PESTICIDE APPLICATION TRAINING

General Manual

KANSAS STATE UNIVERSITY

Extension

General Manual

Table of Contents

Using this Manual

This is a self-teaching study manual. Each chapter begins with a set of learning objectives that help you focus on what you should learn from the chapter. By reading this manual and obtaining an understanding of the competencies, you should be able to gain sufficient knowledge to aid in passing the Kansas Commercial Pesticide Applicators Certification or Recertification Examination.

Certification Procedures

This manual is written to assist people who are preparing themselves for an examination over the General Standards portion of the Commercial Pesticide Applicators Certification Examination. State and federal regulations specify that an individual must meet certain standards of competency relating to both general and specific topics before they are allowed to apply or supervise the application of restricted use pesticides (RUPs). The General Standards portion of the examination must be completed successfully by all categories of commercial pesticide applicators. Therefore, this manual may contain information over topics that do not directly relate to your specific categories or types of application work.

By law, "pesticide" means, but is not limited to, (1) any substance or mixture of substances used to prevent, destroy, control, repel, attract, or mitigate any pest (including weeds and diseases) and (2) any substance or mixture of substances intended to be used as a plant regulator, defoliant, or desiccant.

Pesticides are classified by the U.S. Environmental Protection Agency (EPA) as either restricted use or general use (not restricted). An applicator certification is required when an RUP is used. Under the Kansas Pesticide Law, a "certified commercial applicator" means a certified applicator, whether or not the individual is a private applicator with respect to some uses, who uses or supervises the use of any pesticide that is classified for restricted use for any purpose or on any property other than that provided for in the definition of "certified private applicator." A "certified private applicator" is one who uses or supervises the use of RUPs for purposes of producing an agricultural commodity (1) on property owned or rented by the individual or such person's employer, or (2) on the property of another for no compensation than trading of personal services between producers.

Commercial certification may not be necessary if RUPs are used:

- within the authority granted by a private applicator certification;
- under the supervision of a certified commercial applicator (this does not apply to aerial applicators or where supervision is prohibited by label direction or other legal authority);
- by veterinarians or physicians as part of their professional services; or
- by laboratory personnel in pesticide research.

To qualify for commercial certification, you must:

- be at least 18 years old;
- preregister for examinations online;
- pass the "General Exam" (topics covered by this manual), plus an exam in at least one category/subcategory of application; and
- pay the required fees. (Applicants who fail a specific category exam may take another exam upon paying an additional exam fee. Fees are $45 per exam, including the general exam and any exam retakes.)

Upon meeting the qualifications for certification, a certificate and a pocket card will be issued by the Kansas Department of Agriculture (KDA). Your certification will expire on December 31 of the second calendar year following the year it was issued. For example, if you are issued your certificate on June 1, 2025, it will expire on December 31, 2027.

Completing one of two options can obtain recertification:

1. Passing the general exam, plus an exam in at least one category/subcategory of application.

2. Attending one or more pesticide applicator recertification training program(s) approved by KDA (no examination required).

To qualify for recertification, you must submit an application and pay the applicable fees, or, if eligibility requirements are met, renew your certification online through the KDA portal. Note that if the required training credits were not earned during your effective period of certification, or if you fail to renew in a timely manner, then you forfeit all earned training credits and must retake and pass the general exam plus at least one category/subcategory to recertify.

Certification in another state does not replace the requirement for a pesticide applicator to have a Kansas Commercial Applicator Certification. Kansas has entered into reciprocal agreements with certain states, whereby commercial certification in any of those states may be used in lieu of passing Kansas commercial certification exams. However, the applicator is required to complete the other requirements for Kansas certification, including submitting an application and paying the required fees. Supplemental details on reciprocal certification are available from the Pesticide and Fertilizer Program of the Kansas Department of Agriculture.

Pesticide Business License

Do not confuse your commercial applicator certification with a Kansas Pesticide Business License. A Pesticide Business License is required to (1) advertise, offer for sale, sell, or perform any service for the control of a pest on the property of another or apply a pesticide on the property of another within the state; or (2) perform any service for the control of a pest or apply any pesticide on or at the premises of another person under any commission, division of receipts or subcontracting arrangement with a licensed pesticide business. Obtaining this Pesticide Business License has different procedures and requirements from those for becoming a certified commercial pesticide applicator. In brief, there are four requirements to obtain the business license:

1. Fill out the application form and list all current employees who will be applying pesticides (you must have at least one person certified in the categories/subcategories of business).
2. Pay the required fees of $140 per category (calendar year basis).
3. Obtain proof of financial responsibility.
4. Submit application and fees to the KDA.

Additional information on the Kansas Pesticide Business License can be found in the chapter on Laws and Regulations in this manual or from the KDA website: www.agriculture.ks.gov.

Pest Management

Learning objectives:

- **Define the term "pest."**
- **List the four main groups of pests and give an example of each.**
- **Explain the importance of pest identification.**
- **Define the term "Integrated Pest Management."**
- **Explain the importance of recognizing specific types of damage.**
- **List and describe general methods of pest management.**
- **Discuss the advantages and disadvantages of chemical pest control.**

Principles of Pest Control

Civilization has been combating insects and other pests throughout history. Records contain many examples of how pests have had major impacts on humans, including the bubonic plague and the Irish potato famine. The competition between humans and pests has evolved over time and so have the methods of control.

We often talk about the "war" against insects, plant diseases, weeds, and rats. Yet, in our struggle against pests, how often do we use the handiest or least expensive pesticide? How often do we forget to consider other methods or combinations of methods? How often do we forget about the effects on the environment? It is important to think about all these questions when addressing pest issues.

Using a combination of methods to control pests is basic to all pest control. Modern pest control uses all available methods to keep pests below economically harmful levels and minimize damage to the environment in the process.

The challenge lies in our ability to control pests to minimize injury and to recognize when direct action, such as a pesticide application, is necessary.

A **pest** is an organism that:

- competes with humans, domestic animals, or crops for food, feed, or water;
- injures humans, animals, crops, structures, or possessions;
- transmits disease to humans, domestic animals, or crops; or
- annoys humans or domestic animals.

Pests can be placed in four main groups:

1. invertebrates (insects, mites, ticks, spiders, mollusks (snails and slugs))
2. disease agents or pathogens
3. weeds (undesirable plants)
4. vertebrates (birds, reptiles, amphibians, fish, rodents, and other mammals)

As a certified applicator, you must be familiar with the pests likely to be encountered in the area covered by your certification category. To be able to identify and control the pests, you need to know about some aspects of:

- the common features of pest organisms,
- characteristics of the damage they cause, and
- pest development and biology.

Before trying to control a pest, you need to be able to accurately identify it. Misidentification and lack of information about a pest could cause you to choose the wrong control method or apply the control at the wrong time. Identification aids, publications, website links, and pictures are available from your Cooperative Extension Service agent, or you can ask other experts for advice.

To solve pest problems, the applicator must:

- identify the pest,
- know what control methods are available,

- evaluate the benefits and risks of each method or combination of methods,
- choose the methods that are most effective and will cause the least harm to people and the environment,
- use each method correctly, and
- observe local, state, and federal regulations that apply to the situation.

The most important principle of pest control is this: Use a pesticide only when necessary and at the lowest labeled rate that will prevent the pest from causing more damage than is reasonable to accept.

Even though a pest is present, it may not do very much harm. It could cost more to control the pest than would be lost because of the pest's damage.

The three main objectives of pest control are:

1. **prevention**, or keeping a pest from becoming a problem;
2. **suppression,** or reducing pest numbers of damage to an acceptable level; and
3. **eradication**, or destroying an entire pest population from a limited defined area.

Integrated Pest Management

Integrated Pest Management (IPM) is a strategy designed to manage pest populations to achieve a balance between costs and returns on investment and the overall environment. IPM practices include cultivation, changes in cropping sequence, barriers, use of tolerant varieties, sanitation, traps, beneficial insects, timely planting and harvesting, and judicious use of pesticides. IPM is associated with growers considering all pest management practices and using one or more cost-effective practices that are least disruptive to the environment.

Use of IPM practices is based on information affiliated with the pest problem, such as the numbers and kinds of pests. Inadequate knowledge or improper diagnosis of a pest problem results in a waste of time and money and inadequate management.

Management Tests

IPM must be practical and tailored to each pest problem. Three tests of practicality are:

1. Is the control available for use?
2. Does the practice fit the entire crop or management program?
3. Is the management cost-effective?

The third factor is the basis of two concepts: economic injury level and economic threshold. Economic injury level is the lowest number of pests that will cause injury equal to the cost of applied management practices. Economic threshold is the pest number or density at which management practices should be implemented to prevent pests from exceeding the economic injury level. The economic threshold is generally lower than the economic injury level so management practices can be implemented to prevent pest populations from reaching damaging levels.

Pest Control Methods

Using a combination of methods to control pests is basic to all pest control. The combination of methods you choose will depend on the kind and amount of control you need. Successful pest control is based on the ability to:

- keep pest damage to a minimum by choosing an appropriate combination of control methods;
- recognize when direct action, such as a pesticide application, is necessary; and
- create the least damage to the environment.

Natural Forces

Some natural forces or controls act on pests, causing the populations to rise and fall. These natural forces act independently of humans and may either help or hinder pest control. You usually cannot alter the action of natural forces on a pest population, but you should be aware of their influence and take advantage of them whenever possible. Some forces affecting the pest population include climate, natural enemies, topography, and food and water supply.

Climate

Weather conditions—especially temperature, day length, and humidity—affect pests' activity and their rate of reproduction. Pests may be killed or suppressed by rain, frost, freezing temperatures, drought, or other adverse weather.

Climate also affects pests indirectly by influencing the growth and development of their hosts. The population of plant-eating pests is related to growth of the host plants. Unusual weather conditions can change normal patterns and result in increased or decreased damage.

Natural Enemies

Birds, reptiles, amphibians, fish, mammals, and predatory and parasitic insects feed on some pests and help control their numbers. More than half of all insect and insectlike species feed on other insects, some of which are pests. Disease organisms often suppress pest populations.

Topography

Features such as mountains and large bodies of water restrict the spread of many pests. Other features of the landscape can have similar effects. Soil type is a prime factor affecting wireworms, grubs, nematodes, and other soil organisms. Some pests live in heavy, poorly drained soil, but others inhabit light, sandy soils. Soil type also affects the distribution of plants (including weeds), which in turn affects the population of insects and other plant pests.

Food and Water Supply

Pest populations can thrive only as long as their food and water supply lasts. Once the food source—plant or animal—is exhausted, the pests die or become inactive. The life cycle of many pests depends on the availability of water.

Agricultural Forces

Unfortunately, natural forces or controls often do not control pests quickly enough to prevent unacceptable injury or damage and other pest control methods must be initiated. Available methods include:

- host resistance
- biological control
- cultural control
- mechanical control
- sanitation
- chemical control

Host Resistance

Some crops, animals, and structures resist pests better than others. Some varieties of crops, wood, and animals are immune to or tolerant of certain pests. Use of resistant types helps keep pest populations below harmful levels by making the environment less favorable for the pests. Host resistance works in two main ways:

1. Chemicals in the host prevent the pest from completing its life cycle.
2. The host is more vigorous or tolerant than other varieties and thus less likely to be seriously damaged by pest attacks.

Biological Control

Biological control involves the use of naturally occurring enemies—parasites, predators, and disease agents (pathogens). It also includes methods by which the pest is biologically altered, as in the production of sterile males and the use of pheromones or juvenile hormones. Most kinds of biological control agents occur naturally. Releasing more of a pest's enemies into the target area can supplement this natural control.

Biological control is never complete. The degree of control fluctuates. There is always a time lag between pest population increase and the corresponding increase in natural controls, but under proper conditions, sufficient control can be achieved to eliminate the threat to the crop or animal to be protected. Biological control can be a low-cost control method particularly suited to low-value crops (pastureland, clover, and hay crops) or in areas where some injury can be tolerated (golf course fairways, forest areas).

Cultural Control

Cultural practices are agricultural practices used to alter the environment, the condition of the host, or the behavior of the pest to prevent or suppress an infestation. Planting, growing, harvesting, and tillage practices sometimes can be manipulated to reduce pest populations. Other practices such as crop or pasture rotation, varying the time of planting, and use of trap crops also affect pests.

Mechanical Control

Devices and machines used to control pests or alter their environment are called mechanical controls. Traps, screens, barriers, radiation, and electricity can sometimes prevent the spread of pests or reduce an infestation. Lights, heat, and refrigeration can alter the environment sufficiently to suppress or eradicate some pest populations.

Sanitation

Sanitation practices help to suppress some pests by removing sources of food and shelter. Other forms of sanitation that help prevent pest spread include using pest-free seeds or plants and decontaminating equipment, livestock, and other possible carriers before allowing them to enter a pest-free area.

Chemical Control

A pesticide is defined as any material that is applied to plants, soil, water, harvested crops, structures, clothing and furnishings, or animals to kill, attract, repel, or regulate or interrupt the growth and mating of pests, or to regulate plant growth. Pesticides can be either naturally derived or synthesized. Pesticides include a wide assortment of chemicals with specialized names and functions.

Major benefits associated with the use of pesticides are their effectiveness, the speed and ease of controlling pests, and in many cases, their reasonable cost compared with other control options. Usually, pest damage stops or pests are destroyed within a few hours (for insects) to a few days (for weeds) after application of a pesticide. It is important to choose the best chemical for the job.

By selecting pesticides wisely and applying them correctly, a responsible pesticide applicator can use these chemicals for the benefit of the environment.

Pest Resistance to Pesticides

Pesticide resistance can be defined as the ability of an insect, fungus, weed, rodent, or other pests to tolerate a pesticide that once controlled it. Resistance develops because intensive pesticide use kills the susceptible individuals in a population, leaving only the resistant ones to reproduce. Resistant pests require applications that are more frequent and the use of higher labeled rates to achieve control. Resistance is important to consider when planning pest control management programs that rely on pesticides.

Managing pesticide resistance is a very important aspect of IPM. Monitor pest populations carefully and treat only when necessary, rather than treating on a calendar basis. Continual use of pesticides with the same mode of action will increase the likelihood that resistance will develop, so rotating the mode of action is important. Good pesticide application records are also an important component of resistance management.

Not every pesticide failure is caused by pest resistance. Make sure that you have used the correct pesticide at the correct dosage and that you have applied the pesticide correctly. Remember pests that are present may be part of a new infestation occurring after the chemical was applied.

Factors Affecting Pesticide Use Outdoors

Soil factors: Organic matter in soils may "tie up" pesticides, limiting their activity. Soils with high organic matter content from crop residue may need higher rates of pesticides for best control.

Soil texture also affects the way pesticides work. Soils with fine particles (silts and clays) have the most surface area and may need higher rates for total coverage. Coarser soils (sands) have less surface area, so use lower rates on those soils.

Surface moisture: Pesticides work best with moderate surface moisture. Wetness may keep the pesticide from adequately contacting the protected surface. Dryness may prevent the pesticide from spreading evenly over the surface and contacting the target pest.

Rain may interfere with pest control by causing pesticides to run off or to leach down through the soil. Rain during or soon after over-the-top or foliar applications may wash pesticides off the plant. However, some protectant fungicides are sometimes purposely applied just before periods of expected high humidity and light rain. When preemergence pesticides are applied to the surface, moderate rainfall aids in carrying them down through the soil to the pests. Rain may also release pesticide action after some granular applications.

Humidity and temperature: Humidity also affects the way pesticides work. Herbicides often work best when weeds are growing fast—usually in high humidity and optimum temperature. However, these same conditions may make the protected plant more susceptible to pesticide injuries.

High temperature and sunlight will cause some pesticides to break down when they are left exposed on top of the soil or on other sur-

faces. Low temperatures may slow or stop the activity of some pesticides.

Wind: Wind speed and direction can greatly alter the effectiveness of a pesticide application. Excessive wind can blow the pesticide off target and result in inadequate control. Even moderate winds can greatly alter the coverage of ultra-low volume (ULV) concentrate solutions and mist blower applications. Sometimes the applicator can compensate for minor winds by applying pesticides at an angle where the winds blow the chemical toward the area to be protected.

Invertebrates

Insects

There are more insects on earth than all other living organisms combined. Insects are found in soil, water, hot springs, snow, air, and inside plants and animals.

Insects can be placed into three categories according to their importance.

1. **Insects of minor importance:** About 99 percent of all insects are considered of minor importance. They are food for birds, fish, mammals, reptiles, amphibians, and other insects.

2. **Beneficial insects:** These are predators and parasitoids (parasitic wasps) that feed on pest insects, mites, and weeds. Examples include ladybird beetles, predatory bugs, ground beetles, tachinid flies, praying mantids, parasitoids (parasitic wasps), and predatory mites. Pollinating insects, such as bumble bees and honey bees, moths, butterflies, and beetles are considered beneficial insects.

3. **Pest insects and mites:** These are insects and mites that feed on, cause injury to, or transmit disease to humans, animals, plants, food, fiber, and structures. Aphids, beetles, fleas, mosquitoes, caterpillars, spider mites, and termites are considered pest insects and mites.

Physical Characteristics

All insects have three pairs of jointed legs, and they have three body regions: head, thorax, and abdomen.

Head

The head supports the antennae, eyes, and mouthparts. The antennae vary in size and shape and can help in identifying some insect pests. Insects have compound eyes that consist of many individual eyes. Compound eyes allow insects to detect motion.

The four general types of mouthparts are:

1. chewing
2. piercing-sucking
3. sponging
4. siphoning

Chewing mouthparts are associated with biting or feeding on a food source. Cockroaches, ants, beetles, caterpillars, and grasshoppers have chewing mouthparts. **Piercing-sucking mouthparts** consist of a long slender tube that is inserted into plant or animal tissue to withdraw plant fluids or blood. Stable flies, lice, bed bugs, mosquitoes, true bugs, and aphids have piercing-sucking mouthparts. **Sponging mouthparts** are affiliated with a tubular tonguelike structure with a spongy tip that sucks up liquids or soluble food. Flesh flies, blow flies, and house flies have sponging mouthparts. **Siphoning mouthparts** consist of a long tube for feeding on nectar. Butterflies and moths have siphoning mouthparts.

Thorax

The thorax supports the three pairs of legs and (if present) wings. The various sizes, shapes, and textures of wings and the vein pattern can be used to identify certain insect species.

Abdomen

The abdomen is usually composed of 11 segments. Along each side are openings called spiracles through which insects breathe. In some insects, the tip end of the abdomen has taillike appendages.

Reproduction and Development

Insect reproduction is initiated when males mate with females; however, the females of some aphids and parasitoids (parasitic wasps) produce eggs without mating. Some insects give birth to living young, but most female insects lay eggs. Temperature, humidity, and light are factors that can influence when larvae or nymphs emerge. Eggs are various sizes and shapes, such as elongated, round, oval, and/or flat. Eggs of cock-

roaches, grasshoppers, and praying mantids are laid in pods or clusters. Eggs may be deposited singly or in masses on or near the host in soil or on plants, animals, or structures.

Metamorphosis

The changes in form an insect undergoes when developing from egg to adult is called metamorphosis.

