CHAPTER 33

Pesticide Management and Safety

SAE for ALL Profile

Kevin Whitten, Gunters Greenhouses

Kevin Whitten, who grew up in the countryside of Durham, North Carolina, has always been a quick learner who enjoys working with his hands. He worked with small motors for many years fixing household electrical equipment, such as vacuum cleaners. Kevin's wife Melanie was the daughter of a greenhouse owner, and Kevin often helped his father-in-law when needed. Kevin enjoyed learning horticulture from his wife and her father while working in the greenhouse. Eventually, he became so immersed in the business that he purchased it from his father-in-law. At the turn of this century, he found himself and his wife the owners of Gunters Greenhouses, a nearly 50-year-old family business. At the time, Kevin was a horticulture novice with little business experience. A business owner and grower needs to be a problem solver and critical thinker, which is exactly who Kevin is.

For over 20 years, Kevin has thrived in finding ways to make his business profitable and efficient. What is even more incredible about Kevin's self-taught business savvy is that Gunters has not just survived during times such as the pandemic; it has thrived.

Gunters is known throughout the state for its quality, distinctive plants. It attracts customers from all corners of the state, some of whom have lined up hours before opening on a Saturday morning for the opportunity to purchase one of Kevin's unique plants. Kevin works tirelessly to find exotic plant material to meet the demand of his customers. In 2020, Gunters imported tropical plants from around the world. His three-person team continuously propagates these desired plants but struggles to keep up with demand. In 2021, there was even more demand from collectors seeking unique plants, such as variegated Monsteras and the coveted Philodendron Pink Princess. The workload never eases, but Kevin thoroughly enjoys what he does and is grateful for the achievements of his family business.

Kevin's pesticide management holds environmental stewardship as a pinnacle of the program, and he employs integrated pest management (IPM) techniques every day in his greenhouse operation. Whether he is applying a biopesticide or introducing parasitic insects, he always has his eye on ensuring that his plants are healthy and safe for the consumer to use. Moreover, Kevin practices safe pesticide handling to keep his family and his customers healthy while minimizing detrimental impacts on the environment.

Kevin and his family hope that students considering a future in plant cultivation will pay careful attention to the needs of the plants, the environment, and the customers through safe pesticide management. "One thing is for dang sure, in this business you gotta know that while you sleep those pests are coming up with ways to get to your plants and your dollar. Growers have to be on their A-game with pest management or they will never make a dollar from selling their plants." Kevin urges students to never quit learning and to focus on how to solve problems and not just memorize facts. "Today, you have to know how and where to find the right information, then apply it. That is the only way to survive in the horticulture industry."

- How could someone benefit from a Placement SAE at a greenhouse business when dealing with pest management?
- Kevin talks a great deal about research as a part of a pest management program. How could you create a Research SAE involving IPM?

Kevin Whitten

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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?

Essential Question

What is pesticide management and safety?

Chapter Objectives

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

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

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.

Michael_Siluk/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.

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.

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

STEM Connection

Chemicals from Flowers

A powerful chemical used to control 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 33A

Are ticks a pest to plants?

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, nematicides, 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.

AJCespedes/Shutterstock.com
Inset: Tomasz_Klejdysz/Shutterstock.com

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

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 ingests the poison and dies. This method of delivering the poison is systemic.

Corner Question 33B

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

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

Bildagentur_Zoonar_GmbH/Shutterstock.com

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

Fungicides

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

Art Phaneuf Photography/Shutterstock.com

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

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.

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 299 registered biopesticide active ingredients and more than 1401 biopesticide products registered. 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.

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

Plant Incorporated Protectants

Plant incorporated protectants (PIPs) come from plants that produce pesticidal substances from within the plant due to transgenic modifications. For example, through 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

Controlling Snails and Slugs

Snails and slugs are members of a large group of animals known as mollusks. The most obvious difference between the animals is a large shell. Snails have shells and slugs do not. These small pests feed on plant foliage, leaving holes on larger leaves and completely consuming leaves of seedlings. Many homeowners combat these pests effectively using organic controls instead of using chemical molluscicides.

