to safely store a pesticide, keep these guidelines in mind:

- Purchase only the amount of pesticide that will be used in the near future. This will reduce or eliminate the need to store leftover pesticides.
- Follow all storage instructions on the pesticide label.
- Store pesticides in a temperature-regulated facility.
- Store pesticides in a locked cabinet or storage facility.
- Keep pesticides contents in the original container.
- Keep pesticides out of reach of children and pets.
- Store pesticides away from an ignition source.
- Do not store pesticides in a location where flooding is possible.

Disposal

Proper disposal of pesticides is important for safety. If you purchase only the amount of pesticide you need for an application, you will not have to store or dispose of leftover pesticides. If you cannot use your supply, contact other growers or gardeners who may have the same pest problem, and may have use for the leftover pesticides. Always keep the pesticide label with the pesticide in its original container. If you must dispose of a pesticide, consider the following:

- Do *not* burn leftover pesticides, pour them down a drain, or throw them into the garbage. Pesticides are toxic and, when disposed of improperly, may cause damage to the environment, people, and other living organisms.
- Contact your local cooperative extension service agent and ask for suggestions for disposal of the pesticide.
- Contact your local solid waste agency, health department, or the EPA to learn about hazardous waste collection programs in your community.
- Contact Earth 911 (contact information available online). This agency, and others like it, can help direct you to the appropriate disposal of your leftover pesticide.
- Adhere to state and local laws when applying, storing, and disposing of pesticides. State and local pesticide disposal laws may be harsher than federal requirements found on the pesticide label.

Safety Note

Rinsing Pesticide Containers Safely

Follow these guidelines to rinse pesticide containers safely:

1. While wearing personal protective equipment, pour any excess pesticide into the sprayer.
2. Fill the pesticide container one-fourth full of clean water, recap, and shake the container for 30 seconds. Pour the rinse water into sprayer.
3. Repeat two additional times, shaking the container each time.
4. Carefully rinse the outside of the container and the cap over the sprayer (or a bucket) to catch the rinse water.
5. Dispose of the pesticide container according to local regulations.
6. Apply the diluted rinse material according to label directions onto targeted pests.

Container Reuse

Never reuse empty pesticide containers. An empty pesticide container has as much potential to be hazardous as a full container of pesticide. Residues that are left inside a pesticide container have the potential to be combustible. When empty, rinse the container at least three times and replace the cap securely. Dispose of the container according to the pesticide label instructions.

Careers

When you think about a career in pesticides, you most likely picture someone spraying a house for pests, such as cockroaches and termites. Yes, this is one career associated with pesticides; however, many other careers that involve science, math, technology, engineering, marketing, advertising, communications, and law are related to pesticides. Consider a career as a pesticide chemist, a lawyer for an agricultural chemical company, or the manager of a bee care facility.

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Figure 33-16. Chemists have many opportunities in the pesticide industry.

Pesticide Chemist

A pesticide chemist is someone who researches the use and development of safer chemicals to combat insects, diseases, weeds, and other pests. A pesticide chemist may be employed by a college or university, government agency, or a private company. A pesticide chemist may be a laboratory technician, research assistant, or scientist, depending on the amount of education and training he or she has received. Chemists can create formulations, analyze chemicals, and be involved in quality control. There are many opportunities for chemists in the pesticide industry, **Figure 33-16**.

Lawyer for an Agricultural Chemical Company

Lawyers for agricultural chemical companies must have knowledge of the agriculture industry as well as knowledge of local, national, and even international laws. These lawyers usually have a working understanding of government agencies such as the EPA, USDA, US Fisheries and Wildlife Service, and the Department of Justice. Lawyers deal with regulatory issues, compliance to regulations, environment and chemical exposure, and claims. Lawyers may represent companies in litigation dealing with regulation and practices involving chemicals. Some attorneys are responsible for the creation of legal language on pesticide labels. They review the labels to ensure all legal aspects are covered fully, and that the company creating the label and chemicals has created a legal and binding document in accordance with the EPA and other relevant government agencies.

In addition to a bachelor's degree and a license to practice law, lawyers working in the agricultural industry may also have an education or background in agricultural studies.