Young that emerge from an egg or eggs are called larvae, nymphs, or naiads. After feeding, the young develop to a point where their skin (cuticle) cannot stretch any further. Consequently, the young undergo a molt and form new skin. The number of instars (stages between each molt) varies depending on the insect species and, in some cases, may vary depending on the temperature, humidity, and availability and types of food. The different types of metamorphosis are described below.

No Metamorphosis

Some insects do not change in form except in size between emerging from eggs and reaching the adult stage. Insects increase in size with each successive molt until they reach the adult stage. Silverfish, firebrats, and springtails are examples of insects that exhibit no metamorphosis. The food and habitats of the young are similar to those of the adult.

Gradual or Incomplete Metamorphosis

Insects that undergo gradual metamorphosis have three life stages: egg, nymph, and adult. The nymphs resemble adults, eat the same food source, and occupy the same habitat. Only adults have fully functional wings. Cockroaches, lice, termites, aphids, and scales are examples of insects that undergo gradual metamorphosis.

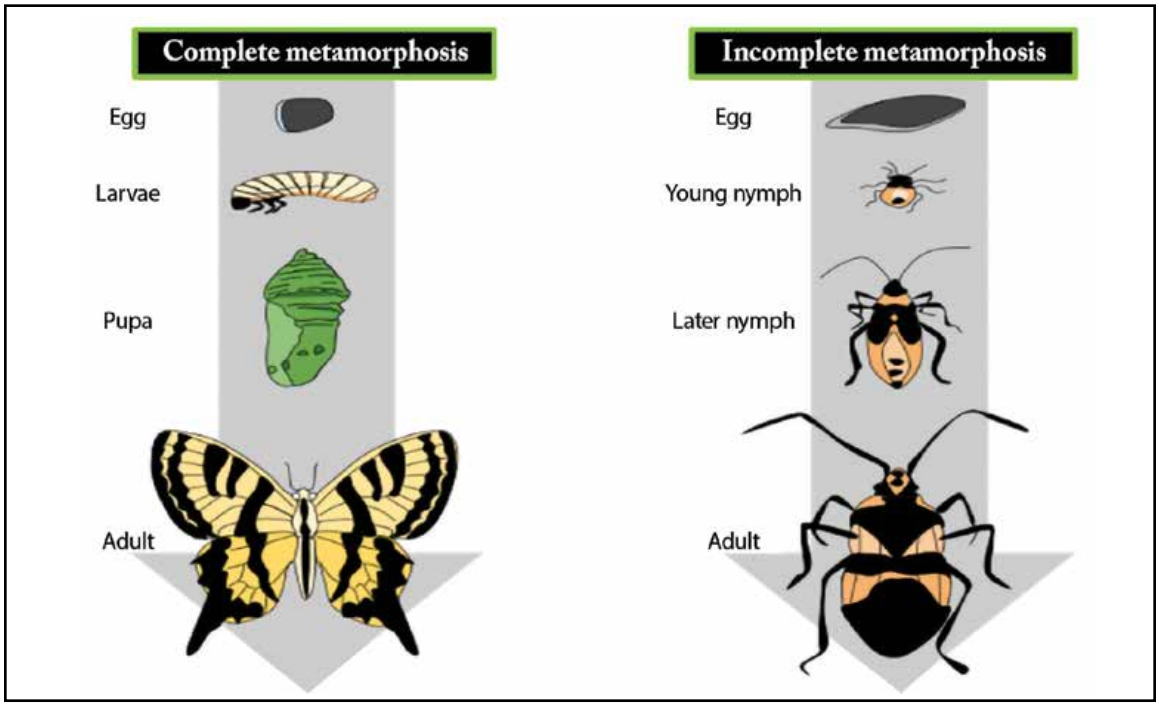
Insects that undergo incomplete metamorphosis transition through three life stages: egg, naiad, and adult. The adult looks like the young, but the naiads are aquatic. Examples include dragonflies, mayflies, and stoneflies.

Complete Metamorphosis

Insects that undergo complete metamorphosis transition through four life stages: egg, larva, pupa, and adult. The larva is often called a caterpillar, maggot, or grub and looks different from the adults. They usually inhabit different locations and in many cases feed on different food sources than adults. Examples include beetles, butterflies, flies, mosquitoes, fleas, bees, and ants.

Larvae emerge from the egg then increase in size by molting through one to several instars. Moth and butterfly larvae are called caterpillars; some beetle larvae are called grubs; and fly larvae are called maggots. Caterpillars often have legs; maggots are legless.

The pupa is a resting stage during which the larva changes into an adult with legs, wings, antennae, and functional reproductive organs.



Complete and incomplete metamorphosis

Insectlike Arthropods

Arachnids

Ticks, scorpions, spiders, and mites have eight legs and only two body regions. They are wingless and lack antennae. Metamorphosis is gradual and includes both larval and nymphal stages. Six-legged larvae emerge from eggs, become eight-legged, and then become adults. Ticks and mites have modified piercing-sucking mouthparts, while spiders and scorpions have chewing mouthparts.

Crustaceans

Sowbugs and pillbugs, water fleas, and wood lice have 14 legs. They are wingless and contain only one segmented body region. They have two pairs of antennae and chewing mouthparts. Sowbugs and pillbugs have a hard, protective shell-like covering. Metamorphosis is gradual, and individuals may progress through up to 20 instars before becoming an adult.

Centipedes and Millipedes

Centipedes have 30 body segments, each containing one pair of legs. They have chewing mouthparts and can inflict painful bites to humans.

Millipedes have 30 body segments and are cylindrical shape. Each body segment has two pairs of legs. The antennae are short, and mouthparts are comblike. Millipedes feed on decaying organic matter, seeds, bulbs, and roots.

Insect Management and Control

Insect management involves an understanding of the insect's life cycle and the most vulnerable life stage. Managing insects is difficult when they are an egg or pupa, because these stages are inactive; they are not feeding, are immobile, and are inaccessible because they are underground, in cocoons or cases, or in cracks or crevices.

Managing insects in the late instar and adult stages is effective; however, larger insects are more difficult to kill with pesticides, and adult females may have laid eggs for the next generation. Insect pests are easier to manage when larvae and nymphs are small.

Insect management requires monitoring pest populations and understanding the pest's life cycle, habitats, and feeding behaviors.

Environmental conditions, such as humidity, temperature, and moisture can alter insects' rate of growth and affect the duration of their life cycle.

Insect management strategies include host plant resistance, biological control, cultural control, mechanical control, sanitation, and pesticides.

Host Plant Resistance

Some crops, animals, and structures resist insects and their relatives better than others. Some varieties of crops and wood are nearly immune to certain insects. Use of resistant types helps keep pest populations below harmful levels by making the environment less favorable for the pests.

Biological Control

Biological control of insects includes:

- predators and parasitoids (parasitic wasps)
- entomopathogenic nematodes

Predators and Parasitoids feed on or attack insect (and insectlike) pests.

Entomopathogenic nematodes are slender, transparent, soft-bodied, non-segmented, microscopic roundworms that parasitize insects. They enter the insect host and release bacteria, which multiplies and kills the insect.

Cultural Control

Cultural control options include:

- crop rotation
- sanitation
- delay in planting
- timing of harvest

Crop Rotation

Rotating the planting of certain crops and alternating crop plantings may deprive pests of host plants. Crop rotations are effective against insects that have long life cycles and infest crops throughout the growing season.

Sanitation

Removing debris and harborages, such as cardboard, from around buildings will help manage pests, which use debris for breeding or shelter.

Sanitation is important in managing animal parasites and filth flies. Proper manure management will reduce problems with flies in and around barns and livestock pens. Fly management in residential areas involves weekly or biweekly removal of garbage, which will reduce populations.

Sanitation indoors can prevent insect pest problems. For example, keeping surfaces in restrooms and food preparation areas clean and dry and cleaning drains is important in managing or eliminating ant, fly, and cockroach infestations.

Delay in Planting

Delaying crop planting may reduce certain pest populations by eliminating host plants required for growth and reproduction. For example, preventing Hessian fly damage in wheat can be avoided by delaying the planting until fly production is completed.

Timing of Harvest

Crops should not remain in the field after maturity. For example, wireworm damage to mature potatoes increases if potatoes remain in the ground even for a short time after maturity.

Mechanical Control

Mechanical controls include:

- screens and barriers
- hand removal
- traps

Screens and barriers are designed to prevent insects from entering homes or attacking plants. Flying insects such as mosquitoes, wasps, and flies can be prevented from entering homes by covering openings with screening. Appropriate mesh size depends on the size of the smallest flying insect pest. Crawling insects can be prevented from entering homes by installing screens or other barriers over openings, such as doors and windows.

Hand removal involves physically removing insects such as caterpillars and beetles from plants. The destruction of insects and egg masses ensures quick control, but it must be performed before damage has occurred and before the development of the insects.

Traps are used to manage certain insect pests; however, traps are mainly used to monitor pest populations to determine when pest populations are present, which provides information on when management strategies should be implemented.

Biopesticides (Microbial Insecticides)

Pathogens such as bacteria, viruses, and fungi are available as biopesticides or microbial insecticides that are applied as sprays to manage certain insect populations. The most commonly available bacterial-based insecticides are *Bacillus thuringiensis* subspecies *kurstaki* for managing caterpillars and *Bacillus thuringiensis* subspecies *israelensis* for managing mosquitoes.

Pesticides

Pesticides used to manage insects and insectlike pests include insecticides, miticides, and acaricides. In general, pesticides work in one of five ways.

1. **Contact:** Active ingredient comes into direct contact with the pest.
2. **Systemic:** Active ingredient is absorbed by or transported through plants, making some or all of a plant toxic to insects.
3. **Translaminar:** Active ingredient does not have surface residues but moves into a leaf where a reservoir remains for a time.
4. **Stomach poison:** Active ingredient enters the target pest via feeding and passing through the digestive system. Control depends on the pest consuming the insecticide.
5. **Repellents:** Active ingredient keeps pests away from the area or specific host. Repellents are primarily used to protect humans from being bitten by mosquitoes, chiggers, and ticks.

Understanding the life cycle and biology of insect pests is important in determining the timing of and frequency of applying pesticides. One well-timed application may provide protection for an extended period. Repeat applications may be required, depending on the residual activity of the pesticide. Read the pesticide label for information on the rate of use and intervals of application.

Indoor insect management is designed to prevent pest problems while minimizing the exposure of humans and animals to pesticides. The most common application techniques are crack and crevice treatments, spot treatments, and fumigation of entire structures, commodities, or individual pieces of equipment.

Mollusks

Mollusks are a large group of land and water animals, including slugs and snails. They have

soft, unsegmented bodies and often are protected by a hard shell.

Snails and Slugs

Land snails and slugs are soft-bodied and have two pairs of antennaelike structures. Their bodies are smooth and elongated. Snails have a spiral-shaped shell into which they can completely withdraw for protection when disturbed or when weather conditions are unfavorable. Slugs do not have a shell and must seek protection in damp places.

Snails and slugs feed on plants at night. They tear holes in foliage, fruits, and soft stems using a rasplike tongue. They may eat entire seedlings. As they move, snails and slugs leave a slimelike mucous trail that dries into silvery streaks. These streaks are undesirable on floral and ornamental crops and on those portions of crops to be sold for human food.

Snails and slugs deposit eggs in moist, dark places. The young mature in a year or more, depending on the species. Adults may live for several years. They overwinter in sheltered areas and are active all year in warm regions and in greenhouses.

Controlling Mollusks

Mollusk pests on land (snails and slugs) can be controlled by many of the same techniques that are used to control insects outdoors. Effective techniques include:

- cultural practices, especially cultivation and trap crops;
- mechanical controls, especially traps and barriers;
- sanitation, especially eliminating crop debris and other sources of moisture; and
- chemicals. Many insecticide formulations also control mollusks and may be used if mollusks are listed as target pests on the label. Specific molluscicides are also available, usually as baits.

Plant Diseases

Plant diseases are caused by microscopic organisms including fungi, viruses, bacteria, and nematodes (microscopic worms). Plant diseases reduce crop quality and yield, causing losses to growers. Plant diseases can also affect the quality and function of landscape plants, turfgrasses, and plants in natural settings. Plant diseases cause many symptoms such as leaf spots, moldy grains, blights, fruit rots, and root rots. Plants can also be affected negatively by non-living stress factors such as drought, improper fertility, poor site conditions, or too much water. These non-living factors are sometimes called environmental stresses, abiotic stresses, or abiotic disorders.

This section will provide a general overview of plant disease biology, management, and diagnosis. Training manuals for specific plant systems such as agricultural crops or turfgrasses/ornamentals go into more details of specific diseases. Learning more details about the specific crops you manage will be important. University/extension fact sheets, newsletters, and reputable websites along with pesticide certification renewal classes and other training programs can provide ongoing education.

What Causes Plant Disease?

The organisms that cause plant diseases are called **pathogens**, and the study of plant diseases is called **plant pathology**. All plant species are susceptible to multiple diseases. By understanding some basic principles, you can prevent and manage plant diseases in an integrated fashion.

Four major groups of plant pathogens, including fungi, bacteria, nematodes, and viruses, are responsible for most of the common plant diseases in Kansas. These organisms can spread from plant to plant, causing outbreaks of disease within plantings. Plant pathogens have scientific genus and species names, but the plant diseases they cause often have common names that are easier to understand and remember. In the context of plant diseases, plants are referred to as "hosts." Understanding some of the basic characteristics of plant pathogens and how they interact with the plant host can provide important insights into plant disease management.

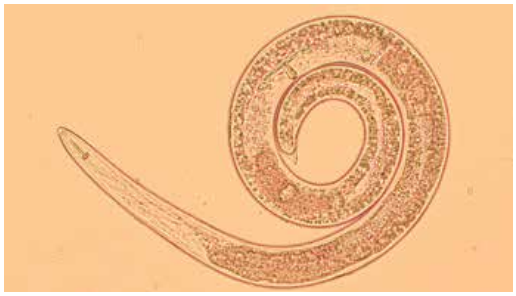
Plant diseases are recognized by the damage (symptoms) that they cause to the plant. Symptoms include spots, cankers, galls, wilts, mosaic patterns, stunting or other deformities. In some cases, the pathogen will produce structures that can be seen with an unaided eye. Other pathogens can be seen only with a hand lens or microscope. These visible pathogen structures are called **signs** of the disease.

- **Fungi** are the most common cause of plant diseases in Kansas. Plant pathogenic

fungi can infect fruit, flowers, leaves, stems, or roots and cause a variety of symptoms. Fungi tend to thrive in wet, humid conditions. Fungi reproduce through the production of microscopic structures called spores. The spores are spread throughout the environment by wind or rain splash. Some fungal diseases can be spread from plant to plant or field to field via insects and farm equipment. Many fungal plant pathogens survive between growing seasons by colonizing plant debris or by producing specialized survival structures.

Fungal spore strucures

- **Bacteria** are single-celled organisms that can multiply quickly under favorable conditions. Many bacteria enter plants through wounds or natural openings in the plants when conditions are favorable for infection. Like fungi, bacteria tend to thrive in wet, humid conditions. Bacteria can be moved by splashing rain, insects, and contaminated tools used in plant propagation. Some bacteria are seed-borne, and some can be introduced on transplants.
- **Viruses** are tiny particles composed of their genetic material (DNA or RNA) surrounded by a protein coat. They depend on the host cell machinery and cannot reproduce outside a living host. Plant viruses spread through different mechanisms, including pruning tools with contaminated sap, cutting/grafting, infected seed, mechanical handling, and/or insects and mites. Weeds can be important reservoirs of virus, meaning they may serve as "carry-over" bridges to cause new infections.
- **Nematodes** are microscopic, non-segmented roundworms. These tiny worms are common and can be found in nearly every environment. In the soil, most nematode species feed on bacteria and other small life forms. Some species of nematodes are plant pathogens. The nematodes that feed on plants have a needlelike feeding structure called a stylet, which is used to pierce and ingest the contents of plant cells. Most nematodes have a simple life cycle. They begin as eggs followed by juvenile and adult stages. Most plant pathogenic nematodes feed on the roots of plants. High nematode populations can severely damage a root system, resulting in plant stunting and yield loss. Root damage (symptoms) caused by nematode feeding can include root tip lesions, stubby or swollen roots, and root galls.



Nematodes

Types of Diseases and Symptoms

Diseases can be grouped based on the kinds of symptoms they cause. Some common examples are as follows.

- **Seed decay and damping-off** occur when fungi or other pathogens attack a plant shortly after planting. In some cases, the seed is destroyed by the pathogens before germination takes place. Seedlings are vulnerable to attack by many soilborne pathogens during germination and emergence. "Damping-off" is the term used when pathogens destroy the root and stem tissues of the seedlings shortly after emergence.
- **Spots, blotches, and blights** are commonly associated with fungal and bacterial diseases of leaves and fruit. The term "spot" is generally used for lesions that remain relatively small. The terms "blotch" and "blight" describe lesions that rapidly expand to destroy larger portions of the infected leaves or fruit.

Fruit spot

Leaf spot

Leaf spot

- **Powdery mildew and rust** diseases can be readily identified by visual structures of the pathogens. Powdery mildew fungi remain on the surfaces of leaves and produce a powdery-white appearance. Rust fungi often produce orange pustules.

Powdery mildew

- **Wilt** diseases destroy or reduce the plant's ability to absorb and distribute water. Drought and many other problems can also cause plants to wilt, and it is often necessary to examine plants for additional symptoms to make a definitive diagnosis. Discoloration of the vascular tissues or roots often helps confirm the cause of the wilting.
- **Cankers** often inhibit normal formation of wood and bark, resulting in sunken or discolored portions of the twigs, branches, or trunk. The infected portions of woody plants may die if a canker enlarges enough to completely encircle a branch or trunk.

Canker

- **Root rot** diseases occur when healthy roots are invaded by a pathogen. Roots may become discolored and/or rotten or decayed. The early symptoms of root rot are usually below ground where they are hidden from sight. Environmental stresses such as drought, freezing conditions, or poor drainage can often predispose plants to root rots. The aboveground portion of the plant eventually declines and may die.

Root rot

Abiotic Disorders

Abiotic plant disorders often cause symptoms that resemble plant diseases. Abiotic disorders are sometimes referred to as physiological disorders or environmental stresses. Some of the most common abiotic disorders in Kansas are caused by extremes in temperature, moisture, or fertility. Disorders may also result from poor site selection, soil compaction, or chemical toxicities. In addition, abiotic disorders can weaken plants and increase their susceptibility to diseases caused by pathogens. Understanding the normal growth habit of various plant types can help identify abiotic disorders and facilitate their differentiation from diseases.