- **Diatomaceous earth**—Diatomaceous earth is made from fossilized remains of diatoms, which have a broken glass-like texture that slugs and snails avoid. Growers place the diatomaceous earth around the plants to create a barrier. Diatomaceous earth must be applied regularly as it is ineffective once wet. As the slugs cross the barrier, the silicon causes cuts that lead to their dehydration and eventual death.
- **Crushed eggshells**—Crushed eggshells have an abrasive texture that deters snails. The shells are spread around the plants. The shells also provide nutrients, such as calcium, to plants as they decompose.
- **Seaweed mulch**—Seaweed is mixed in the soil around the plants to create a mulch that deters the snails and slugs. The snails and slugs are deterred by the iodine smell. Seaweed also adds nutrients to the soil. These pests are also deterred by the smell of mint, rosemary, and thyme. These edible plants can be planted near the problem areas and provide fresh herbs as well.
- **Hand picking**—Slugs can be picked off plants by hand and disposed of in a closed container. Use a flashlight to search under leaves and around plants for successful picking. This type of removal is best done at night, when slugs are most active.
- **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.
- **Sacrificial clover**—Plant a patch of sacrificial clover. The slugs will feast on the clover instead of your prized plants.
- **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. They will drown when they fall into the trap.

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Consider This

1. Do snails and slugs have a useful purpose in the landscape?
2. How effective are organic controls compared to chemical controls?
3. How many other types of effective organic controls can you find? Research the topic and create a small poster explaining the methods and their effectiveness.

Eric Buermeyer/Shutterstock.com

Figure 33-6. Insect traps are used to capture pests and assess an infestation.

Peter Trimming/Flickr

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

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.

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.

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.

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**—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.

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 safety data sheet (SDS) and pesticide label by the letter A.

***Corner Question* 33C**

Can algae be farmed?

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.

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.

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.

lightpoet/Shutterstock.com

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

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.

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 manner that 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 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 imperative 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

***Corner Question* 33D**

What is FIFRA?

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.

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.

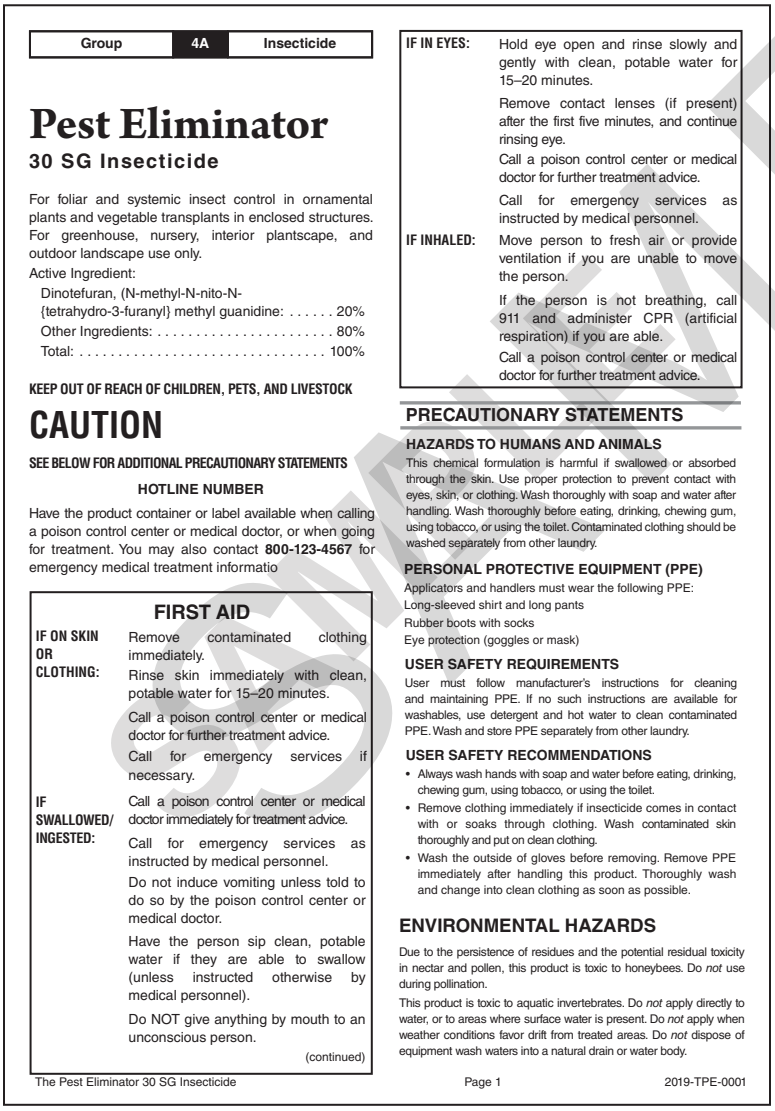
A Legal Document

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 detailed and meant to cover many issues associated with its application. The EPA requires specific information to be included on the label, and the manufacturer may also include information designed to market and promote the chemical. Some of the most pertinent information on the pesticide label includes the following (**Figure 33-10**):