Career Connection Dr. Rebecca Langer-Curry

Bayer Bee Care

Dr. Rebecca Langer-Curry works for Bayer CropScience and is head of the North American Bayer Bee Care Program. Together, Dr. Langer-Curry and her colleagues use the Bayer Bee Care Program, and the Bayer Bee Care Center, to promote and protect pollinator health in North America and around the world.

Bayer has more than 25 years invested in research related to promoting bee health. To further their efforts, Bayer opened the Bayer Bee Care Center in North Carolina. Dr. Langer-Curry is the project manager at the center, which focuses on promoting cooperative efforts between apiculturists and agriculturists to establish sustainable solutions for bee care problems. The center is open to the public and provides a platform for education, research, and demonstration for scientists and the public.

Dr. Langer-Curry has a doctorate in pathobiology. Her career in science includes management of biosafety programs for labs and greenhouses. She has also worked in academia. Dr. Langer-Curry encourages students interested in apiculture to study a science and not to "fall into habit, but rather ask new questions and seek answers to those questions." Dr. Langer-Curry also advises students to explore business and marketing because knowledge in these areas will be helpful in the business world.

Dr. Rebecca Langer-Curry

CHAPTER 33

Review and Assessment

Chapter Summary

- An agricultural pest is an insect, disease, weed, or animal that attacks a crop or food source and causes damage. Pests should be controlled using a strategic plan called integrated pest management (IPM).
- When all other methods of IPM have been exhausted, pesticides (chemicals) may be used to control pests. Pesticides destroy pests that attack plants, animals, and other organisms.
- Many types of pesticides are available, including insecticides, miticides, herbicides, fungicides, nematicidies, molluscicides, biopesticides, rodenticides, and algaecides.
- A pesticide formulation is a stable mixture of active and inert ingredients used to create a product that controls pests. Formulations for pesticides include aerosol sprays, dust, wettable powders, granular pellets, liquid concentrates, and emulsifiable concentrates.
- Reading the pesticide label is very important before selecting, purchasing, mixing, applying, storing, or disposing of a pesticide. The pesticide label is a legal and binding agreement between the applicator and the pesticide manufacturer.
- The information found on a pesticide label is very detailed and can be dozens of pages long. This information is meant to cover many issues associated with the pesticide.
- Signal words on a pesticide label are used to call attention to potential threats to human health. The words *caution*, *warning*, and *danger* are the signal words indicated by the EPA.
- Factors to consider in applying pesticides safely include gaining applicator certification, selecting personal protective equipment, determining the correct amount to use, mixing properly, applying correctly, and enforcing restricted entry intervals.
- The toxicity of a pesticide is its ability to poison organisms. Poisons enter an organism through dermal contact, inhalation, or oral contact (ingestion).
- Recognizing pesticide poisoning is critical in preventing serious injury or death. Individuals must be able to recognize a pesticide poisoning and provide appropriate first aid to the victim.
- Storage and disposal of pesticides are just as important as proper application. Read the label and follow the directions for storage and disposal.
- Several careers that involve science, math, technology, engineering, marketing, advertising, communications, and law are related to pesticides. Three of these careers include, a pesticide chemist, a lawyer for an agricultural chemical company, and a project manager for a bee care facility.

Words to Know

Match the key terms from the chapter to the correct definition.

A. active ingredient	H. contact pesticide	O. molluscicide
B. acute toxicity	I. EPA registration number	P. nematicide
C. agricultural pest	J. fungicide	Q. pesticide formulation
D. algaecide	K. insecticide	R. restricted entry interval (REI)
E. biochemical pesticide	L. LC_{50}	S. rodenticide
F. biopesticide	M. LD_{50}	T. signal word
G. chronic toxicity	N. miticide	U. systemic pesticide