- **Temperature:** Each plant species has an optimal temperature range. Exposure to temperatures outside that range can be stressful. In Kansas, temperatures can fluctuate rapidly, and this disrupts normal metabolism. For example, a warm spell in winter can cause a plant to emerge from dormancy prematurely, or an early fall frost can harm plant tissues that have not yet adapted to cold temperatures.
- **Moisture:** Water is essential for plant growth, but too much or too little water can be damaging. Excess water depletes the oxygen supply to roots. As root health deteriorates, the plant cannot take up enough water and nutrients. This condition is sometimes called wet feet, and certain plants are more vulnerable than others. Wet soils can also trigger certain root rot pathogens that are favored by moist conditions.
- **Fertility:** Plants need the correct amounts of essential nutrients such as nitrogen, phosphorus, potassium, plus a few minor elements, including iron, sulfur, and zinc. These nutrients can come from the soil or from fertilizers (manufactured products as well as natural organic sources such as manures and compost) added to the soil. Fertility imbalances are damaging, and some fertility issues can mimic diseases.
- **Chemical injury:** While pesticides and fertilizers can enhance plant health and lead to yield and quality benefits, misapplication can lead to injury. It is critical to read and follow the label for all pesticide and fertilizer applications. Chemical injury to plants is referred to as phytotoxicity and it can be caused by several sources, including:
    - **Herbicide drift, carryover and spray tank contamination.** Herbicides can drift from a neighboring site onto an unintended crop, plant, or site. They can also persist in the soil from one crop to the next. Crop damage can occur if the spray tank is not adequately cleaned between the use of different products. Herbicides are discussed in more detail elsewhere in this manual.
    - **Inappropriate rates.** Pesticides can be applied at rates that are toxic to the plants. It is important to read the label and calibrate equipment to ensure proper application rates.
    - **Incompatible tank mixes.** Pesticides that are safe when applied alone can be highly phytotoxic when applied in combination. Read the label for advice on incompatibility.

Management of Plant Diseases

Managing plant diseases requires an understanding of the plant, the environment, and the potential pathogens in the area. IPM is an approach that focuses on long-term prevention of pest and disease problems through multiple methods that work together to build a healthy plant system. The EPA states, "Integrated Pest Management (IPM) is an effective and environmentally sensitive approach to pest management that relies on a combination of common-sense practices. IPM programs use current, comprehensive information on the life cycles of pests and their interaction with the environment. This information, in combination with available pest control methods, is used to manage pest damage by the most economical means, and with the least possible hazard to people, property, and the environment."

In terms of plant diseases, an integrated approach will help (1) break the disease life cycles so pathogens cannot survive and spread; (2) make the plant more resistant or tolerant to disease; and/or (3) make the environmental conditions less favorable to disease. Pesticides should be used only when the economic benefit is greater than the loss that will be incurred if they are not used. This is commonly known as the economic threshold of damage.

Organic growing methods have specific rules about which pesticides and practices can be used, and only certain disease control materials may be used for pest control. One source of information is www.omri.org (Organic Materials Review Institute), but growers and other plant managers interested in organic production should always check with their certifier.

Understanding the biology of plant diseases is critical to identifying appropriate disease management strategies. The "plant disease triangle" is often used to identify the three factors important for disease development: (1) the presence of a viable pathogen; (2) a susceptible host plant; and (3) an environment that favors disease. When developing management strategies, it is important to consider all three parts of the disease triangle and how to manipulate the system to reduce disease pressure. For example, what strategies can be used to prevent the introduction of a pathogen to a site? If a pathogen is known to survive in the debris of a previous crop, is removal of debris an option to prevent carryover to the next season? In terms of the host plant, are resistant varieties available to avoid disease risk? Are cultural practices available that can make the environment less favorable for disease?

The principles below can be used to prevent and manage plant diseases.

- **Select resistant varieties:** Using disease-resistant or -tolerant cultivars, when available, should always be one of the first lines of defense in developing pest management strategies. Terms such as "resistance" and "tolerance" are used to describe a plant's reaction to pathogens. In some cases, resistance is complete—the variety does not become infected. In other cases, resistance is not complete, meaning the cultivar can be infected at low levels. University publications and other production guides are a good source of information about a variety's resistance to specific diseases.
- **Start with clean planting material:** Using clean, disease-free seed or propagating materials is an excellent first step to disease management. This includes using seed from reliable sources such as certified seed producers. Hot water-treated seed or fungicide-treated seed may be an option for certain production systems. For vegetatively propagated plants, only cuttings from reliable sources should be used. Inspect transplants carefully for unusual symptoms on foliage or roots.
- **Use sanitation to remove infected material:** Weeds, crop debris, volunteer plants, and previously infected plants can harbor some plant pathogens as well as insects that spread certain plant diseases. Do not pile plant debris near the production site, as it may spread back into the crop or landscape.
- **Tillage:** Tillage is the turning of soil, often for weed control or to promote seed germination. In some cropping systems, tillage may help reduce disease by promoting the breakdown of infected crop materials and destroying overwintering pathogen structures. However, tillage practices must be balanced with soil conservation needs, which often discourage the destruction of crop residues.

- **Avoid problematic sites:** Avoid planting susceptible varieties into sites with a history of disease problems. For example, if a certain kind of plant is highly susceptible to root diseases that are favored by saturated soils, do not plant it into locations with poor drainage or a known history of such diseases. Choose the "right plant for the right place" based on drainage, soil type, shade, etc.
- **Manage moisture and humidity:** Frequent rains, overirrigation, wet soils, and high relative humidity can favor many plant diseases. Therefore, managing moisture can help reduce disease pressure. For example, for some fruit, vegetable and ornamental crops, staking and trellising allows for greater air movement. Similar changes to canopy structure can be achieved in crop plants by adjusting row spacing and planting density. Wider row spaces and a more open canopy will reduce drying times following rain or heavy dews and reduce the risk of disease. Using drip irrigation instead of overhead watering will also reduce leaf wetness and therefore reduce disease pressure in ornamentals and turf.
- **Rotate crops to avoid buildup of pathogens:** Plant pathogen populations tend to increase at sites where the same crop or closely related crops are grown for multiple years. Crop rotation can be an effective way to manage some diseases. Make sure that the rotational crop is NOT also susceptible to the problematic disease, or the rotation will not be effective. The length of rotation required to manage a disease problem varies considerably. Some soilborne diseases may require multiple years of rotation to effectively reduce pathogen populations.
- **Manage disease vectors:** Insects or arthropods spread many plant diseases and are called disease vectors. Aphids, whiteflies, thrips, and certain mites are common examples, but there are others. In some cases, the management of the insect or arthropod is the primary means of achieving disease control. Insects and mites are covered elsewhere in this guide.

Pesticides as a Disease Management Tool

Understanding disease biology, accurate disease diagnosis, and following all label instructions are critical to the safe and effective use of pesticides.

Pesticides for plant disease management are classified based on the type of organism they control. The three most common groups are fungicides (to control fungi), bactericides (to control bacteria), and nematicides (to control nematodes). Pesticides have both a technical name that identifies the active ingredient and a trade name to identify a specific commercially licensed product. Some products contain a mixture of pesticides, such as two different fungicides or a fungicide and an insecticide formulated together.

Pesticides are typically labeled for specific diseases on specific crops, so it is key to understand which diseases you are trying to control. In addition, pesticides are labeled to be used at specific rates. Using too low a rate may result in inadequate disease control, further increasing economic loss. Low-rate usage has also been implicated in the faster development of resistant fungal populations in a field. Overly high rates may have human health or environmental safety considerations. Too high a rate can also result in phytotoxic effects, which injure or even kill the plant.

Proactive scouting/surveying for diseases will provide key information to guide pesticide use decisions. Effective scouting requires familiarity with the common plant diseases in the area as well as knowing when during the growing season or under what weather conditions the disease is most likely to occur. For some diseases, forecasting systems can help optimize applications. Spraying at the wrong time will result in little or no control because the vulnerable stage of the pathogen's life cycle was missed.

Fungicides can be classified in several ways. One broad way to classify fungicides is "contact vs. systemic" based on their movement (or lack thereof) within the plant. Another way to classify fungicides is based on their mode of action, meaning the specific mechanism by which they affect fungal growth. Both contact and systemic fungicides have multiple modes of action.

- **Contact fungicides:** These fungicides are applied to and remain on the plant surface. Contact fungicides work best when applied prior to the arrival of pathogen spores, so they are sometimes referred to as protectants. There are some advantages to using contact fungicides. One is that they are usually effective against a broad range of fungi. A second advantage is that they attack multiple metabolic sites within the fungus simultaneously, making it difficult for a fungus to develop resistance to this class of fungicides. However, contact fungicides tend to be less rainfast and may have shorter windows of activity.
- **Systemic fungicides:** These fungicides are absorbed into the plant. Some systemic fungicides can move within the plant, either within a leaf or for longer distances. This varies from product to product. Some systemic fungicides can be applied for curative purposes, meaning they can be effective even after the infection process has begun. This curative action is usually limited to the first 24 to 48 hours of the infection process. Curative fungicides will not be effective against severely diseased plants. The curative activity of a fungicide varies with pathogen sensitivity, environment, and type of plant treated. A disadvantage of systemic fungicides is that they have a narrow mode of action, sometimes targeting a single enzyme within the fungus. The narrow mode of action increases the risk that a fungal population will become resistant to a fungicide. Fungicide labels and specific plant production guides will provide more information on preventing resistance.

Bactericides are compounds that kill or slow the growth of bacteria. They are sometimes referred to as antibiotics. Very few bactericides are labeled for use in Kansas for a relatively small number of specific diseases. Repeated use results in the same type of antibiotic resistance that is familiar in humans and animals.

Nematicides are used to manage nematodes. These products have different modes of action and different application methods. Seed treatments and soil drenches are the most common application methods. As with all pesticides, nematicides are labeled for specific uses on specific crops and must be used following all label instructions. Some nematicides are very toxic compounds. Nematode management is best achieved by a combination of resistant cultivars and extended crop rotations.

Diagnosing Plant Diseases

As described in the above sections, many factors can affect plant health. There are many different diseases, and they can be difficult to tell apart. In addition, symptoms caused by pathogens can resemble damage by abiotic factors and vice versa. In many cases, multiple factors are interacting, and managing the problem requires a holistic strategy. University/extension factsheets, diagnostic guides, newsletters, and websites can aid in a proper identification. Local Cooperative Extension personnel can assist in finding and interpreting these resources.

When solving plant health problems, it can be helpful to ask questions that may reveal important clues. Below are some questions to keep in mind as you attempt to diagnose a problem.

- **Which species and cultivars (varieties) are affected?** Pathogens tend to be host-specific. If multiple species or multiple plant families are affected, this may be a clue that an abiotic factor is involved.
- **Which plant parts are affected?** Check the leaves, fruit, stem, crown, and roots. Comparison with healthy plants may be helpful.
- **What is the spatial pattern within the site?** Check for patterns. Are all the affected plants clustered together in a patch? Are they all in the same row? Are the diseased plants randomly scattered in a field?
- **How does the problem change over time?** If symptoms appeared all at once, that could suggest an abiotic stress event, such as a sudden exposure to toxic chemicals, low temperatures, etc. If the symptoms grow worse over time, it is more likely to be a pathogenic problem.
- **What cultural practices have been used?** Consider cropping decisions such as crop rotation and irrigation. Lack of rotation can lead to a buildup of pathogens. Overhead irrigation can lead to extended periods of leaf wetness, thus increasing disease pressure.

- **Are insect vectors present?** Remember that insects can spread certain diseases. Inspect your plants for the presence of potential vectors.
- **What has the weather been like recently?** Did an unusual weather event coincide with the onset of symptoms?
- **Are there any site problems?** Look for drainage problems, soil structure, presence of hardpans, slopes, etc.

Even after checking resources, many plant health problems will require diagnosis at a plant disease diagnostic lab by a trained professional using specialized microscopic techniques and laboratory tests. A good sample with lots of background information is the key to the most timely and accurate diagnosis. Below are some tips on how to submit materials to a plant disease lab, such as the K-State Plant Disease Diagnostic Lab.

- **The physical sample**: The type of sample needed depends on the plant and the nature of the problem. Consider contacting the lab in advance to get advice on what to send. Try to collect material that has fresh symptoms, because in tissues that are already far in decline or dried out, it is difficult to find the true pathogen among all the contaminants in the dead tissue. For some tests, the diagnostic lab needs roots to make an accurate diagnosis. If the plant is small, dig up the entire plant, tie a plastic bag around the root ball, and place another plastic bag around the entire sample. For woody plants such as tree fruit or grapevines, send several symptomatic branches that are at least 12 inches long. Keep the sample cool prior to shipping.
- **Packaging and mailing**: Pack the sample in a crush-proof container such as a padded envelope or a box with packing material. If possible, send the sample early in the week so that it does not spend a long weekend in a hot postal truck.
- **Background information:** Details about the site, timing of symptom development, recent weather, varieties affected, and site pattern will help the diagnostician understand the situation and provide clues to the potential problem(s).
- **Photos:** Digital or print photos can add important information about the site and patterns. Take photos that include a close-up of the symptoms, the whole plant, and the overall site.

Weeds

Any plant can be considered a weed when it is growing where it is not wanted. Weeds are a problem because they reduce crop yields, increase costs of production, and reduce the quality of agricultural products. In addition, some weeds cause skin irritation and hay fever, and some are poisonous to humans and livestock. Weeds also can interfere with recreational activities and spoil the beauty of designed and natural landscapes.

Weeds interfere with agricultural production by:

- competing for water, nutrients, light, and space;
- contaminating the product at harvest;
- harboring pest insects, mites, vertebrates, or plant disease agents; and
- releasing chemicals in the soil, which inhibit growth of desirable plants.

Weeds may become pests in water by:

- hindering fish growth and reproduction;
- promoting mosquito production;
- hindering boating, fishing, and swimming; and
- clogging irrigation ditches, drainage ditches, and channels.

Weeds can harm grazing animals by:

- poisoning, or
- causing an "off-flavor" in milk and meat.

Weeds are undesirable in rights-of-way because they:

- obscure vision, signs, guideposts, crossroads, etc.;
- increase mowing costs;
- hinder travel;
- provide cover for rodents and other pest animals; and
- clog drainage areas.

Weed species, weed size, weed density, and other conditions depend on:

- current crop or vegetation,
- cropping history,
- tillage practices,
- frequency of mowing,
- herbicide used, and
- management practices.

Development Stages

All plants have four stages of development.

1. **Seedling:** Young plant recently established from a germinating seed.
2. **Vegetative:** Rapid growth; production of stems, roots, and foliage.
3. **Seed production:** Energy directed toward production of seed. Uptake of water and nutrients is slow and is directed mainly to flower, fruit, and seed structures.
4. **Maturity:** Little or no energy production or movement of water and nutrients.

Life Cycles of Plants

Annuals

Annual plants live for a single season. They grow from seed and mature in one year or less.

Summer annuals are plants that grow from spring-sprouting seeds. They grow, mature, produce seed, and die before winter. Examples include crabgrass, foxtail, cocklebur, pigweeds, and lambsquarters.

Winter annuals are plants that grow from fall-sprouting seeds. They grow, mature, produce seed, and die before summer. Examples include downy brome, cheat, henbit, mustards and pennycress.

Biennials

Plants with a two-year life cycle are **biennials**. They grow from seed and develop a large taproot and compact cluster of leaves near the ground (called a rosette) the first year. In the second year, they mature, produce seed, and die. Examples include mullein, burdock, and musk thistle.

Perennials

Plants that live more than two years are **perennials**. Perennial plants may mature and reproduce in the first year and then repeat the vegetative, seed production, and maturity stages for several following years. In other perennials, the seed maturity and production stages may be delayed for several years. Some perennial plants die back each winter; others, such as trees, may lose their leaves but do not die back to the ground. Most perennials grow from seed; many also produce tubers, bulbs, rhizomes (belowground rootlike stems), or stolons (aboveground stems that produce roots). Examples of perennials include johnsongrass, field bindweed, dandelion, and plantain.

Simple perennials normally reproduce by seeds. However, root pieces which may be left by cultivation can produce new plants. Examples are dandelions, plantain, trees, and shrubs.

Bulbous perennials may reproduce by seed, bulblets, or bulbs. Wild garlic, for example, produces seed and bulblets above ground and bulbs below ground.

Creeping perennials produce seeds but also produce rhizomes (belowground stems) or stolons (aboveground stems that produce roots). Pieces of rhizomes or stolons can produce new plants. Examples are johnsongrass, field bindweed, and Bermudagrass.

Weed Classification

Land Plants

Most pest plants on land are grasses, sedges, or broadleaves.

Grasses

Grass seedlings have only one leaf as they emerge from the seed. Their leaves are generally narrow and upright with parallel veins. Most grasses have a fibrous root system. The growing point on seedling grasses is sheathed and located below the soil surface. Some grass species are annuals; others are perennials.

Sedges

Sedges are similar to grasses except they have triangular stems and three rows of leaves. They are often listed under grasses on the pesticide label. Most sedges are found in wet places, but principal pest species can also be found in fertile, well-drained soils. Yellow and purple nutsedge are perennial weed species that produce rhizomes and tubers.

Broadleaves

Broadleaf seedlings have two "seed leaves" (cotyledons) as they emerge from the seed. Their leaves are generally broad with netlike veins. Broadleaves usually have a taproot and a relatively coarse root system. All actively growing broadleaf plants have exposed growing points at the end of each stem and in each leaf axil. Perennial broadleaf plants may also have growing points on roots and stems above and below the surface of the soil. Broadleaves con-

tain species with annual, biennial, and perennial life cycles.

Aquatic Plants

Vascular Plants

Many aquatic plants are similar to land plants and have stems, leaves, flowers, and roots. Most act as perennial plants, dying back and becoming dormant in the fall and beginning new growth in the spring. There are four categories of aquatic plants.

1. **Emergent** (emersed): Plants are rooted in the bottom and produce most of their leaves and flowers at or above the water surface. Examples are watershield arrowhead and water primrose.

2. **Floating**: All or part of the plant floats on the surface. Examples are waterlilies, duckweeds, water meal, and American lotus.

3. **Marginal**: Emersed weeds that can and frequently do grow on saturated soil above the water surface. Examples are sedge, bulrush, rush, cattails, and smartweeds.

4. **Submergent** (submersed): All of the plant grows beneath the water surface. Examples are watermilfoil, elodea, naiads, pondweeds (Potamogeton), and coontails.

Emergent and floating plants, like some land plants, have a thick outer layer on their leaves and stems that hinders herbicide absorption. Submergent plants have a very thin outer layer on their leaves and stems and are highly susceptible to herbicide injury.

Algae

Algae are aquatic plants without true stems, leaves, or vascular systems. For control purposes, they may be classified as follows.

- **Plankton algae:** Microscopic plants floating in the water. They sometimes multiply very rapidly and cause "blooms" in which the surface water appears soupy green, brown, or reddish brown, depending on the algal type.
- **Filamentous algae:** Long, thin strands of plant growth that form floating mats or long strings extending from rocks, bottom sediment, or other underwater surfaces. Examples are cladophora and spirogyra.
- **Macroscopic freshwater algae:** These larger algae look like vascular aquatic plants. The two should not be confused, because their control is different. Many are attached to the bottom and grow up to 2 feet tall; however, they have no true roots, stems, or leaves. Examples are chara and nitella.

Parasitic Seed Plants

Dodder and witchweed are important weeds on some agricultural, ornamental, and forest plants. They live on and get their food from the host plants. They can severely stunt and even kill the host plants by using the host plant's water, food, and minerals. These plants reproduce by seeds. Some can also spread from plant to plant in close stands by vining and twining.

Managing Weeds

Weed control is nearly always designed to suppress a weed infestation. Prevention and eradication are usually attempted only in regulatory weed programs.