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



Group | 4A | Insecticide

Pest Eliminator

30 SG Insecticide

For foliar and systemic insect control in ornamental plants and vegetable transplants in enclosed structures. For greenhouse, nursery, interior plantscape, and outdoor landscape use only.

Active Ingredient:

Dinotefuran, (N-methyl-N-nito-N-{tetrahydro-3-furanyl} methyl guanidine: 20%

Other Ingredients: 80%

Total: 100%

KEEP OUT OF REACH OF CHILDREN, PETS, AND LIVESTOCK

CAUTION

SEE BELOW FOR ADDITIONAL PRECAUTIONARY STATEMENTS

HOTLINE NUMBER

Have the product container or label available when calling a poison control center or medical doctor, or when going for treatment. You may also contact **800-123-4567** for emergency medical treatment informatio

FIRST AID

IF ON SKIN OR CLOTHING: Remove contaminated clothing immediately. Rinse skin immediately with clean, potable water for 15–20 minutes. Call a poison control center or medical doctor for further treatment advice. Call for emergency services if necessary.

IF SWALLOWED/ INGESTED: Call a poison control center or medical doctor immediately for treatment advice. Call for emergency services as instructed by medical personnel. Do not induce vomiting unless told to do so by the poison control center or medical doctor. Have the person sip clean, potable water if they are able to swallow (unless instructed otherwise by medical personnel). Do NOT give anything by mouth to an unconscious person.

(continued)

The Pest Eliminator 30 SG Insecticide

IF IN EYES: Hold eye open and rinse slowly and gently with clean, potable water for 15–20 minutes. Remove contact lenses (if present) after the first five minutes, and continue rinsing eye. Call a poison control center or medical doctor for further treatment advice. Call for emergency services as instructed by medical personnel.

IF INHALED: Move person to fresh air or provide ventilation if you are unable to move the person. If the person is not breathing, call 911 and administer CPR (artificial respiration) if you are able. Call a poison control center or medical doctor for further treatment advice.

PRECAUTIONARY STATEMENTS

HAZARDS TO HUMANS AND ANIMALS

This chemical formulation is harmful if swallowed or absorbed through the skin. Use proper protection to prevent contact with eyes, skin, or clothing. Wash thoroughly with soap and water after handling. Wash thoroughly before eating, drinking, chewing gum, using tobacco, or using the toilet. Contaminated clothing should be washed separately from other laundry.

PERSONAL PROTECTIVE EQUIPMENT (PPE)

Applicators and handlers must wear the following PPE:
Long-sleeved shirt and long pants
Rubber boots with socks
Eye protection (goggles or mask)

USER SAFETY REQUIREMENTS

User must follow manufacturer's instructions for cleaning and maintaining PPE. If no such instructions are available for washables, use detergent and hot water to clean contaminated PPE. Wash and store PPE separately from other laundry.

USER SAFETY RECOMMENDATIONS

- Always wash hands with soap and water before eating, drinking, chewing gum, using tobacco, or using the toilet.
- Remove clothing immediately if insecticide comes in contact with or soaks through clothing. Wash contaminated skin thoroughly and put on clean clothing.
- Wash the outside of gloves before removing. Remove PPE immediately after handling this product. Thoroughly wash and change into clean clothing as soon as possible.

ENVIRONMENTAL HAZARDS

Due to the persistence of residues and the potential residual toxicity in nectar and pollen, this product is toxic to honeybees. Do *not* use during pollination.

This product is toxic to aquatic invertebrates. Do *not* apply directly to water, or to areas where surface water is present. Do *not* apply when weather conditions favor drift from treated areas. Do *not* dispose of equipment wash waters into a natural drain or water body.

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Figure 33-10. Identify the parts of the illustrated label.

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.