1. A chemical used to prevent, control, or decimate insect populations.
2. An insect, disease, weed, or animal that attacks a crop or food source and causes damage.
3. An insecticide that kills insects through touch, or by entering the insect's system through ingestion.
4. A chemical that is translocated through a plant's vascular system; targets insects with piercing and sucking mouthparts.
5. A product used to control or prevent mites.
6. A chemical used to control or prevent fungal growth.
7. A chemical product used to control nematodes.
8. A chemical product used to control mollusks (snails and slugs).
9. A pesticide that is derived from natural products, such as other plants, animals, and microorganisms.
10. A non-toxic, naturally occurring mechanism used to control pests.
11. A chemical substance used to control rodents.
12. A chemical used to control algae.
13. A mixture of active and inert ingredients (adjuvants, surfactants, and carriers) used to create a product that controls pests.
14. A chemical in a pesticide that works to control the targeted pest.
15. A number given to a pesticide once it has been reviewed and verified by the Environmental Protection Agency (EPA).
16. Language, such as *caution*, *warning*, and *danger* on a pesticide label used to call attention to potential threats to human health.
17. The time that must elapse before someone can enter an area after it has been treated with a pesticide.
18. A measure of how poisonous a pesticide is after a single exposure.
19. A measure of acute oral and dermal toxicity needed to kill 50% of a test population of animals.
20. A measure of how poisonous a pesticide is after repeated exposures, over a length of time.
21. A measure of acute inhalation toxicity needed to kill 50% of a test population of animals.

Know and Understand

Answer the following questions using the information provided in this chapter.

1. What is an agricultural pest?
2. What is integrated pest management?
3. What are pesticides?
4. What are some types of pesticides used to control selected or target pest populations?
5. What is an herbicide and when are post-emergent herbicides used?
6. What are four ways to control slugs besides using a molluscicide?
7. What are three types of biopesticides?
8. Describe the type of biopesticide called a plant incorporated protectant.
9. What are four types of substances that can be included in a pesticide formulation?
10. What are six formulations in which pesticides are available?
11. What type of legal repercussion may result from failure to comply with the directions of a pesticide label?
12. What are some types of important information found on a pesticide label?
13. What do the signal words *caution*, *warning*, and *danger* mean when printed on a pesticide label?
14. What must a person do to qualify as a certified applicator?
15. Why should a pesticide applicator cover as much of his or her bare skin as possible?
16. What are some safety protocols that should be followed when mixing pesticides?
17. When is the best time of day to apply pesticides in a garden and why?
18. What are four ways poison can enter an organism?
19. What should you do in the event of a pesticide poisoning?
20. What guidelines should you keep in mind when storing pesticides?

Thinking Critically

1. You recently noticed your neighbor spraying what appeared to be a pesticide in his lawn right next to a stream that leads to a river and, eventually, the ocean. What would you do?
2. On a visit to a relative's home, you notice that pesticides in the garage are not stored properly, and they are within the reach of children. The situation appears to be dangerous. What would you do to address the situation?

STEM and Academic Activities

1. **Science.** You have a small hobby greenhouse that has been infested with thrips. What would be the most effective method of covering all plant material with an insecticide? Justify your answer.

2. **Science.** Identify a biopesticide and research how it is engineered. Describe the process through an illustrated diagram.
3. **Math.** Calculate how much insecticide will be needed to treat a lawn that is 0.25 acres if the pesticide used should be applied at a rate of 0.25 fluid ounces per gallon and 1 gallon of pesticide should be applied per 100 ft^2 (30.48 m^2).
4. **Language Arts.** Write a position paper on whether you think neonicotinoids are contributing to the loss of bee colonies. Include facts and statements from scientific research that is well cited. Use MLA format for the report.
5. **Language Arts.** Contact a Cooperative Extension Service agent to determine the requirements in your state for a pesticide license. Create a poster or pamphlet that outlines the process to inform people in your school or community about pesticide certifications in your state.

Communicating about Horticulture

1. **Reading and Speaking.** Research two pesticides you have at your home and determine how to store and dispose of each pesticide properly. Create a five-minute presentation about the appropriate methods of storage and disposal for each.
2. **Writing and Speaking.** Visit your local extension office and interview them about any recent pesticide accidents within your community, region or state. Create an informative poster about your experience to tell the story of pesticide problems where you live.

SAE Opportunities

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1. **Exploratory.** Job shadow a pesticide sales representative.
2. **Experimental.** Use an organic and a synthetic product to control weeds in your lawn. Compare the results of both treatments.
3. **Exploratory.** Research pesticide safety and worker protection standards within the local area, the state, and the nation. Create a video to demonstrate your understanding of these standards that could be shown to people working with pesticides in various settings.
4. **Improvement.** Work with your local Cooperative Extension Service office and develop a pesticide recycling program for your community. Make your school or another point in your community a drop-off point for these chemical containers.
5. **Exploratory.** Volunteer with the EPA, USDA, or a Cooperative Extension Service office to learn more about pesticide safety.