To control weeds growing among or close to desirable plants, you must take advantage of the differences between the weeds and the desired species. Be sure that the plants you are trying to protect are not susceptible to the weed control method that you choose. Generally, the more similar the desirable plant and the weed species are, the more difficult weed control becomes. For example, broadleaved weeds are most difficult to control in broadleaved crops, and grass weeds are often difficult to control in grass crops.

Weed Management Strategy

A successful weed management strategy should integrate multiple forms of weed management. An **integrated weed management** strategy may include two or more of the following:

- biological control
- cultural control
- sanitation
- chemical control

Biological Control

Biological weed control usually involves the use of insects or disease-causing agents that attack certain weed species. An example is the control of St. Johnswort by the Chrysolina beetle in the western United States. To be effective, a biological control agent should meet two criteria.

1. The insect or disease must be specific to the weed to be controlled; otherwise, it may spread to other species, such as crops and ornamentals, and become a pest itself.
2. The insects must have no natural enemies that interfere with their activity.

Grazing is another form of biological control sometimes used to control plant growth along ditches, fencerows, and roadsides. Sheep and goats are used most often, but geese are used for weeding some crops.

Cultural Control

Several cultural control methods are available.

Tillage: This is an effective method for managing weeds in row crops, nurseries, and forest plantings. However, tillage may bring buried seeds to the surface, where they can either germinate or compete with the newly planted crop. Seeds, rhizomes, or other reproductive plant parts may spread to nearby fields if tillage equipment is not thoroughly cleaned between fields. Tillage also may increase soil erosion and may contribute to the spread of plant pathogens.

Time of planting: Crops can be planted early to give them a competitive advantage over later-emerging weeds, or the planting date can be delayed until after weeds have germinated and been destroyed by cultivation or herbicides.

Nurse crops: Plant species (usually annuals) that germinate quickly and grow rapidly are sometimes planted with a perennial crop to provide competition with weeds and allow the crop to become established. The nurse crop is then harvested or removed to allow the perennial crop to take over. For example, oats are sometimes used as a nurse crop to help establish alfalfa or clover. Annual ryegrass is sometimes used in mixtures to provide a nurse crop for perennial rye, fescue, or bluegrass.

Burning: Fire may be used to control limited infestations of annual or biennial weeds. Fire destroys only the aboveground parts of plants and may stimulate germination of some seeds. If used alone, fire is usually not effective against many herbaceous perennial weeds.

Mulching: Mulching is used to prevent light from reaching weed seeds, thus preventing weed growth between rows, around trees and shrubs, or in other areas where no plants are desired. Mulching is commonly used in vineyards, nurseries, and commercial vegetable production.

Mowing: Mowing may be used to reduce competition between weeds and crops and to prevent seed production of annual or biennial weeds. Mowing is often used in orchards to control weeds and prevent soil erosion. To be most effective, mowing height must be adequate to ensure control of weed plants and encourage desired vegetation. Mowing is an important aspect of turfgrass weed control.

Mowing and harvesting is good for both short-term and long-term control of aquatic weeds. It depletes the nutrients, removes seeds, and reduces vegetative spread.

Flooding: Flooding has long been used for weed control in rice. The water covers the entire weed, killing it by suffocation.

Reduced tillage: This method has been used successfully to reduce weed growth and to reduce soil erosion. With limited tillage, weed seeds are not turned up, and those that do germinate do not have as much light or space to get started. However, the remaining debris may harbor insects and plant disease agents.

Shading: Aquatic weeds are sometimes controlled by shading them with floats of black plastic, adding dye to the water, or using similar methods for shading out the sunlight. Land weeds can be shaded by planting crops so closely together that they block the light from emerging weeds.

Sanitation

Using crop seed with few weed-seed contaminants is important in reducing weed problems. Sanitation may also involve cleaning equipment such as tillage implements, landscaping equipment, mowers, or harvest machinery to prevent the introduction of weeds to a new area.

Chemical Control

Chemicals used to control weeds are called herbicides. They kill plants by contact or systemic action. **Contact herbicides** kill only the plant parts the chemical touches. Contact herbicides are usually used to control annuals and biennials and are characterized by the quick die-back they cause. Products containing the active ingredients glufosinate, diquat, or

paraquat are examples of contact herbicides. **Systemic herbicides** are absorbed by roots or foliage and carried throughout the plant. Systemic herbicides are particularly effective against perennial weeds because the chemical reaches all parts of the plant, even relatively inaccessible deep roots and woody stems. Systemics may take a longer time to provide the desired result—up to 2 or 3 weeks, or even longer for woody perennials. Products that contain the active ingredient glyphosate or 2,4-D are examples of systemic herbicides.

Herbicide activity is either nonselective or selective.

Nonselective herbicides are chemicals that kill all plants present if applied at an adequate rate. They are used where no plant growth is wanted such as fencerows, ditch banks, driveways, roadsides, parking lots, and recreations areas.

Selective herbicides are used to kill certain weeds without significant damage to desired plants. They are used to reduce weed competition in crops, lawns, and ornamental plantings.

Herbicide selectivity may vary according to the application rate. High rates of selective herbicides usually will injure all plants at the application site. Some nonselective herbicides can be used selectively by applying them at a lower rate. Herbicide selectivity can also be affected by plant genetics. For example, some crops are genetically altered to withstand herbicides that would kill non-resistant varieties or hybrids. Other factors that affect selectivity include the time and method of application, environmental conditions, and the stage of plant growth.

Several factors affect a plant's susceptibility to herbicides.

- **Growing points:** Those that are sheathed or located below the soil surface are not reached by contact herbicide sprays.
- **Leaf shape:** Herbicides tend to bounce or run off narrow, upright leaves. Broad, flat leaves tend to hold the herbicide longer.
- **Wax and cuticle:** Foliar sprays may be prevented from entering the leaf by a thick wax and cuticle layer. The waxy surface also tends to cause a spray solution to form droplets and run off the leaves.
- **Leaf hairs:** A dense layer of leaf hairs holds the herbicide droplets away from the leaf surface, allowing less chemical to be absorbed into the plant. A thin layer of leaf hairs causes the chemical to stay on the leaf surface longer than normal, allowing more chemical to be absorbed into the plant.
- **Size and age:** Young, rapidly growing plants are more susceptible to herbicides than larger, more mature plants.
- **Metabolism:** Plants can detoxify certain selective herbicides and are less susceptible to injury from these chemicals. Such plants may become dominant over time if similar herbicides are used repeatedly.
- **Plant growth stage:** Seedlings are very susceptible to herbicides and to most other weed control practices. Plants in the vegetative and early bud stages are susceptible to translocated herbicides. Plants with seeds or in the maturity stage are the least susceptible to weed control practices.
- **Stages in the life cycle:** Plants that germinate and develop at different times than the crop species may be susceptible to carefully timed cultivation or herbicide applications.

Chemicals That Change Plant Processes

Plant growth regulators, defoliants, and desiccants are classified as pesticides in federal laws. These chemicals are used on plants to alter normal plant processes in some way. They must be measured carefully, because they usually are effective in very small amounts. Overdosing will kill or seriously damage the plants.

A plant growth regulator will speed up, stop, retard, prolong, promote, start, or in some other way influence vegetative or reproductive growth of a plant. They are used, for example, to thin apples, control suckers on tobacco, control the height of cotton and some floral potted plants, promote dense growth of ornamentals, and stimulate rooting.

A defoliant causes the leaves to drop from plants without killing the plants. A desiccant speeds up the drying of plant leaves, stems, or vines. Desiccants and defoliants are often called harvest-aid chemicals. They usually are used to make harvesting of a crop easier or to advance the time of harvest. They are often used on cotton, soybeans, tomatoes, and potatoes.

Vertebrates

All vertebrate animals have a jointed backbone. They include mammals, birds, reptiles, amphibians, and fish. Native vertebrate animals are usually not pests. They are a necessary and enjoyable part of our environment.

A few native vertebrate animals can be pests in some situations. Some, such as blackbirds, woodchucks, raccoons, or deer, may eat or injure agricultural and ornamental crops. Pheasants and ground squirrels may eat newly planted seeds. House sparrows and Norway rats consume stored food and often contaminate, and ruin even more than they eat. Coyotes and wild domestic dogs may prey on livestock and poultry. Large numbers of roosting blackbirds and crows can soil populated areas.

Sometimes rodents, other mammals, and some non-native birds are potential reservoirs of diseases of humans and domestic animals. Non-native rodents are an annoyance and a health hazard when they inhabit homes, restaurants, offices, and warehouses.

Burrowing and gnawing mammals may damage dams, drainage and irrigation tunnels, turf, and outdoor wood products.

Beavers may cause flooding in low-lying land by building dams.

Undesirable fish species may crowd out desirable food and sport species. The few species of venomous snakes can become a problem.

Controlling Vertebrates

As in insect pest control, techniques for control of vertebrate pests depend on proper pest identification.

Indoor vertebrate pest control usually is aimed at preventing pest entrance and eradicating non-native pest infestations. Nearly all indoor vertebrate pests are non-native rodents or birds, but others, such as bats and raccoons, also may require control.

Outdoors, the strategy usually is to remove individual animals to a level where the damage or injury is economically acceptable.

Local and state laws may prohibit the killing or trapping of some animals, such as birds, muskrats, and beavers, without special permits. Always check with local authorities before beginning a control program.

Vertebrate Damage Control Strategy

Methods of vertebrate damage control include:

- prevention of damage
- mechanical control
- sanitation
- chemical control

Prevention of Damage

Prevention of damage should always be an alternative. Planting alternate crops, harvesting date changes, penning livestock, protection of young livestock, lambing in sheds, use of guardian dogs, lighting, and biological control methods are only a few ways that should be considered to prevent future damage.

Mechanical Control

Mechanical control methods for vertebrate pests include traps, barriers, shooting, attractants, and repellents.

- **Traps:** Traps are sometimes desirable in vertebrate pest control. Foothold traps have been used traditionally. Such traps are often a good choice in remote rural areas for large predators such as coyotes. Body-gripping traps and snares are more desirable in some situations for some animals such as beavers, muskrats, and smaller mice and rats. Traps should be checked daily to meet legal requirements and to maintain their effectiveness.
- **Barriers:** Barriers are designed to exclude pests from a resource. These include fences, screens, and other barriers that cover openings, stop tunneling, and prevent gnawing. Materials used include sheet metal, hardware cloth, concrete, and similar materials. This kind of approach is especially effective in control of rodents, bats, and birds in structures.
- **Shooting:** Shooting, though highly selective, is expensive and time-consuming. It works best in combination with other methods.
- **Attractants:** Many techniques, such as scents and sound, are used to attract pests to a trap. Predator calling can increase the efficiency of shooting efforts on larger predators.

- **Repellents:** Repellents include a variety of devices aimed at keeping pets from doing damage. Automatic exploders, noisemakers, recordings of distress calls, moving objects, and lights are some of the repellents used. The efficacy of some of these devices is variable and may be highly dependent on placement and frequency of movement to a new location.

Sanitation

Removing sources of food and shelter helps to suppress most vertebrate pests. Sanitation techniques are used widely to control rodents in and around homes, institutions, restaurants, food-processing facilities, and other related areas.

Chemical Control

The chemicals used to control vertebrate pests include rodenticides, piscicides (fish), avicides (birds), and predacides (predators).

Pesticides for vertebrate pest control usually are formulated in baits. The chemicals may be highly toxic to humans, livestock, and other animals; therefore, correct bait placement is important to control the pest while protecting non-pest species. Thorough knowledge of the pest's habits is necessary.

Few pesticides are available for native vertebrate pest control, and most require special local permits for use. Registered chemicals are usually bait applications.

Pesticide Formulations

Learning objectives:

- **Describe what a pesticide formulation is.**
- **Explain common abbreviations used to describe formulations.**
- **Identify the advantages and disadvantages of common formulation types.**
- **Explain the role of adjuvants during pesticide applications.**
- **Define the terms "compatibility," "synergism," "persistence," and "phytotoxicity."**

Pesticide active ingredients are described by the types of pests they control and how they work. There are many different types of pesticides, and each is meant to be effective against specific pests. Well-known types of pesticides include fungicides, herbicides, insecticides, and rodenticides. Disinfectants, plant defoliants, and plant growth regulators are less well-known pesticides. The following list helps to illustrate the wide range of pesticide types.

- **Algicides** kill algae in lakes, canals, swimming pools, water tanks and other sites.
- **Antifoulants** kill or repel organisms that attach to underwater surfaces, such as barnacles that cling to boat bottoms.
- **Antimicrobials** kill microorganisms such as bacteria and viruses.
- **Attractants** lure pests to a trap or bait; for example, attracting an insect or rodent into a trap.
- **Biopesticides** are derived from natural materials such as animals, plants, bacteria, and certain minerals.
- **Biocides** kill microorganisms.
- **Defoliants** cause leaves or foliage to drop from a plant, usually to facilitate harvest.
- **Desiccants** promote drying of living tissues, such as unwanted plant tops.
- **Disinfectants and sanitizers** kill or inactivate disease-producing microorganisms on inanimate objects.
- **Fungicides** kill fungi (including blights, mildews, molds, and rusts).
- **Fumigants** produce gas or vapor intended to destroy pests, such as in buildings or soil.
- **Herbicides** kill weeds and other plants that grow where they are not wanted.
- **Insect growth regulators** disrupt the molting, maturing from pupal stage to adult, or other life processes of insects.
- **Insecticides** kill insects and other arthropods.
- **Miticides** (also called acaricides) kill mites that feed on plants and animals.
- **Microbial pesticides** are microorganisms that kill, inhibit, or outcompete pests, including insects or other microorganism pests.
- **Molluscicides** kill snails and slugs.
- **Nematicides** kill nematodes (microscopic, wormlike organisms that feed on plant roots).
- **Ovicides** kill eggs of insects and mites.
- **Pheromones** disrupt the mating behavior of insects.
- **Plant growth regulators** alter the expected growth, flowering or reproduction rate of plants (does not include fertilizers).
- **Plant-incorporated protectants** are substances that plants produce from genetic material that has been added to the plant.
- **Repellents** repel pests, including insects (such as mosquitoes) and birds.
- **Rodenticides** control mice and other rodents.

The active ingredients in a pesticide are the concentrated chemicals that control the target pest. The pesticide product you purchase is rarely made up of only active ingredients. Usually, the pesticide is diluted in water or a petroleum solvent and other chemicals are added before the product is offered for sale. Inert

ingredients do not possess pesticidal activity and are added to serve as a carrier for the active ingredient. Inert ingredients may include wetting agents, spreaders, stickers, extenders, or diluents. They usually improve application effectiveness, safety, handling, and storage of the chemical. This mixture of active and inert (inactive) ingredients is called a pesticide formulation. Some formulations are ready for use, while others must be further diluted with water, a solvent, or air by the user before they are applied.

Formulation abbreviations

A	=	**Aerosol**
AF	=	**Aqueous flowable**
AS	=	**Aqueous solution or aqueous suspension**
B	=	**Bait**
C	=	**Concentrate**
CM	=	**Concentrate mixture**
CG	=	**Concentrate granules**
D	=	**Dust**
DF	=	**Dry flowables**
DS	=	**Soluble dust**
E	=	**Emulsifiable concentrate**
EC	=	**Emulsifiable concentrate**
F	=	**Flowable (liquid)**
G	=	**Granules**
GL	=	**Gel**
L	=	**Liquid (flowable)**
LC	=	**Liquid concentrate or low concentrate**
LV	=	**Low volatile**
M	=	**Microencapsulated**
MTF	=	**Multiple temperature formulation**
P	=	**Pellets**
PS	=	**Pellets**
RTU	=	**Ready-to-use**
S	=	**Solution**
SD	=	**Soluble dust**
SG	=	**Soluble granule**
SP	=	**Soluble powder or soluble packet**
ULV	=	**Ultra low volume**
ULW	=	**Ultra low weight or ultra low wettable**
W	=	**Wettable powder**
WDG	=	**Water-dispersible granules**
WP	=	**Wettable powder**
WS	=	**Water soluble**
WSG	=	**Water-soluble granules**
WSL	=	**Water-soluble liquid**
WSP	=	**Water-soluble powder or water-soluble packet**

Types of Formulations

A single active ingredient often is sold in several different kinds of formulations. You must choose the formulation that will be best for each use. In making your choice, consider:

- the plant, animal, or surface to be protected (from phytotoxicity, animal absorption, pitting or marring surface);
- application equipment available and best suited for the job;
- hazard of drift and runoff (nearness to sensitive areas, likelihood of wind or rain);
- safety to applicator, helpers, and other humans and pets likely to be exposed;
- habits or growth patterns of the pest (bait versus broadcast spray, granular versus foliar spray);
- cost; and
- type of environment in which the application must be made (agricultural, aquatic, forest, urban, etc.).

Liquid Formulations

Emulsifiable Concentrates (EC or E)

An emulsifiable concentrate formulation usually contains the active ingredient, one or more petroleum solvents (which give ECs a strong odor), and an emulsifier that allows the formulation to be mixed with water. Each gallon of EC usually contains 2 to 8 pounds of active ingredient. ECs are among the most versatile formulations. They are used against agricultural, ornamental and turf, forestry, structural, food processing, livestock, and public health pests. ECs are adaptable to many types of application equipment, from small, portable sprayers to hydraulic sprayers, low-volume ground sprayers, mist blowers, and low-volume aircraft sprayers.

Advantages:

- High concentration means price per pound of active ingredient is relatively low and product is easy to handle, transport, and store.
- Little agitation is required; ECs are not abrasive and will not settle out or separate when equipment is running.
- ECs leave little visible residue on fresh fruits and vegetables or on finished surfaces.

Disadvantages:

- High concentration requires extra care when mixing and loading equipment.
- High concentration makes it easy to overdose or underdose through mixing or calibration errors.
- Phytotoxicity (damage to plants) hazard is usually greater.
- Easily absorbed through skin of humans or animals.
- Solvents may cause rubber or plastic hoses, gaskets, and pump parts and surfaces to deteriorate.
- May cause pitting or discoloration of painted finishes.
- May be corrosive.

Solutions (S)

A few pesticide active ingredients readily dissolve in water. Formulations of these pesticides contain the active ingredient and one or more additives. When mixed with water, they form a solution that will not settle out or separate. Solutions may be used in any type of sprayer indoors or outdoors.

Advantages:

- No agitation necessary.

Disadvantages:

- Very few formulations of this type are available.
- Solutions may move off target because of their high water solubility.

Ultra Low Volume (ULV) Concentrate Solutions

Ultra low volume (ULV) concentrate solutions contain 8 or more pounds of active ingredient per gallon. Concentrates may approach 100 percent active ingredient. ULV concentrate is designed to be used as is or to be diluted with only small quantities of specified solvents. These special-purpose formulations must be applied with highly specialized spray equipment. They are mostly used in outdoor applications such as in agricultural, forestry, ornamental, and mosquito control programs. The advantages and disadvantages are similar to those for ECs.