Active Ingredients

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

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 have been used as a symbol of warning on containers, such as those filled with poison.

Jess Kraft/Shutterstock.com

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 dangerous pesticide that has more potential to affect human health negatively.
- **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 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.

The directions for use help the applicator understand the purpose of the product and what pests it is designed to control, **Figure 33-11**. 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 nontarget 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.

mrfiza/Shutterstock.com

Figure 33-11. 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.

Corner Question 33E

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

STEM Connection

Pesticides and Beneficials: The Wilsonville Bee Kill

Kate Scott/Shutterstock.com

What pesticide use resulted in the death of thousands of bumblebees? In 2013, a large bee kill occurred in Wilsonville, Oregon, an area in which many horticultural crops are cultivated. A maintenance crew sprayed a product containing dinotefuran on 55 blooming linden trees in a shopping center parking lot to control aphids. As bees are the primary pollinators for linden trees, many were collecting pollen from the new blooms. The dinotefuran killed an estimated 40,000 bumblebees. The misuse of the pesticide resulted in a loss of at least 150 bee colonies in the local ecosystem.

Dinotefuran is classified as a neonicotinoid, which is a systemic chemical absorbed into the plant tissues. These long-lasting chemicals can make the plants themselves toxic to insects. There was a temporary ban of the chemical's use in the United States, but it is currently labeled for use in landscape settings. The chemical is banned in Europe.

Consider This

1. What other pesticides are harmful to beneficial insects, such as the bumblebee?
2. Are there any controls in place to prevent another large bee kill?
3. Are the pesticides, such as neonicotinoids, found in honey or other foods?
4. Which flowers, fruits, and other food crops depend on bees for pollination?
5. What examples of environmental damage can you find to justify the ban of a specific chemical used in weed or pest control?

Safety First

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 nontarget populations. Unintentional contamination through pesticide application is the fault of the applicator and is punishable by law.

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 the following:

- 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 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. PPE that should be worn during pesticide application includes long-sleeved shirts, goggles, long pants, shoes, socks, and nonpermeable gloves. 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.

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).

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)

Safety First

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 two 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.

Safety First

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. Know what you need to wear to protect yourself, and wear the PPE even if it is uncomfortable.

Hands-On Horticulture

Biopesticide Application

Finding a chemical pesticide that can be used with little to no restricted entry interval (REI) time can prove to be difficult. Often, chemical applications require a defined amount of time after application before a person can reenter a treated area. Many biopesticides (derived from natural materials like minerals and living organisms) have relatively few environmental and nontargeted living organism hazards. Examples of biopesticides can include canola oil, baking soda, and hydrogen peroxide.

1. Identify a plant with an apparent disease or insect problem. Work to identify the problem correctly.
2. Research a biopesticide that can be applied to the infected plant.
3. If the biopesticide can be made at home, research an appropriate recipe or concentration of the biopesticide and determine how to apply. Use reputable resources like those found through colleges, universities, and government agencies.
4. If the biopesticide must be purchased, be sure to research a product and ensure it has an authentic EPA registration number and chemical label before purchase and application.
5. Apply the biopesticide to the infected plant material. Take a photo before the application of the plant. If there are insects observed, consider counting the population of the insects.
6. Apply the biopesticide to the infected plant material. Wait for 24 hours and take another image of the infected plant. What changes do you note? Is there a reduction in the number of insects present? How effective does this biopesticide appear to be?
7. Wait a week and reassess. Take another photo. Compare your 24-hour and one-week results. Did the application of the biopesticide yield positive results? Does another application need to be made? Do you need to try another method of pest control?

- Pesticide needed is 1 ounce of pesticide per 1000 ft^2 (304.8 m^2). Thus, 2 ounces of pesticide is needed. The pesticide must be diluted to 0.5 ounce per 1 gallon of water. Thus, if 2 ounces were 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. Safety protocols include the following:

- 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

Safety First

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.*

pesticide-soaked material into a garbage bag, and dispose of it according to the pesticide storage and disposal section of the label.

Applying Pesticides

Always assess the surrounding environment before application of a pesticide begins. Thoroughly read the 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 when 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.

Applying insecticides during the appropriate part of an insect's life cycle is essential for the chemical to work effectively. Identifying the pest correctly 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 essential.