Ready-to-Use (RTU) Low Concentrate Solutions

These formulations, usually solutions in petroleum solvents, contain small amounts

(usually 1 percent or less) of active ingredient per gallon. They are designed to be used without further dilution. RTU low-concentrate solutions are used for:

- lawn and garden pests,
- structural and institutional pests,
- clothes moths,
- livestock and poultry pests,
- space sprays in barns and warehouses, and
- mosquito control.

Advantages:

- No mixing necessary.
- Household formulations have no unpleasant odor and do not stain fabric.

Disadvantages:

- Expensive (high cost per unit).
- Limited number of uses and availability.

Flowables or Liquids (F or L)

Some active ingredients are insoluble solids. These may be formulated as flowables in which the finely ground active ingredients are mixed with a liquid, along with inert ingredients, to form a suspension. Fs are mixed with water for application and are similar to EC formulations in ease of handling and use. They are used in the same types of pest control operations for which ECs are used.

Advantages:

- These formulations seldom clog nozzles.
- Easy to handle and apply.

Disadvantages:

- Require moderate agitation; will settle out.
- May leave a visible residue.

Aerosols (A)

Aerosol formulations contain one or more active ingredients and a solvent. Most aerosols contain a low percentage of active ingredients. There are two types of aerosol formulations: the ready-to-use type, and those made for use in smoke or fog generators.

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

Advantages:

- Easy to use.
- Easily stored and portable.
- Convenient way of buying a small amount of a pesticide.
- Retain their potency over a fairly long time.

Disadvantages:

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

Formulations for smoke or fog generators are not under pressure. They are used in machines that break the liquid formulation into a fine mist or fog (aerosol) using a rapidly whirling disk or heated surface. These formulations are used mainly for insect control in yards or structures, such as greenhouses and warehouses; for disinfection to prevent infection; and for mosquito and biting fly control outdoors.

Advantages:

- Easy method of filling entire space with pesticide.

Disadvantages:

- Highly specialized use.
- Fairly expensive for pounds of active ingredient per gallon.
- Difficult to confine to target site or pest.
- Risk of inhalation injury.

Invert Emulsions

This unusual mixture contains a water-soluble pesticide dispersed in an oil carrier. Invert emulsions require a special kind of emulsifier that allows the pesticide to be mixed with a large volume of petroleum carrier, usually fuel oil. When applied, invert emulsions form large droplets that do not drift easily. Invert emulsions are most commonly used in vegetation control along rights-of-way where drift to susceptible nontarget plants is a problem.

Fumigants

Fumigants are pesticides that form poisonous gases when applied. Sometimes the active ingredients are gases that become liquids when packaged under high pressure. These formula-

tions become gases when released during application. Other active ingredients are volatile liquids when enclosed in an ordinary container and so are not formulated under pressure. They become gases during application. Others are solids that release gases when applied under conditions of high humidity or in the presence of water vapor.

Fumigants are used for structural pest control, in food and grain storage facilities, and in regulatory pest control at ports of entry and at state and national borders. In agricultural pest control, fumigants are used in soil and in greenhouses, granaries, and grain bins.

Advantages:

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

Disadvantages:

- The target area must be enclosed or covered to prevent the gas from escaping.
- Fumigants are highly toxic to humans—specialized protective equipment, including respirators, must be used.
- No residual activity.

Dry Formulations

Dusts (D)

Most dust formulations are ready to use and contain a low percentage of active ingredient (usually 1–10 percent), plus a very fine dry inert carrier made from talc, chalk, clay, nut hulls, or volcanic ash. The size of individual dust particles is variable.

Dust concentrates contain a greater percentage of active ingredient. These must be mixed with dry inert carriers before they can be applied.

Dusts are always used dry and easily drift into nontarget areas. They sometimes are used for agricultural applications. In structures, dust formulations are used in cracks and crevices and for spot treatments. They are widely used in seed treatment. Dust formulations are also used to control lice, fleas, and other parasites on pets and domestic animals and poultry.

Advantages:

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

Disadvantages:

- Drift hazard is high.
- Expensive because of low percentage of active ingredient.
- Leave an obvious surface residue.

Baits (B)

A bait formulation is an active ingredient mixed with food or another attractive substance. The bait attracts the pests, which are then killed by eating the pesticide it contains. The amount of active ingredient in most bait formulations is quite low, usually less than 5 percent. Baits are used inside buildings to control ants, roaches, flies, and other insects and for rodent control. Outdoors, they are used to control slugs, termites, and some insects, but their main use is for control of vertebrate pests such as birds, rodents, and other mammals.

Advantages:

- Ready to use.
- Entire area need not be covered, since pest goes to bait.
- Controls pests that move in and out of an area.

Disadvantages:

- Often attractive to children and pets.
- May kill domestic animals and nontarget wildlife outdoors.
- Pest may prefer the crop or other food to the bait.
- Dead pests may cause odor problem.
- Other animals feeding on the poisoned pests may also be poisoned.
- Application costs are high.

Granules (G)

Granular formulations are similar to dust formulations, but granular particles are larger and heavier. The coarse particles are made from an absorptive material, such as clay, corncobs, or walnut shells. The active ingredient either coats the outside of the granules or is absorbed into them. The amount of active ingredient is relatively low, usually ranging from 1–15 percent.

Granular pesticides are most often used to apply chemicals to the soil to control weeds, nematodes, and insects living in the soil. They also may be used as systemics—formulations that are applied to the soil, then absorbed

into the plant through the roots and carried throughout the plant. They are applied by aircraft and ground equipment. Granular formulations are also used to control larval mosquitoes and other aquatic pests. Granules are used in agricultural, ornamental, turf, aquatic, right-of-way, and public health (biting insect) pest control operations.

Advantages:

- Ready to use; require no mixing.
- Drift hazard is low; particles settle quickly.
- Low hazard to applicator because granules require no spray and generate little dust.
- Weight carries the formulation through foliage to soil target (except for woody vegetation).
- Application equipment is simple, often seeders or fertilizer spreaders.
- May be more persistent than WPs or ECs.

Disadvantages:

- More expensive than WPs or ECs.
- May need to be incorporated into soil.
- May need moisture to activate pesticidal action.

Pellets (P or PS)

Pelleted formulations are made of clay or similar material and created by extruding or molding under pressure. This process results in particles of uniform size and specific weight. The active ingredient is usually absorbed into the pellet and released by water into the soil. The amount of active ingredient ranges from 1 to over 40 percent.

Pelleted formulations are most often used to apply pesticides to the soil to control weeds, brush and nematodes. They are applied by aircraft, ground applicators, and spot treatment methods. Uses include agriculture, ornamental, turf, rights-of-way, and non-cropland operations.

Advantages:

- Ready to use; require no mixing.
- Drift hazard is low because pellets settle quickly.
- Low hazard to operator: no spray, some dust.
- Excellent distribution due to uniform size.
- Generally more persistent than WPs (see below) or ECs.
- Some pesticides can be applied in off-season period by commercial applicators.

Disadvantages:

- More expensive than WPs or ECs.
- Moisture is needed to activate or move active ingredient into soil.
- Precision application equipment is needed for broadcast application.
- Storage requirements may be greater than liquid or fine particle formulations.
- In woody vegetation, aerial application must be made during dormant season for best distribution.

Wettable Powders (WP or W)

Wettable powders are dry, finely ground formulations that look like dust. They usually must be mixed with water for application as a spray. A few products, however, may be applied either as a dust or as a WP—the choice is left to the applicator. WPs contain 5–95 percent active ingredient, usually 50 percent or more. WP particles do not dissolve in water. They settle out quickly unless constant agitation is used to keep them suspended.

WPs are one of the most widely used pesticide formulations. They can be used for most pest problems and in most types of spray machinery where agitation is possible.

Advantages:

- Low cost.
- Easy to store, transport, and handle.
- Lower phytotoxicity hazard than ECs and other liquid formulations.
- Easily measured and mixed.
- Less skin and eye absorption than ECs and other liquid formulations.

Disadvantages:

- Inhalation hazard to applicator while pouring and mixing the concentrated powder.
- Require good and constant agitation (usually mechanical) in the spray tank.
- Abrasive to many pumps and nozzles, causing them to wear out quickly.
- Residues may be visible.

Soluble Powders (SP)

Soluble powder formulations look like wettable powders. However, when mixed with water, SPs dissolve readily and form a true solution. After they are thoroughly mixed, no additional agitation is necessary. The active ingredient in SPs ranges from 15–95 percent—usually over 50 percent.

SPs have the same advantages of WPs and none of the disadvantages except the inhalation hazard during mixing. Few pesticides are available in this formulation, because few active ingredients are soluble in water.

Microencapsulation

Microencapsulated formulations are microscopic particles of pesticides (either liquid or dry) surrounded by a very thin plastic coating. The formulated product is mixed with water and applied as a spray. Once applied, the capsule slowly releases the pesticide. The encapsulation process can prolong the active life of the pesticide by providing a timed release of the active ingredient.

Advantages:

- Safer for the applicator.
- Easy to mix, handle, and apply.

Disadvantages:

- Constant agitation necessary in tank.
- Some bees may pick up the capsules and carry them back to hives, where the released pesticide may poison entire hives.

Water-Dispersible Granules (Dry Flowables)

Water-dispersible granular formulations are like WP formulations, except the active ingredient is prepared as granule-sized particles. Water-dispersible granules must be mixed with water to be applied. The formulation requires constant agitation to keep it suspended in water. Water-dispersible granules share the advantages and disadvantages of WPs, except:

- They are more easily measured and mixed.
- They cause less inhalation hazard to the applicator during measuring and mixing.

Adjuvants

An adjuvant is an inert material added to a pesticide formulation or tank mix to increase the effectiveness of the active ingredient. Most pesticide formulations contain at least a small percentage of additives. Some applicators add additional adjuvants while mixing for special applications. Some product labels may caution the user against adding adjuvants. Common adjuvants and their purposes are as follows.

- **Wetting agents:** Allow wettable powders to mix with water and stick on plant or animal surfaces.
- **Emulsifiers:** Allow petroleum-based pesticides (ECs) to mix with water.
- **Invert emulsifiers:** Allow water-based pesticides to mix with petroleum carrier.
- **Spreaders:** Allow pesticide to form a uniform coating layer over the treated surface.
- **Stickers:** Allow pesticide to stay on the treated surface.
- **Penetrants:** Allow the pesticide to get through the outer surface to the inside of the treated area.
- **Foaming agent:** May reduce drift by decreasing fines.
- **Drift suppressants:** May reduce drift by increasing droplet size.
- **Safeners:** Reduce phytotoxicity of pesticide to protected crop.
- **Compatibility agents:** Aid in combining pesticides effectively.
- **Buffers:** Allow mixing of pesticides of different acidity or alkalinity.
- **Antifoaming agents:** Reduce foaming of spray mixtures that require vigorous agitation.

Compatibility

Two or more pesticides that can be mixed to control a wider range of pests with a single application are said to be compatible with each other. Sometimes, the pesticides are formulated together by the manufacturer, but the applicator often must mix separate formulations in the tank. It is important to remember that not all pesticides work well in combination. Incompatible pesticides can cause:

- loss of effectiveness against the target pests;
- injury to the treated surface (phytotoxicity in plants, toxicity in treated animals, stains or corrosion on treated surfaces); or
- separation of ingredients into layers or settling out of solids.

Some pesticide labels list compatible products. Pesticide publications, land-grant universities, and independent experts can supply information based on local experience. Be careful with do-it-yourself mixes; they could cost time and money.

Synergism

Synergism is when two or more chemicals (such as insecticides) achieve a greater toxicity together than when used separately. These

synergists make insecticide ingredients more effective at killing pests. They generally are low in toxicity to humans. Synergists can be found in products that kill insects, fungi, and nematodes. These products are commonly mixed with natural pyrethrins or synthetic pyrethroid insect-killing products.

Labels and Labeling Comprehension

Learning objectives:

- **Distinguish between mandatory and advisory labeling language.**
- **Explain the differences between federal registration, state registration, special local needs registrations, experimental use permits, and emergency exemptions.**
- **Describe product classifications and list who may use each product type.**
- **Locate label instructions, warnings, terms, symbols, restrictions, and precautions.**
- **Identify the common, chemical, and brand names as well as the percentage of active ingredient(s) in a formulation.**
- **Recall how to obtain information in product Safety Data Sheets.**

Each pesticide you buy has a label that gives instructions on how to use the product. The pesticide label is the main method of communication between a manufacturer and pesticide user. The manufacturer may also provide additional forms of labeling, such as brochures or website links. By law, pesticide users are required to comply with all the instructions and use directions found on the pesticide product label. It is a violation of federal law to use any registered product in a manner inconsistent with its labeling.

Labeling provides comprehensive information from the manufacturer about the product. Labeling includes not only the label on the product container, but also any supplemental information accompanying the product. This may include brochures, leaflets, website links, and additional information handed out where you purchased the product.

The label is the information printed on or attached to the container of pesticides. To the manufacturer, the label serves as a "license to sell;" to the state and federal government, the label controls the distribution, storage, sale, use, and disposal of the product. To the buyer and user, the label is a source of information on how to use the product legally. To physicians, the label serves as a source of information on proper treatment in case of poisoning. Some labels are easy to understand, while others can be quite complicated. All labels will tell you how to use the product correctly. This section will explain the items that must be on a label.

Label formats vary according to pesticide type, registration, toxicity, and manufacturer. The Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) establishes four types of pesticide registration.

1. **Section 3:** Product has standard registration (the most common type of registration).
2. **Section 25(b):** Product has been exempted from registration because it poses minimal risk (each state has its own statues and regulations; product may need to be registered by the state).
3. **Section 24(c):** Product has been registered based on a special local need (allows states to expand or limit the uses of certain registered pesticides).
4. **Section 18:** Product has been given an emergency exemption (to address pest problems for which no pesticides are registered).

Parts of the Label

Brand, Trade, or Product Names

Each manufacturer has a brand name for its products. Different manufacturers may use different brand names for the same pesticide active ingredient. Most companies register each brand name as a trademark and will not allow any other company to use that name.

The brand or trade name is the one used in ads and by company salespersons. The brand name shows up plainly on the front panel of the label. Applicators must beware of choosing a pesticide product by brand name alone. Many companies use the same basic name with only minor variations to designate entirely different pesticide products. For example, Roundup Ultra (glyphosate) and Roundup for Lawns (MCPA, quinclorac, dicamba, and sulfentrazone) contain different pesticides.

Ingredient Statement

Each pesticide label must list what the product contains. The list is written so you can quickly see the active ingredients and the amount (as a percentage) of each ingredient listed. The ingredient statement must list the official chemical names and/or common names for the active ingredients. Inert ingredients need not be named, but the label must show what percentage of the total contents they comprise.

Ingredient statement example

Active ingredients:

Isoctyl (2-ethylhexyl) ester of 2,4-dichlorophenoxyacetic acid..... **32.45%**

2-ethylhexylester of (+)-r-2-(,4-dichlorophenoxy) propionic acid **15.90%**

Dicamba: 3,6-dchloro-o-anisic acid **5.38%**

Inert ingredients 46.27%

Total 100.00%

Chemical Name

The chemical name is a complex name that identifies the chemical components and structure of the pesticide. This name is almost always listed in the ingredient statement on the label. For example, the chemical name of atrazine is 2-chloro-4-ethylamino-6-isopropylamino-1, 3, 5-triazine.

Common Name

Because pesticides have complex chemical names or active ingredients, many are given a shorter "common" name. Only common names officially accepted by the EPA may be used in the ingredient statement on the pesticide label. The official common name may be followed by the chemical name in the list of active ingredients.

By purchasing pesticides according to the common or chemical names, you will always be certain of getting the right active ingredient.

Type of Pesticide

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

- insecticide for control of certain insects on fruits, nuts, and ornamentals
- soil fungicide
- herbicide for the control of woody brush, and weeds
- algaecide

Net Contents

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

Name and Address of Manufacturer

The law requires the maker or distributor of a product to put the name and address of the company on the label. This is so you will know who made or sold the product.

Registration and Establishment Numbers

These numbers are needed by the pesticide applicator in case of accidental poisoning, claims of misuse, or liability claims. They are also used by regulatory agencies in cases of misbranding, adulterated products, or other regulatory actions.

Registration Numbers

An EPA registration number must appear on pesticide labels (for example, EPA Reg. No. 3120-280). This indicates that the pesticide product has been registered, and the EPA has approved the label. In cases of special local needs, pesticide products may be approved in a specific state. These registrations are

designated, for example, as EPA SLN No. KS-250002. In this case, SLN indicates "special local need," and KS means that the product is registered for use in Kansas. These registrations are temporary and carry an expiration date.

EPA registration number examples

EPA Reg. No. 3120-280-1492

- 3120 identifies the manufacturer
- 280 identifies the specific product
- 1492 identifies the distributor

EPA SLN No. KS-250002

- SLN indicates special local need
- KS means the product is registered for use in Kansas
- 25 means it was registered in 2025
- 0002 means it was the second local special needs product registered in Kansas

Establishment Numbers

The establishment number (for example, EPA Est: No. 5840-AZ-1) appears on either the pesticide label or container. It identifies the facility that produced the product. This is necessary in case a problem arises or the product is found to be adulterated in any way.

Signal Words and Symbols

Most pesticide labels include a signal word to give the user an indication of the relative toxicity of the product to humans and animals. Very low toxicity (Category IV) is no longer required to display a signal word, although many manufacturers still include a "Caution" signal word on these products. Knowing the product's hazard helps you choose the proper precautionary measures for yourself, your workers, and other people (or animals) who may be exposed.

The signal word must appear in large letters on the front panel of the pesticide label. It immediately follows the statement, "Keep Out of Reach of Children," which must appear on every pesticide label.

- **DANGER:** This signals that the pesticide is highly toxic. A taste to a teaspoon taken by mouth could kill an average-sized adult. Any product that is highly toxic orally, dermally, or through inhalation or that causes severe eye and skin burning will be labeled "DANGER."
- **POISON:** All pesticides that are highly toxic orally, dermally, or through inhalation will also carry the word "POISON" printed in red and the skull and crossbones symbol.
- **WARNING:** This word signals that the product is moderately toxic. As little as a teaspoon to a tablespoon by mouth could kill the average-sized adult. Any product that is moderately toxic orally, dermally, or through inhalation or that causes moderate eye and skin irritation will be labeled "WARNING."
- **CAUTION:** This word signals that the product is slightly toxic. An ounce to more than a pint taken by mouth could kill the average adult. Any product that is slightly toxic orally, dermally, or through inhalation or that causes slight eye and skin irritation will be labeled "CAUTION."

Agricultural Use Requirement: Worker Protection Standard

This section is found only on product labels covered by the EPA Agricultural Worker Protection Standard (WPS). The WPS (as revised in 2015) must be complied with when pesticide products are used on agricultural establishments (farms, forests, nurseries, and greenhouses) for the commercial or research production of agricultural plants. The WPS requires employers to provide agricultural workers and pesticide handlers with protections against possible harm from pesticides. People who must comply with these instructions include owners/operators of the agricultural establishment and owners/operators of commercial businesses that are hired to apply pesticides on the agricultural establishment or to perform crop-advising tasks on such establishments. You and any family members who work on your agricultural or commercial pesticide establishment are considered employees in many situations and must receive some of the required protections. Some basic requirements the WPS establishes for employers include:

- displaying information about pesticide safety, emergency procedures, safety data

sheets and recent pesticide applications on an agricultural establishment;
- training workers and handlers annually about pesticide safety;
- helping employees get medical emergency assistance in case of a work-related pesticide emergency;
- setting up decontamination sites and supplies for washing pesticide residues off hands and body;
- compliance with restricted-entry intervals (the time immediately after a pesticide application when workers may not enter the treated area);
- notifying workers (through posted and/or oral warnings) about areas where applications are taking place and areas where restricted-entry intervals are in effect;
- allowing only trained and equipped pesticide handlers to be present during a pesticide application;
- providing personal protective equipment for pesticide handlers and for workers who enter pesticide-treated areas before expiration of the restricted-entry interval (in the few very limited circumstances permitted by the WPS);
- protecting pesticide handlers by giving them safety instruction about the correct use of personal protective equipment and mixing, loading, and application equipment; inspecting and maintaining equipment they will be using; and monitoring them in hazardous situations; and
- implementing restrictions during applications by ensuring that pesticides applied do not contact workers or other people. In addition, handlers must suspend an application if workers or other people are in the application exclusion zone.

For detailed information about your responsibilities under the WPS, get a copy of EPA's manual, "How to Comply with the Worker Protection Standard for Agricultural Pesticides." It will tell you what you need to do to comply with federal requirements. The manual may be available from EPA regional offices, state or tribal pesticide agencies, extension services, pesticide dealers, the EPA website, and other commercial sources.

Precautionary Statements

All pesticide labels contain additional statements to help you decide the proper precautions to take to protect yourself, your helpers, and other people (or domestic animals) who may be exposed. Sometimes these statements are listed under the heading, "Hazards to Humans and Domestic Animals." They are composed of several sections.

Route of Entry Statements

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

Typical DANGER label statements include:
- Fatal if swallowed,
- Poisonous if inhaled,
- Extremely hazardous by skin contact—rapidly absorbed through skin, and
- Corrosive—causes eye damage and severe skin burns.

These statements are not uniform on all labels, so many variations may be found. More than one or even all four precautions may be stated on the same label.

Typical WARNING label statements include:
- Harmful or fatal if swallowed,
- Harmful or fatal if absorbed through the skin,
- Harmful or fatal if inhaled, and
- Causes skin and eye irritation.

Statements on a WARNING label may be exactly like those found on a DANGER label or a CAUTION label, or they may combine

the two; for example, "harmful or fatal." Many WARNING label precautionary statements simply drop the words "may" or "may be" from the caution statements. This leaves a stronger signal, which is in keeping with the moderate toxicity of products possessing a WARNING label.

Typical CAUTION label statements include:

- Harmful if swallowed,
- May be harmful if absorbed through the skin,
- May be harmful if inhaled, and
- May irritate eyes, nose, throat, and skin.

These statements may vary considerably. They usually are more moderate than the statements found on a DANGER label, using "harmful" instead of "fatal" or "poisonous;" "irritant" instead of "corrosive;" and qualifying the warnings with "may" or "may be." This is in keeping with the much lower toxicity of products possessing a CAUTION label.

Specific Action Statements

These statements usually follow immediately after the route of entry statements. They recommend the specific action you should take to prevent poisoning accidents. These statements are directly related to the toxicity of the pesticide product (signal word) and the route or routes of entry that must particularly be protected.

DANGER labels typically contain statements such as:

- Do not breathe vapors or spray mist,
- Do not get on skin or clothing, and
- Do not get in eyes.

(You would not deliberately swallow the pesticide, so the "Do not swallow" statement is omitted.)

These statements correspond to the strongest statements in the "route of entry" section. For example, if the only reason a product has a DANGER label is because it can cause corrosive eye damage, the specific action statement might read: "Do not get in eyes. Avoid contact with skin and breathing vapors, dusts, or spray mists." Most DANGER label products, however, are highly toxic through most or all entry routes, so several "Do not" statements will appear.

Typical WARNING labels combine specific action statements from DANGER and CAUTION labels. Depending on which route or routes are most likely to cause poisoning, the label might list "do not get on skin or in eyes," but "avoid breathing vapors and spray mist." This indicates that poisoning by inhalation of the pesticide ("avoid") is less likely than receiving skin or eye injury ("do not").

CAUTION labels generally contain specific action statements that are much milder than those on the DANGER label, such as:

- Avoid contact with skin or clothing;
- Avoid breathing dust, vapors, or spray mists; and
- Avoid getting in eyes.

These statements indicate that the toxicity hazard is not as great.

The specific action statements help you prevent pesticide poisoning by taking the necessary precautions and wearing the correct protective clothing and equipment.

Protective Clothing and Equipment Statements

Pesticide labels that fall under the WPS have very specific statements regarding personal protective equipment. However, many other labels carry no statement at all. You should follow all advice on protective clothing or equipment that appears on the label. However, the lack of any statement or the mention of only one piece of equipment does not rule out the need for additional protection.

A label, for example, might carry the statements: "Causes skin and eye irritation. Do not get in eyes, on skin or clothing. Wear goggles while handling." Even though the label does not specifically require them, you should wear a long-sleeved shirt, long-legged trousers, and gloves. You should consider wearing rubberized or waterproof clothing if you will be in prolonged contact with or wet by an overhead spray application.

Some pesticide labels fully describe appropriate protective clothing and equipment. A few list the kinds of respirators that should be worn when handling and applying the product. Others require the use of a respirator but do not specify type or model to be used.

Other Precautionary Statements

Labels often list other precautions to take while handling the product. These are self-explanatory.

- Do not contaminate food or feed.
- Remove and wash contaminated clothing before reuse.
- Wash thoroughly after handling and before eating or smoking.
- Wear clean clothes daily.
- Not for use or storage in and around a house.
- Do not allow children or domestic animals into the treated area.

These statements represent actions a competent applicator will always follow. The absence of any or all of them from the label DOES NOT indicate that these precautions should be ignored.

Statement of Practical Treatment

This section lists first aid treatments recommended in case of poisoning or accidental exposure. Typical statements include:

- In case of contact with skin, wash immediately with plenty of soap and water.
- In case of contact with eyes, flush with water for 15 minutes and get medical attention.
- In case of inhalation exposure, move from contaminated area and give artificial respiration, if necessary.
- If swallowed, drink large quantities of milk, egg white, or water—do not induce vomiting.
- If swallowed, induce vomiting.

All DANGER labels and some WARNING and CAUTION labels contain a note to physicians describing the appropriate medical procedures for poisoning emergencies and may identify an antidote. The label should always be available in emergencies.

Environmental Hazards

Pesticides may be harmful to the environment. Some products are classified as Restricted Use because of environmental hazards alone. Watch for special warning statements on the label concerning hazards to the environment.

Endangered Species

To protect specific endangered species from adverse effects of pesticides, many product labels will change. They will include a statement directing users to obtain and abide by a special bulletin identifying specific geographical areas where the pesticide may not be used. These actions are required by the Endangered Species Act. EPA has made Endangered Species Bulletins available to users through the website: https://www.epa.gov/endangered-species/bulletins-live-two-view-bulletins.

The U.S. Fish and Wildlife Services (FWS) is the final authority for interpretation of the Endangered Species Act, particularly for geographic areas where certain pesticides may be used with certain safeguards or are prohibited. Implementation of the endangered species labeling project will continue as product registrations are reviewed.

Resistance Statement

The possibility of a pest population developing resistance is a concern when using pesticides. The product label may have advisory pesticide resistance management guidelines based on target site/mode of action (how the pesticide kills the pest). The resistance statement may also suggest non-chemical controls to consider. Many product labels feature one or more group numbers denoting a product's mode of action. This allows the applicator to select pesticides with different modes of action. A label may state something like, "Weeds resistant to Group 14 herbicides may be effectively managed using herbicide(s) from a different group."

Special Toxicity Statements

If a particular pesticide is especially hazardous to wildlife, that will be stated on the label. For example:

- This product is highly toxic to bees.
- This product is toxic to fish.
- This product is toxic to birds and other wildlife.

These statements alert you to the special hazards that the use of the product may pose. They should help you choose the safest product for a particular job and remind you to take extra precautions.

General Environmental Statements

Some statements appear on nearly every pesticide label as reminders of common-sense actions to avoid contaminating the environment. The absence of any or all these statements does not indicate that you do not have to take adequate precautions.

Sometimes these statements follow a "specific toxicity statement" and provide practical steps to avoid harm to wildlife. Examples of general environmental statements include:

- Do not apply when runoff is likely to occur.
- Do not apply when weather conditions favor drift from treated areas.
- Do not contaminate water by cleaning of equipment or disposal of wastes.
- Keep out of any body of water.
- Do not allow drift on desirable plants or trees.
- Do not apply when bees are likely to be in the area.

Physical or Chemical Hazards

This section of the label will tell you of any special fire, explosion, or chemical hazards the product may pose. For example:

- **Flammable**: Do not use, pour, spill, or store near heat or open flame. Do not cut or weld container.
- **Corrosive**: Store only in a corrosion-resistant tank.

Note: Hazard statements (hazards to humans and domestic animals, environmental hazards, and physical-chemical hazards) are not located in the same place on all pesticide labels. Some newer labels group them in a box under the headings listed above. Other labels may list them on the front panel beneath the signal word. Still other labels list the hazards in paragraph form somewhere else on the label under headings such as "Note" or "Important." Search the label for statements to help you apply the pesticide more safely and knowledgeably.

Classification Statement

Every pesticide will, sooner or later, be classified by the EPA as either a general use pesticide or a restricted use pesticide (RUP). If EPA has not completed the classification of a pesticide product, then it is considered unclassified.

Any pesticide product that has been restricted must carry this statement in a prominent place at the top of the front panel of the pesticide label:

Restricted-use pesticide

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

In general, general use pesticides are either less toxic or more environmentally friendly than RUPs. Thus, to purchase or apply RUPs, the applicator must be trained and certified or working under the direct supervision of a trained/certified applicator.

Note: The absence of a restricted use statement does not necessarily indicate that the product has a low hazard level. Use the signal word and the precautionary statements to judge the toxicity hazard of all pesticide products.

Restricted-Entry Intervals (REI)

Some pesticide labels may address restricted-entry statements under the agricultural use requirements (see above), but reentry restrictions for uses outside of agriculture (lawns, golf courses, aquatic areas, rights-of-ways) will be listed under the non-agricultural use requirements. This statement tells you how much time must pass before people can reenter a treated area. These reentry intervals are set by both EPA and some states. Reentry intervals set by states are not always listed on the label; it is your responsibility to determine if one has been set. Ignoring reentry intervals is illegal.

The minimum legal protective clothing items for reentry following agricultural and other outdoor treatments are:

- long-sleeved shirt
- long-legged trousers or coveralls
- hat
- sturdy shoes with socks

Gloves are suggested. For early reentry in enclosed areas, a respirator may be necessary.

The reentry statement may be printed in a box under the heading "Reentry," or it may be

in a section with a title such as "Important," "Note," or "General Information."

If no reentry statement appears on the label or is set by your state, the minimum reentry level requires waiting at least until sprays are dried or dusts have settled before reentering or allowing others to reenter a treated area.

Storage and Disposal

All pesticide labels contain general instructions for the appropriate storage and disposal of the pesticide and its container. State and local laws vary considerably, so specific instructions usually are not included. Typical statements include:

- Not for use or storage in or around the home.
- Store herbicides away from fertilizers, insecticides, fungicides, and seeds.
- Store at temperatures above 32°F (0°C).
- Do not reuse container, render unusable.
- Do not contaminate water, food, or feed by storage and disposal.
- Open dumping is prohibited.
- Triple rinse and offer this container for recycling or reconditioning, or dispose in an approved landfill or bury in a safe place.
- Use excess or dispose in an approved landfill or bury in a safe place.

One or more of these statements may appear on a pesticide label. You should try to determine the best storage and disposal procedures for your operation and location. These statements may appear in a special section of the label titled "Storage and Disposal" or under headings such as "Important," "Note," or "General Instructions."

Bulk Storage

Bulk storage of pesticides is becoming a more common practice. Special concerns arise when storing large volumes of pesticides in individual containers, including:

- fire and explosion hazards
- spills-ruptured/leaking tanks
- runoff and environmental contamination
- security.

Pesticide products in undivided containers greater than or equal to 500 gallons for liquid and 4,000 pounds for dry shall be considered bulk pesticides and must stored in approved secondary containment. Although it is recommended that all pesticide products be stored in secondary containment, liquid pesticide products in containers less than 500 gallons and dry pesticide in containers less than 4,000 pounds are no longer considered bulk and are not required to be in secondary containment.

Filling pesticide containers, washing application equipment, rinsing pesticide containers or application equipment, mixing operations, and loading of application equipment must be performed in secondary containment or on a mixing and loading pad in these areas.

Directions For Use

Instructions on how to use the pesticide are an important part of the label. This is the best way to find out the right way to apply the product. The use instructions will tell you:

- the pests that the manufacturer claims the product will control;
- the crop, animal, or site the product is intended to protect;
- in what form the product should be applied;
- how much to use;
- how often to apply;
- mixing directions;
- compatibility with other often-used products;
- phytotoxicity and other possible injury or staining problems;
- how the material works;
- where the material should be applied;
- when it should be applied; and
- other special information.

Labels for agricultural pesticides often list the least number of days that must pass between the last pesticide application and harvest of crops or slaughter or grazing of livestock. These are intervals set by EPA to allow time for the pesticide to break down in the environment. This prevents illegal residues on food, feed, or animal products and possible poisoning of grazing animals. This information may appear as a chart, or it may be listed after application directions for the target crop or animal.

It is illegal and considered a misuse to use any registered pesticide in a manner inconsistent with its labeling. Examples of pesticide misuse include applying a pesticide to a site that is not listed on the label, applying a pesticide at a higher-than-labeled rate, not being certified in the appropriate certification

category, and handling a pesticide in a manner that violates specific label instructions (storage near food or water, improper container disposal).

Special Requirements

Some product labels require that the applicator receive additional training prior to purchase or use of the product. A label may outline additional recordkeeping requirements. Some labels may require a certified applicator to be physically present at the site of application. These requirements and any online information to which the label directs you are part of the labeling and must be followed.

Mandatory vs. Advisory Statements

A mandatory statement on a label is intended to be enforceable. They include directions for use and precautions that direct the user to take or avoid certain actions**.** These statements are usually written in imperative or directive sentences, such "wash application equipment," "users must," or "do not use."

Advisory statements are intended to be informational. They provide information to the user on such topics as product characteristics and how to reduce risk and maximize efficacy while using the product. Effective advisory statements give the user a positive reason for performing or not performing the action. Terms such as "should," "may," and "recommend" may be an indication of an advisory statement on the label.

Label Terminology

Many terms are used on the label to describe when and how to use pesticides. They also are found in leaflets and bulletins that you may get from your local extension agent, land-grant university, the manufacturer, or other agencies. Your understanding of these terms will help you get the best results from pesticides.

Terms that tell you when to use the pesticide product include:

- **Preplant**: used before the crop is planted.
- **Preemergence**: used before crop or pests emerge. May also refer to use after crops emerge or are established, but before pests emerge.
- **Postemergence**: used after the crop or pests have emerged.

Terms that tell you how to use the pesticide product include:

- **Band**: application to a strip over or along a crop row or on or around a structure.
- **Basal**: application to stems or trunks at or just above the ground line.
- **Broadcast**: uniform application to an entire, specific area.
- **Crack and crevice**: application in structures to cracks and crevices where pests may live.
- **Dip**: complete or partial immersion of a plant, animal, or object in a pesticide.
- **Directed**: aiming the pesticide at a portion of a plant, animal, or structure.
- **Drench**: saturating the soil with a pesticide; also, the oral treatment of an animal with a liquid.
- **Foliar**: application to the leaves of plants.
- **In-furrow**: application to the furrow in which a plant is planted.
- **Over-the-top**: application over the top of the growing crop.
- **Pour-on**: pouring the pesticide along the mid-line of the back of livestock.
- **Sidedress**: application along the side of a crop row.
- **Soil application**: application to the soil rather than to vegetation.
- **Soil incorporation**: use of tillage implements to mix the pesticide with the soil.
- **Soil injection**: application beneath the soil surface.
- **Spot treatment**: application to a small area.

Reading the Label

Before buying a pesticide, read the label to determine:

- whether it is the pesticide is registered for your intended use;
- whether restrictions or conditions prohibit the use of the pesticide on the intended site;
- whether the pesticide can be used safely under the application conditions (weather, life stages, etc.); and
- what personal protective equipment or special equipment will be needed.

Before you mix the pesticide, read the label to determine:

- how to mix and apply the material safely;

- what precautions should be taken to prevent exposure to people and nontarget organisms;
- what the pesticide can be mixed with (compatibility); and
- first aid and medical treatments that are necessary in case of an accident.

Before you apply the pesticide, read the label to determine:

- what safety measures you should follow;
- where the pesticide can be used (livestock, crops, structures, etc.);
- when to apply the pesticide (including the waiting period for crops and animals);
- how to apply the pesticide; and
- whether there are any restrictions for use of the pesticide.

Before you store or dispose of the pesticide or pesticide container, read the label to determine:

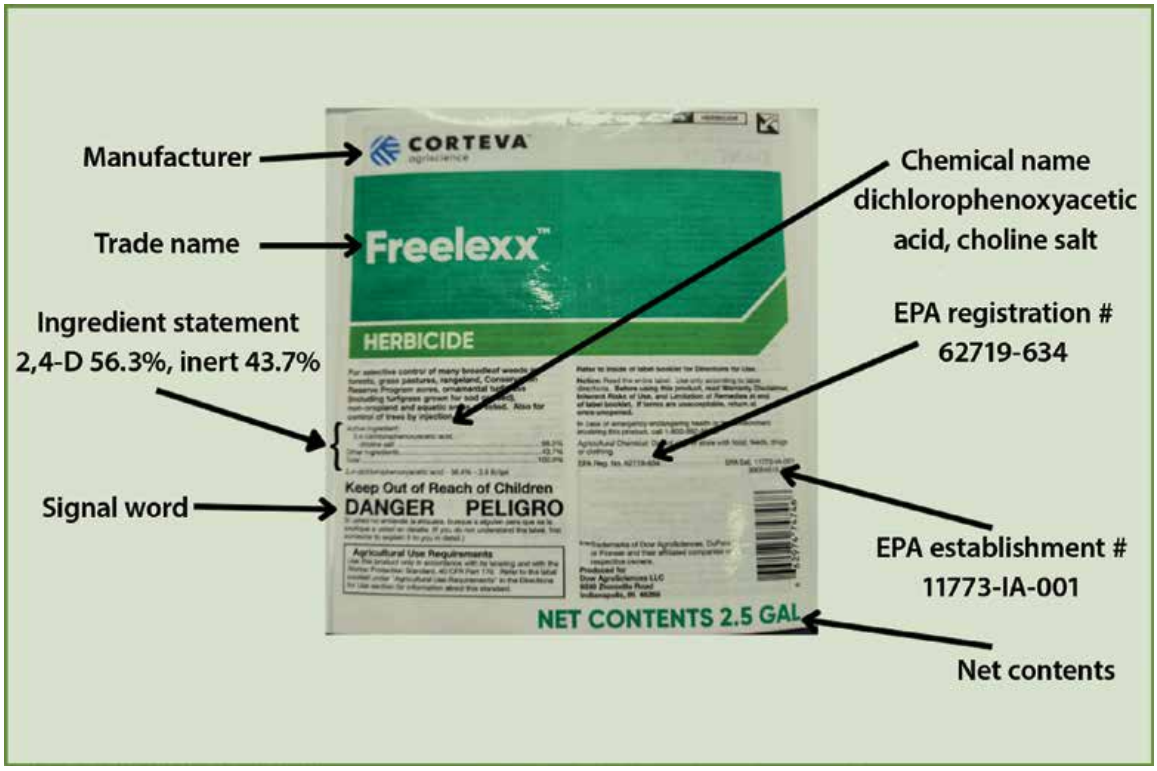
- where and how to store the pesticide,
- how to decontaminate and dispose of the pesticide container, and
- where to dispose of surplus pesticides.