USDA Agricultural Research Service

Figure 33-12. Some pesticides are effective only 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

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 an REI of zero hours while others may have an REI of up to 48 hours.

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.

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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.

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 the following:

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

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.

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.

Lethal Dose

A measurement used to determine the amount of acute oral and dermal toxicity is ***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 toxicity becomes higher as the LD_{50} number becomes lower. 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 ***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.

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. Pesticides with greater toxicity have a greater REI:

- **Toxicity I chemicals**—The signal words *danger* and *danger-poison* are included on the pesticide label, as well as the skull and crossbones symbol. 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 the following:

- 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.

Safety First

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 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 the Statement of Practical Treatment on the pesticide label.

First Aid

First aid should precede, but never replace, professional medical assessments and treatment. Once first aid has been administered, call **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 to 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.

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. Open the windows and doors to ventilate an enclosed space if you cannot move the person. 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 33-14**.

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, you must also receive medical attention.

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Figure 33-14. Learning and knowing CPR and other first-aid procedures can help in treating a person who has been poisoned.

Storage and Disposal

The storage and disposal of a pesticide are as potentially harmful to human and environmental health as improper mixing or application. When considering how to store a pesticide safely, keep the following 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.

Safety First

Rinsing Pesticide Containers Safely

Follow these guidelines to rinse pesticide containers safely:

1. While wearing PPE, 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 the 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.

- Store pesticides in a temperature-regulated facility.
- Store pesticides in a locked cabinet or storage facility.
- Keep pesticides in their original containers.
- 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 essential 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. Always keep the pesticide label with the pesticide in its original container. If you must dispose of a pesticide, consider the following:

- Contact other growers or gardeners who may have use for any leftover pesticides.
- 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.

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 in Pesticide Management and Safety

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.

Pesticide Formulation Chemist

A pesticide formulation chemist researches the use and development of safer chemicals to combat insects, diseases, weeds, and other pests. A formulation chemist may be employed by a college or university, government agency, or a private company. This type of chemist may be a laboratory technician, research assistant, or scientist, depending on the amount of education and training he or she has received. Along with chemical formulations, the chemist may analyze chemicals and be involved in quality control. There are many opportunities for chemists in the pesticide industry. The US Bureau of Labor Statistics places the annual salary range for this position at $60,000 to $81,000. Salaries vary by experience, education, geographical location, and employers.

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. The current median annual salary is $72,000.

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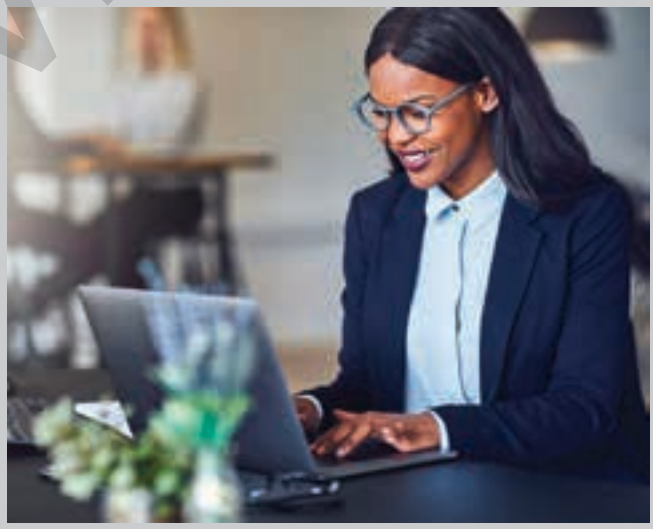

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Chapter 33 Review and Assessment

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 essential 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.
- Proper 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.

Vocabulary Review

Match the vocabulary terms listed in the *Words to Know* to the correct definition.