Pesticide Label Examples

Examples of pesticide labels are below and on the following pages. Make sure you know how to read and follow any labels.

Safety Data Sheets

Safety data sheets (formally known as material safety data sheets) are very useful documents for learning about specific chemical and physical properties of pesticides (herbicides, insecticides, fungicides, rodenticides, disinfectants, etc.) or other potentially hazardous products. Manufacturers are required to develop and provide a safety data sheet for each product. The safety data sheet provides detailed information about the identification of the product, the physical and chemical properties, toxicological and human health data, and recommendations for personal protection. This document should be used in combination with the label to obtain the most in-depth product information.



GRAVEYARD DEAD®
Contact Herbicide 2S

PESTGONE Corporation
1200 Nuisance Lane
Salina, Kansas 67402

Active Ingredient
Paraquat dichloride……..29.1%
(1,1-dimethyl-4,4-bipyridnium dichloride)

Inert Ingredients……70.9%
Total 100%

EPA Reg. No. 999-123 **EPA Est. 999-OR-1**

Net Contents: 2.5 Gallons
Contains two pounds of active ingredients per gallon.

RESTRICTED USE PESTICIDE
For retail sale to and use only by certified applicators or persons under their direct supervision and only for those persons uses covered by the certified applicator's certification. Direct supervision for this product is defined as the certified applicator being physically present during application, mixing, loading, repair and cleaning of application equipment. Commercial certified applicators must also ensure that all persons involved in these activities are informed of the precautionary statements.

KEEP OUT OF REACH OF CHILDREN

POISON

DANGER  **PELIGRO**

Extremely toxic if ingested. Symptoms are prolonged and painful. Onset of symptoms may be delayed for up to 3 days after swallowing. Do not use or store around the home. Do not remove contents except for immediate use and never put into food, drink or other containers.

PRECAUTUCION AL USUARIO: Si usted no lee ingles, no use este producto hast que la etiqueta le haya sido explicada ampliamente.

STATEMENT OF PRACTICAL TREATMENT

If Swallowed: Immediately induce vomiting by inserting finger in throat. Drink large quantities of water and further induce vomiting. If the person is unconscious, do not give anything by mouth and do not induct vomiting. Transport the person immediately to a hospital or medical facility.

If on Skin: May cause skin irritation. Wash with plenty of water. Get medical attention if irritation persists. Repeated contact with skin may result in poisoning.

If in Eyes: May cause blindness or eye injury. Flush eyes with plenty of water for at least 15 minutes. Seek medical attention immediately.

If Inhaled: Remove to fresh air. Exposure may cause irritation, nose bleeds, and may lead to poisoning. Seek medical attention if respiratory irritation occurs or if breathing becomes difficult.

Note to Physicians: Call at any time to obtain toxicology and medical management consultation, a supply of bentonite clay, and paraquat analysis. Symptoms following ingestion may be delayed up to 3 days. To be effective, treatment for paraquat poisoning must begin immediately. Treatment consists of binding paraquat in the gut with suspensions of bentonite clay or charcoal and removal of paraquat from the blood by prolonged charcoal hemoperfusion or continuous hemodialysis.

For 24-hour Emergency Medical Assistance Call 1-800-123-4567.
For Chemical Emergency: Spill, leak, fire, exposure or accident call 1-800-876-5432.

This is a fictitious label for use as an example or examination purposes only.

GRAVEYARD DEAD® Contact Herbicide 2S

DIRECTIONS FOR USE

Crop	Use Pattern	Graveyard Dead Contact Herbicide 2S Rate per Acre	Minimum Total Spray Per Acre	Grazing or Preharvest Interval (Days)	Precautions, Restrictions and Comments
Mint (Peppermint, Spearmint)	Dormant Season	1.5-2.4 pints (2.4 pints = 38 fl oz)	Ground: 10 gal Air: 5 gal	See Notes	• For suppression of weeds such as Italian ryegrass, prickly lettuce, groundsel, chickweed, downy brome, and bluegrass. • Apply when crop is dormant before spring growth begins and when weeds are less than 6 inches tall. • Do not apply more than 2.4 pints per acre per dormant season. • May be tank mixed with Sinbar® herbicide (turbacil) weed killer for improved contact activity and residual control of Italian ryegrass, prickly lettuce and groundsel. Apply this tank mixture no more than once per season. Refer to the Sinbar® label for rates, directions, and cautions and for a list of weeds controlled. • This product cannot be used in California.

Notes: Grazing of crop residues treated with Graveyard Dead Contact Herbicide 2S is prohibited.

Agricultural Use Requirements:

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

The requirements in this section only apply to uses of this product that are covered by the Worker Protection Standard.

For preplant or preemergence (Broadcast or Banded), postemergence directed spray, and dormant season application and "between cutting" application in alfalfa: Do not enter or allow worker entry into treated areas during the restricted entry interval (REI) of 12 hours.

For harvest aid and desiccation applications: Do not enter or allow worker entry interval (REI) into treated areas during the restricted entry interval (REI) of 12 hours.

This is a fictitious label for use as an example or examination purposes only. Page 2 of 3

GRAVEYARD DEAD®
Contact Herbicide 2S

PPE required for early entry to treated areas that is permitted under the Worker Protection Standard and that involves contact with anything that has been treated, such as plant, soils, or water, is:

- Coveralls over long-sleeved shirt and long pants
- Waterproof gloves
- Chemical-resistant footwear plus socks
- Protective eyewear
- Chemical-resistant headgear for over-head exposure

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

STORAGE AND DISPOSAL

PROHIBITIONS: Do not contaminate water, food, or feed by storage, disposal or cleaning equipment. Open dumping is prohibited.

STORAGE: Store at temperatures above 32 degrees F. Do not contaminate feed, foodstuffs or drinking water. Do not store next to feed of food, or transport in or on vehicles containing foodstuffs or feeds. For help with any spill, leak fire or exposure involving this material, call **CHEMTREC 1-800-424-9300**.

Pesticide Disposal: This product is acutely hazardous. Improper disposal of excess pesticide, spray mixture or rinsate is a violation of Federal law. If these wastes cannot be disposed of by use according to label instructions, contact your State Pesticide or Environmental Control Agency, or the Hazardous Waste representative at he nearest EPA Regional Office for guidance.

Container Disposal: Triple rinse (or equivalent). Do not reuse container. Offer for recycling or reconditioning, or puncture and dispose of in a sanitary landfill, or dispose of by other procedures allowed by state and local authorities.

CONTAINER IS NOT SAFE FOR FOOD, FEED OR DRINKING WATER.

This is a fictitious label for use as an example or examination purposes only.

Protecting the Environment

Learning objectives:

- **Outline how site conditions affect the movement of pesticides.**
- **List ways that pesticides can move from the site of application.**
- **Describe how sensitive areas could be adversely affected by pesticide application, mixing and loading, storage, and equipment washing.**
- **Explain how to prevent pesticide drift, runoff, and loss to unintended areas of the environment.**
- **Define the terms "point source pollution" and "nonpoint source pollution."**

The environment comprises everything around us, and important parts include its many forms of life, water, air, soil, plants, and wildlife. Because pesticides can be pollutants, you must use them correctly to prevent harm to the environment. Be aware of how pesticide contamination can affect our natural resources. By knowing and following good application practices, you can protect the environment and yourself and be a responsible pesticide applicator.

Pesticide Characteristics

To understand how pesticides move in the environment, it is important to understand certain physical and chemical characteristics of pesticides and how they can affect the environment. These characteristics are solubility, adsorption, persistence, and volatilization.

Solubility

Solubility is the measure of the ability of a pesticide to dissolve in a solvent, usually water. Pesticides that have a high solubility easily dissolve in water. These pesticides are more likely to move with water insurface runoff or through soil water than less soluble pesticides.

Adsorption

Adsorption is the process whereby a pesticide binds to the soil particles. The attraction between the chemical and the soil causes adsorption. Typically, oil-soluble pesticides are more attracted to clay particles and organic matter than water-soluble pesticides. A pesticide that absorbs to soil particles is less likely to move from the spray site than a chemical that does not absorb.

Persistence

Persistence is the pesticide's ability to remain present and active in the environment in its original form before it breaks down. The properties and formulation of the product affect the persistence of a pesticide. Pesticides degrade through microbial activity, chemical activity or sunlight. Pesticide persistence is often expressed in terms of half-life, or the length of time required for one-half of the original amount to break down. Persistent pesticides typically have a soil half-life of more than 100 days and can cause environmental concerns due the amount of time it takes them to break down.

Volatility

Volatility is the tendency of a pesticide to turn into a gas or vapor. Some pesticides are more volatile than others. Conditions of low humidity, high temperatures, and increased wind increase the likelihood of volatility.

Potential Hazards

When pesticides are used in a way other than as directed on the label, they can:

- injure nontarget plants and animals,
- leave harmful residues,
- move from the application site into the surrounding environment, and
- move into the groundwater and surface waters.

Direct Kill of Nontarget Plants and Animals

Improperly applied pesticides can kill nontarget organisms. Drift from the target area may injure fish, birds, other wildlife, and sensitive plants. Drift of herbicides can damage nearby crops, forests, or landscape plantings. Poorly timed applications can kill bees and other pollinators working in the area or may kill beneficial parasitoids and predators that help control pests.

Runoff from treated areas can kill fish and other aquatic animals and plants in nearby ponds, streams, and lakes. Aquatic life can be killed by careless tank filling or draining and by rinsing or discarding used containers alongside or in waterways.

Pesticides can harm other wildlife, too. Even tiny amounts of pesticide may kill them or destroy their sources of food. Pesticides applied over large areas, such as in mosquito, biting fly, aerial, right-of-way, and ag plant applications, must be chosen with great care to avoid poisoning nontarget plants and animals in the area.

Ask for help in choosing the safest pesticide for the job. Injury or death to nontarget plants and animals can lead to lawsuits, fines, and loss of your applicator certification.

Long-Term Effects

Pesticides can be harmful in the environment even if they do not cause direct kills of nontarget plants and animals. Some pesticides can build up in the bodies of animals (including humans). These are called accumulative pesticides. The chemicals may be stored in an animal's body until they are harmful to it or to the predator that feeds on it. Long-term effects may include eggs that will not hatch and young that will not develop normally. Most accumulative pesticides are chlorinated hydrocarbons and have had very limited uses in the United States for a long time.

Some pesticides stay in the environment without change for long periods of time. These are persistent pesticides. Persistent pesticides that are not stored by animal tissues are often harmless to the environment. They may stay on or in the soil and provide long-term pest control without repeated applications. Sometimes, these pesticides injure sensitive plants seeded in the treated soil.

Pesticides that break down quickly in the environment to form harmless materials are called nonpersistent. These pesticides are often broken down easily by microorganisms or sunlight. Most organophosphate and carbamate insecticides are nonpersistent.

Pesticide Movement

Pesticides that move away from the target area are problems in the environment. Highly volatile pesticides such as 2,4-D esters can move great distances as invisible vapor in the air and injure nontarget plants. Dusts, aerosols, and fogs can easily drift away from the target area with air currents. Drift is the airborne movement of pesticides to nontarget areas. Off-target movement can occur in the form of spray droplet drift, vapor drift, or particle (dust) drift. Any application that produces fine dust or spray particles may result in drift. It is important to evaluate weather conditions for temperature inversions, wind direction, and wind speed before making the decision to spray.

Pesticides move off target in other ways, as they may be carried off target by rain and runoff water. They may leach through the soil to areas nearby or to ground water below. Runoff or leaching may occur when too much pesticide is applied or spilled on the surface or a highly water-soluble or persistent pesticide was used. Pesticide can also move through the soil into the groundwater with too much rainwater or irrigation.

Whenever you are applying a pesticide, select the pesticide, the formulation, and the application equipment that will most likely result in an application staying on target.

Soil Contamination

Pesticides that move off target onto soil or persist in soil may limit the use of that soil. Agricultural, ornamental, turf, and forestry crops may be killed or contaminated if planted on the site. Residential, grazing, and recreational uses of the soil may be impossible if the soil contains pesticide residues. The pesticide label will list crop rotation limits and other growing restrictions.

Air Contamination

Pesticide movement away from the application site by wind or air currents is called drift.

The movement of pesticides in the air cannot be controlled. The polluted air creates a hazard for people, animals, or plants that come into contact with it. Pesticides in the air may settle onto water, crops, livestock, trees, parks, or houses. Provide adequate spacing or a buffer zone when applying pesticides near sensitive areas. Keep in mind that the wind can carry pesticide particles or droplets many miles off target.

Prevention of Air Contamination Within a Structure

Outside Applications

1. Request consumers to close all windows and shut off air conditioning when treating the yard or around the perimeter of the house.

2. Make sure applications do not enter air ducts or plenums.

Inside Applications

1. Be aware of how easily some pesticides move offsite in the air currents created by ventilation systems and by forced-air heating and cooling systems.

2. Apply pesticides close to the floor whenever possible to decrease the chances of drift in air currents.

3. Ventilate dwellings or animal structures after application even if there is no odor. Provide adequate ventilation for crawl spaces when applicable.

Surface Water Contamination

Surface water is often a source of drinking water. Humans and animals need clean water for drinking and bathing. Most fish and other aquatic animals and plants can survive only slight contamination of their water environment.

Farmers, ranchers, horticulturists, foresters, and turf growers need uncontaminated water for their livestock and for irrigation. Pesticides that move in runoff water or with eroded sediment may contaminate plants and animals located downslope and may reach sources of surface water. Polluted water can injure plants or animals directly or cause illegal residues in food, feed, poultry, or livestock products.

Pesticides get into water in many ways. Sometimes they are applied directly to the water to control aquatic pests. Pesticide contamination of water occurs most often when pesticides reach the water through carelessness or misuse of pesticides. It is important to realize that slope, vegetative cover, soil characteristics, volume and rate of water movement, temperature, and rainfall intensity and amount all are factors that affect runoff and leaching rates.

Groundwater Contamination

Groundwater is by far the largest water resource in Kansas. Groundwater provides 70 percent of the water used for public and private water supplies, irrigation, and industry. A few of the uses of groundwater include drinking, cooking, irrigation (including lawns), municipal, industrial, recreational (such as swimming pools), and many other uses.

In general, the sources of groundwater include water from rain (and other precipitation), lakes, streams, ponds, etc., that slowly leach through the surface soil and accumulate in the underlying sand and gravel layers. Such layers may be only a few feet from the soil surface, and others are several hundred feet below. These groundwater collection layers are called aquifers and can be thought of as underground lakes.

There are many potential sources of groundwater contamination. Some of these include industrial and municipal wastes, livestock and human waste septic systems, pesticide use, and various microbes. Fortunately, as the water slowly leaches through the soil, most (if not all) of these contaminants are removed through chemical and microbiological actions in the soil. However, aquifers that are only a few feet below the soil surface (known as a shallow water table) are being contaminated with a variety of chemicals—including pesticides.

Pesticides are essential chemical tools used in the production, transportation, and storage of food, feed, and fiber. They are also vital in pest control related to food preparation, serving, and in health- and recreation-related situations. It is extremely important that pesticide users recognize the importance of properly handling pesticides to avoid surface water and soil contamination with these products.

Minimizing Groundwater Contamination

Pesticide contamination of groundwater is a public concern. Contamination results from two types of sources: point and non-point.

Point Source Contamination

Point source contamination results from localized spills or accidents that can be traced back to an identifiable source. Point source contamination accounts for large doses being introduced into groundwater and, as a result, poses the greatest risk of rendering the water unfit for drinking.

Spills and other mishaps that occur during the handling and mixing of pesticides are a major contributing factor. We can take several steps to minimize contamination.

Wells are a direct conduit to the groundwater, and extra care should be taken at these sites when handling pesticides. In addition, many wells are not adequately sealed, which increases the risk of contamination in the event of a spill. Mix pesticides at least 200 feet from a well. Using a nurse-tank as a water source helps avoid these problems. Prevent back-siphoning into the well by keeping the end of the filler hose above the water level of the tank at all times. Anti-backflow devices for hoses can be purchased from irrigation and spray equipment suppliers. Clean up spills, especially near wells and other water supplies.

Additional practices that help prevent point source contamination include triple-rinsing and the proper disposal of pesticide containers and excess pesticides.

Non-Point Source Contamination

Contamination that occurs from non-point sources cannot be traced back to a specific location or event. Examples of non-point source contamination would include the leaching of pesticides through the normal course of pesticide use, or pesticides carried in surface runoff because of soil erosion. The extent of non-point source contamination is dependent upon the pesticide (herbicide, insecticide, fungicide), soil type, geological factors, production management, and weather factors.

Several practices can minimize non-point source contamination. Apply the proper amount of pesticide for the crop, pest, and site. Read the label to determine the minimum use rate. Proper sprayer calibration ensures application uniformity and more effective control. The amount of product can be reduced by using band applications instead of broadcast treatments. These practices not only reduce the potential for groundwater contamination but also decrease the chance of crop injury or residual problems and make control more economical.

In choosing an herbicide, less mobile, short-residual products are less likely to leach to the water table. Crop and herbicide rotation also reduces risk by using different herbicides each year.

Identifying high-risk areas is also helpful. The greatest risk for contamination exists where the groundwater table is shallow. In addition, herbicides are more likely to contaminate groundwater when applications are made to coarse-textured soils low in organic matter. High-pH soils also present concerns because some herbicides leach more readily under these conditions. Extra care should be taken when any of these situations exist.

Prevention of Surface and Groundwater Contamination

Apply pesticides only when and where necessary, and only in amounts adequate to control pests. The chance of groundwater contamination increases in areas with sandy soil, sinkholes, wells, streams, ponds, or shallow groundwater. Avoid pesticide application in these areas if possible.

When filling a tank with water, be sure to keep the water pipe or hose above the level of the pesticide mixture. This prevents contamination of the hose and keeps pesticides from back-siphoning into the water source. Back-siphoning starts with a reduction in water pressure and can draw very large quantities of pesticide directly into the water source. The Kansas Department of Health and Environment (KDHE) requires the use of an anti-backflow device or a fixed air gap when filling from a public water supply.