A. active ingredient
B. acute toxicity
C. agricultural pest
D. algaecide
E. biochemical pesticide
F. biopesticide
G. chronic toxicity
H. contact pesticide
I. EPA registration number
J. fungicide
K. insecticide
L. LC_{50}
M. LD_{50}
N. miticide
O. molluscicide
P. nematicide
Q. pesticide formulation
R. restricted entry interval (REI)
S. rodenticide
T. signal word
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 nontoxic, 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?
   A. An unknown factor affecting only plants
   B. An insect, disease, weed, or animal that attacks a crop or food source and causes damage
   C. A food source that causes damage to other organisms to help farmers
   D. An animal that attacks a crop or food source and causes damage
2. What is integrated pest management?
   A. An approach to managing pests that uses common sense
   B. An approach that includes economical practices
   C. A control method that results in the least possible hazard to people, property, and the environment
   D. All of the above
3. What are pesticides?
   A. Chemicals used to destroy pests that attack plants, animals, and other organisms
   B. Biological chemicals used to destroy all pests
   C. Synthetic chemicals used to destroy all pests
   D. Organisms used to destroy all pests
4. Which of the following is *not* a type of pesticide used to control selected or target pest populations?
   A. Miticides
   B. Insecticides
   C. Homicides
   D. Fungicides
5. What is the intended purpose for an herbicide?
   A. Kills plants
   B. Kills weeds
   C. Kills edible herbs
   D. Prevents plant injury
6. Which of the following is a type of biopesticide?
   A. Plant Incorporated Protectants (PIPs)
   B. Biochemicals
   C. Biomicrobials
   D. All of the above.
7. What is an alternative method to controlling slugs other than molluscicides?
   A. Slugs can be controlled using diatomaceous earth
   B. Placing a copper barrier around plants
   C. Planting clover as an alternate food source
   D. All of the above.
8. What of the following describes a plant-incorporated protectant?
   A. They come from plants that produce pesticidal substances from within the plant due to chemical regulation.
   B. They come from plants that produce pesticidal substances from within the plant due to transgenic modifications.
   C. Bt cabbage produces a nerve toxin called *Bacillus thuringiensis* within the plant via genetic modification.
   D. Bt corn produces a nerve toxin called *Bacillus thuringiensis* within the plant via sexual propagation.

9. Which of the following substances can be included in a pesticide formulation?
   A. Carriers
   B. Active ingredients
   C. Adjuvants
   D. All of the above.
10. Which of the following is *not* a formulation in which pesticides are available?
   A. Aerosols
   B. Liquid concentrates
   C. Adjuvants
   D. Dust
11. *True or False?* If someone knowingly does not follow the directions of the pesticide label, they can be criminally prosecuted.
12. *True or False?* Some of the most pertinent information on the pesticide label includes trade, common, and chemical names; EPA registration number; active ingredients list; signal words; precautionary statements; and disposal information.
13. *True or False?* Signal words have specific meanings: *danger* is the least harmful to human health while *caution* is the most dangerous type of pesticide that is only available for use by licensed or certified pesticide applicators.
14. *True or False?* Only specially trained and certified applicators may apply restricted pesticides.
15. What are some safety protocols that should be followed when mixing pesticides?
16. When is the best time of day to apply pesticides in a garden and why?
17. *True or False?* Poisoning occurs through eye contact, oral contact, dermal contact, or inhalation.
18. What are five symptoms of poisoning?
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 acre if the pesticide used should be applied at a rate of 0.25 fluid ounce 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 *for* **ALL** *Opportunities*

1. **Foundational: Career Exploration and Planning SAE**—The pesticide industry presents endless prospects for those interested in pest management. Create a list of occupations in pest management and identify two or three that interest you. Next, research the requirements of these occupations and create a list of paths to obtain this occupation. Determine if you will need on-the-job training or need to further your education in a community college or four-year college or university. Connect the requirements, skills, safety, salary, and benefits and assess personally pursuing a career in this pathway. Finally, identify local pest management companies that you could contact for an interview or future internship.
2. **Immersion: Entrepreneurship SAE**—Develop a biopesticide for a pest local to your growing region. Sell this product at a local farmers market or via a social media outlet.
3. **Immersion: Placement SAE**—Get a job working for a garden supply store and specialize in pest management.
4. **Immersion: Service Learning SAE**—Work with your school, local extension agents, and a waste management company. Use your school as a site for an annual pesticide collection and disposal site.
5. **Immersion: School-Based Enterprise SAE**—Develop virtual learning modules in Spanish and English for local farms and growers to educate their employees about pesticide safety. Sell access to the training modules.
6. **Immersion: Research SAE**—Compare the efficacy of a biopesticide (biochemical) using various concentrations of the product.

SAE *for* **ALL** *Check-In*

- How much time have you spent on your SAE this week?
- Have you logged your SAE hours?
- What challenges are you having with your SAE?
- How can your instructor help you?
- Do you have the equipment you need?