Avoid mixing, loading, or storing pesticides in areas where a spill, leak, or overflow could allow pesticide to get into water sources. Locate mix-load sites and equipment cleaning sites at least 200 feet from surface water or from direct links to groundwater. Use containment pads or install dikes or other barriers, or

grade soil to divert any potential seepage into soil.

Locate pesticide storage facilities at least 100 feet from wells, springs, sinkholes, and other sites that directly link to groundwater to prevent their contamination from runoff or firefighting water.

Pollinator Protection

Pesticides can harm bees and other beneficial insects. Applicators must be aware of bee activity when planning pesticide applications. Preventing bee loss is the joint responsibility of the applicator, the grower, and the beekeeper. Notify beekeepers in the area before applying pesticides so they can protect and move their bee colonies. Minimize losses of bees to insecticide poisoning by reading the label and following the directions. Use pesticides and formulations that are the least hazardous to pollinators. Emulsifiable concentrates are safer than powders or dust formulations. Do not spray when weeds or other plants around the treatment site are in bloom. Do not spray an entire field if a spot treatment will control the pest.

Protecting Endangered Species

Certain plants and animals have been identified as endangered or threatened species. It is important to make every effort to avoid causing harm to these populations. To protect these species from the harmful effects of pesticides, each state is responsible for implementing the Federal Endangered Species Protection Program in cooperation with the EPA. Under this program, pesticide products that might adversely affect an endangered species carry a label statement instructing applicators to consult a bulletin to determine if they must take any precautionary measures when using the product. These actions are required by the Endangered Species Act. EPA has made Endangered Species Bulletins available to users through the website: https://www.epa.gov/endangered-species/bulletins-live-two-view-bulletins.

It is important to note that endangered species changes are ongoing and may prompt the need to review additional websites or information prior to using a product. If product labels refer to websites, applicators are required to consult those sites and follow the directions.

Potential Benefits

Pesticides can help the environment when they are used carefully and wisely. For years, they have been used to control pests that are harmful to humans. With the help of pesticides, we produce food, feed, and fiber. Forests, ornamentals, buildings, and turfgrass plantings can be protected. Diseases, insects, and other plant pests can be greatly reduced. Pesticides can help us attain higher yields and better crop quality using less land to produce more food products.

Pesticides can be used to enhance outdoor activities in parks and camping areas. Fly and mosquito control programs give relief from the annoying pests. Aquatic pest control programs help keep lakes and waterways usable for swimming, boating, and fishing.

Pesticides protect livestock and domestic animals from harmful and annoying pests. The quantity and quality of livestock products—milk, eggs, meat, wool, and leather—are improved when pests are controlled.

Herbicides help keep rights-of-way clear of weeds. Highways, runways, train tracks, and utility rights-of-way must be weed-free to allow safe, unobstructed traffic flow. Barnyards, warehouses, utility lines, and other similar areas are safer when herbicides are used to keep weeds out.

By selecting pesticides wisely and applying them correctly, the responsible pesticide applicator can use these chemicals for the benefit of the environment.

Pesticide Equipment

Learning objectives:

- **Identify some common types of application equipment.**
- **Describe the common characteristics and importance of spray nozzles.**
- **Describe how nozzles play a role in reducing drift.**
- **Identify types of drift.**

Application Methods

The pesticide application method you choose depends on the nature and habits of the target pest, the characteristics of the target site, the properties of the pesticide, the suitability of the application equipment, and the cost and efficiency of alternative methods. Each of these factors affect which type of application method you use. The following are some common application methods.

- **Band application** involves applying a pesticide in parallel strips or bands, such as between rows of crops, rather than uniformly over the entire field.
- **Basal application** directs herbicides to the lower portions of brush or small trees to control vegetation.
- **Broadcast application** is the uniform application of a pesticide to an entire area or field.
- **Crack-and-crevice application** is the placement of small amounts of pesticide into cracks and crevices in buildings, such as along baseboards and in cabinets, where insects or other pests commonly hide.
- **Directed-spray application** specifically targets pests to minimize pesticide contact with nontarget plants and animals.
- **Foliar application** directs pesticide to the leafy portions of a plant.
- **Rope-wick or wiper treatments** release pesticides onto a device that is wiped onto weeds taller than the crop, like rye, or wiped selectively onto individual weeds in an ornamental planting bed.
- **Soil application** places pesticide directly on or in the soil instead of on a growing plant.
- **Soil incorporation** is the use of tillage, rainfall, or irrigation equipment to move pesticide into the soil.
- **Soil injection** is the application of a pesticide under pressure beneath the soil surface.
- **Space treatment** is the application of a pesticide in an enclosed area.
- **Spot treatment** is the application of a pesticide to small, distinct areas.
- **Tree injection** is the application pesticides under the bark of trees.

The pesticide application equipment you use is important to the success of your pest control job. The vast array of equipment on the market must coordinate with the pesticide as well as the size and type of application. Selecting the right kind of application equipment is important. Then, you must use the equipment correctly, and then clean and properly maintain the equipment. These things are true whether you use hand-carried, tractor-drawn, self-propelled, or aircraft-mounted equipment or unmanned aerial systems (UAS). Here are some things you should know about choosing, using, and caring for equipment.

Sprayers

Your sprayer should have the capability to do the job you want to do. It should be durable and convenient to fill, operate, and clean. The application equipment or device must apply the pesticide to the intended target at the proper rate.

Hand Sprayers

Hand sprayers are used for small jobs. Use them in restricted areas where a power unit would not work.

Advantages:

- Economical.
- Simple.
- Easy to use, clean, and store.

Limitations:

- Frequently lack good agitation and screening for wettable powders; you'll need to keep wettable powders in suspension by shaking the sprayer.

Low-Pressure Hydraulic Sprayers

These sprayers deliver low to moderate volume at 15–50 psi. Most are used for treating field and forage crops, pastures, fencerows, and structures. They also may apply fertilizer and pesticide mixtures.

Advantages:

- Medium to large tanks.
- Low cost.
- Lightweight.

Limitations:

- Low gallonage output may limit their use when high volume is required, as in liquid fertilizer applications.
- Low pressure limits versatility.
- Agitation system may be of limited capacity.

High-Pressure Sprayers

These sprayers are designed to deliver medium volumes at high pressure. They are used to spray fruits, vegetables, trees, landscape plants, noxious weeds, and livestock. When fitted with the correct pressure regulators, they can also be used at low pressures. Applications usually are made at high gallonages (100 gallons or more per acre above 100 psi). Even though very large tanks are used, they may need to be filled often.

Advantages:

- Well built.
- Usually have mechanical agitation.
- Last a long time, even when using abrasive solutions.

Limitations:

- High cost.
- Require large amounts of water, power, and fuel.
- High tire loads.
- High-pressure spray drifts easily.

Air Blast Sprayers

These units use a high-speed, fan-driven air stream to break the nozzle output into fine drops that move with the air stream to the target. The air is directed to either one or both sides as the sprayer moves forward. These sprayers are used in applying pesticides to landscape plants, fruits, and vegetables and for biting fly control. Most air blast sprayers can be adapted to apply either high or low volumes of spray. These sprayers should not normally be used to apply herbicides or for field broadcast applications.

Advantages:

- Good coverage and penetration.
- Low pump pressures.
- Mechanical agitation.

Limitations:

- Drift hazards.
- Chance of overdosages.
- Difficult to use in small areas.
- Hard to confine discharge to limited target areas.

Ultra-Low-Volume (ULV) Sprayers

ULV sprayers deliver undiluted pesticides from the air, on the ground, or in buildings. Pesticide is applied directly as formulated.

Advantages:

- No water is normally needed.
- Equal control with less gallonage.

Limitations:

- Does not provide for thorough wetting.
- Hazards of using high concentrates.
- Chance of overdosage.
- Small number of pesticides labeled for use in this manner.

Nozzles

Agricultural chemical spraying is becoming increasingly sophisticated and precise. Chemicals used by farmers today are designed for specific needs and require different nozzles to be applied properly.

The difference in nozzle styles is important because nozzles control the amount of material applied, the size of the droplets, and the pattern of the droplets. Pesticide labels may or may not contain information about the kind of spray nozzle that should be used but will generally describe the recommended droplet sizes (Table 1), which will provide guidance for nozzle selection. In addition, the type of nozzle control system will influence nozzle selection, as some nozzles are not approved for use with pulse width modulation systems.

Table 1: Nozzle droplet sizes and recommended uses

Droplet size	Median droplet size by volume (microns)	Degree of atomization	Relative size	Recommended uses
Fine	150	Fine mist	Sewing thread	Not recommended for field applications
Medium	190	Fine drizzle	--	Contact herbicides, insecticides
Coarse	275	Fine drizzle	Toothbrush bristle	Systemic herbicides, insecticides, fungicides
Very coarse	350	Light rain	--	Soil-applied products, some systemic herbicides
Extremely coarse	480	Light rain	Staple	Soil-applied products, some systemic herbicides
Ultra coarse	660	Light rain	--	Soil-applied products, some systemic herbicides

There are three basic types of spray patterns: flat fan, cone, and flood.

Each has a distinctive spray distribution that affects when and how the nozzle should be used. Multiple types of nozzles are available with each spray pattern. Nozzle styles are summarized to distinctive spray distributions and recommended uses in Table 2.

Table 2: Nozzle spray types and recommended uses

Nozzle type	Spray pattern	Recommended uses	Comments
Flat fan		Contact pesticides	Generally, flat fan nozzles will produce the finest droplets; modified versions have been designed to reduce drift
Twin		Contact or systemic pesticides	Can be a flat fan or venturi nozzle
Air induction/ venturi		Contact, systemic, or soil-applied pesticides	Required for application of certain Group 4 herbicides
Even flat fan		Banded applications	Don't require overlap with adjacent nozzles
Hollow cone		Contact fungicides and insecticides	Often used for air blast sprayers
Solid cone		Contact fungicides and insecticides	Often used for sucker control
Flood		Systemic or soil-applied pesticides	Often used for applications that include fertilizers

Questions to Consider When Selecting a Nozzle

It is not easy to make specific nozzle recommendations, because many questions must be considered.

- What kind of pesticide will be sprayed: herbicide, insecticide, fungicide?
- How is the chemical taken up by the pest: contact, systemic, soil-applied?
- Is reducing spray drift a priority?
- What will carry the chemical: water, liquid fertilizer?
- What kind of sprayer will be used in the application?
- What pressure range is desired?
- At what speed will the sprayer operate?
- What is nozzle spacing on the boom?
- What is the desired boom height?

Nozzle Materials

You can purchase nozzles made from many materials. Here are the main features of each kind.

Brass

- inexpensive
- wears quickly from abrasion

Stainless Steel

- will not corrode
- resists abrasion, especially if it is hardened

Nylon

- resists corrosion and abrasion
- some solvents may cause swelling of older nylon compounds
- available in color-coding for easy identification

New combination nozzles featuring stainless steel orifice inserts in injection-molded nylon bodies offer the advantages of both stainless steel and nylon at a reasonable price.

The formulation of the pesticide being sprayed determines the material from which the nozzle can be made. Brass nozzle tips should not be used with wettable powder or other abrasive formulations.

Check Nozzles Often

Keep nozzles in good working condition. For most boom applications, select nozzles of uniform type and size.

Nozzle caps should not be overtightened. Adjust nozzle height and spacing to suit the target, allowing for crop height if necessary. Follow the nozzle manufacturer's instructions and the pesticide label. Check each nozzle for uniform flow with a marked container or a digital calibration tool.

Replace any nozzle tips that discharge more than 5 percent more or less than the amount specified by the nozzle manufacturer when new.

Also replace any nozzles with faulty spray patterns. A good check is to spray on asphalt pavement or bare ground moving slowly enough to wet the area thoroughly. Watch for streaks as you increase speed or as spray dries.

Clean nozzles only with a toothbrush or wooden toothpick. A nail or pocketknife can damage the nozzle tip and ruin the spray pattern.

Operation and Maintenance

Always read and follow the operator's manual for all spray equipment. The manual will tell you exactly how to use and care for the equipment. After each use, rinse out the entire system. Remove and clean nozzles, nozzle screens, and strainers, and complete any required maintenance. Check for leaks in lines, valves, seals, and tank both after filling with water and while spraying.

Be alert for nozzle clogging and changes in nozzle patterns. If nozzles clog or other trouble occurs in the field, be careful not to contaminate yourself while correcting the problem. Shut off the sprayer and move it to the edge of the field before dismounting. Wear protective clothing while making repairs.

Clean the sprayer thoroughly when changing chemicals or before storing. Contamination from the previous chemical can injure your crop or react with the new chemical to decrease its effectiveness. Refer to Table 3 for recommended cleaning solutions and methods.

The following steps are suggested for a thorough cleaning. Spray and mix/load equipment should have been thoroughly rinsed with clean water and the rinsate applied to a field area prior to the cleaning process. Additional precautions may be necessary for certain chemicals.

1. Choose a cleaning area where the discharge will not contaminate streams or

water supplies. Keep children, pets, and livestock away from puddles.

2. Hose down the inside of the tank and fill it about half full, then flush the cleaning water out through the nozzles by operating the sprayer.
3. Repeat step 2.
4. Select the proper cleaning solution and follow instructions in Table 3.
5. Flush the sprayer one final time with clean water.
6. Remove the nozzle tips and screens and clean them with kerosene or a detergent solution. Nozzle tips should be dried and stored in a dry place or may be stored in light oil or diesel fuel.
7. If the sprayer is to be stored, fill the tank almost full of clean water. Add a small amount of new, light oil to the tank. Coat the system by pumping tank contents out through the nozzles or handgun. Drain the pump and plug its openings or fill the pump with light oil or antifreeze. Remove nozzles and nozzle screens and store in light oil or diesel fuel.

Table 3: Cleaning solutions and methods for cleaning sprayers

Pesticide used	25 gallons cleaning solution	2.5 gallons cleaning solution	Instructions
Hormone herbicides, amine formulations (2,4-D, dicamba, MCPA)	1 qt household ammonia or 1 lb washing soda (sal soda) or 2 lbs trisodium phosphate or ½ lb fine activated charcoal and ½ c powder detergent	½ c household ammonia or 3 Tbsp washing soda (sal soda) or ½ lb trisodium phosphate or 2 Tbsp fine activated charcoal and 1–2 oz powder detergent	Thoroughly agitate, flush small amount through system, and let remainder stand in sprayer overnight. Flush and rinse. Same as above, except let stand for at least 2 hours. Agitate, operate sprayer for 2 minutes, let remainder stand for 10 minutes, then flush through sprayer. Rinse.
Hormone herbicides, ester formulations (2,4-D, brush killers, [MCPA])	1 lb washing soda + 1½ gallons kerosene + ½ lb powder detergent[1]	4 oz washing soda + 1½ cups kerosene + 1 Tbsp powder detergent[1]	Rinse inside of tank and flush small amount through sprayer. Let stand for 2 hrs. Flush and Rinse.
Other herbicides (atrazine, simazine, alachlor)	½ lb powder detergent[1]	1 Tbsp powder detergent[1]	Rinse with clean water before and after using sudsy solutions.
Insecticides[2] and/or fungicides	½ lb powder detergent[1]	1 Tbsp powder detergent[1]	Agitate, flush, and rinse.

[1] Liquid detergent may be substituted for powder detergent; mix at a rate to make a sudsy solution.
[2] Organophosphate and carbamate insecticides may be detoxified by adding household ammonia to the cleaning solution (1 quart/25 gallons or ½ cup/2.5 gallons).

Dusters and Granular Applicators

Hand Dusters

Like hand sprayers, hand dusters can be used around homes and in gardens. They may consist of a squeeze bulb, bellows, tube, shaker, sliding tube, or a fan powdered by a hand crank.

Advantages:

- Pesticide is ready to apply.
- Good penetration in confined spaces.

Limitations:

- High cost for pesticide.
- Hard to get good foliar coverage.
- Dust is subject to drift.

Power Dusters

Power dusters use a powered fan or blower to propel the dust to the target. They range from knapsack or backpack types to those mounted on or pulled by tractors. Their capacity in area treated per hour compares favorably with some sprayers.

Advantages:

- Simply built.
- Easy to maintain.
- Low cost of equipment.

Limitations:

- Drift hazards.
- High cost of pesticide.
- Application may be less uniform than with sprays.

Selecting a Duster

Look for a power duster that is easy to clean. It should offer a uniform application rate as the hopper is emptied. Look for both manual and power dusters that keep the dust cloud well away from the user.

Granular Applicators

Granular applicators include hand-carried knapsack and spinning disk types for broadcast coverage, mounted equipment for applying bands over the rows in row crops and mounted or tractor-drawn machines for broadcast coverage.

Advantages:

- Eliminates mixing.
- Minimizes drift.
- Is less hazardous to applicator.

Limitations:

- High cost for pesticide.
- Limited use against some pests because granules won't stick to most plants.
- Need to calibrate for each granular formulation.
- Poor lateral distribution, especially on side slopes.

Selecting a Granular Applicator

Choose a granular applicator that is easy to clean and fill. It should have mechanical agitation over the outlet holes. This will prevent bridging and maintain a constant flow rate. Application should stop when drive stops, even if outlets remain open.

Use and Maintenance

Both dusters and granular applicators are speed-sensitive, so maintain uniform speed. Do not travel too fast for ground conditions. Bouncing equipment will cause the application rate to vary. Stay out of any dust cloud that may form. Watch banders to see that bandwidth stays the same. Small height changes due to changing soil conditions may cause rapid changes in bandwidth.

Clean equipment as directed by the operator's manual.

Controlling Drift

Drift is one of the major problems facing applicators of agricultural chemicals. ln addition to the potential damage to nontarget areas, drift tends to reduce the effectiveness of chemicals and waste money. Drift is generally inconsistent with pesticide labeling and is a violation of state and federal laws. There are two different types of drift.

Vapor Drift

Vapor drift occurs when a chemical vaporizes after being applied to the target area. The vapors are then carried to another area where damage may occur. The amount of vaporization that occurs depends largely on the temperature and formulation of the chemical being used. Volatile ester formulations vaporize rapidly in temperatures as low as 65°F, while "low vola-

tile" esters resist vaporization up to 85 to 100°F. Amine formulations are referred to as "non-volatile." Thus, choosing the correct herbicide formulations can significantly reduce the dangers of vapor drift.

Physical Drift

Physical drift is the actual movement of spray particles away from the target area. Many factors affect physical drift (Table 4), but one of the most important is droplet size. Small droplets fall through the air much more slowly, so they are carried farther by air movement. The particle may be trapped in a temperature inversion and carried for a great distance if weather conditions are unfavorable. In addition, evaporation has a greater effect on smaller droplets, which in turn slows the settling rate and creates still more opportunity for drift. The result is that the carrier in some of the smaller particles evaporates completely before reaching the ground.

All nozzles produce a wide range of droplet sizes, and very small, drift-prone particles cannot be eliminated. However, applicators can do several things to minimize unwanted physical drift.

First, use adequate amounts of carrier, usually 15–20 gallons per acre (GPA). This has several benefits from the standpoint of drift control. With lower concentrations, more drift droplets will be necessary to produce ill effects. In addition, more carrier means larger nozzles, which in turn usually produce larger droplets. Although this will increase the number of refills, the added carrier may also improve coverage and increase the effectiveness of the chemicals.

Avoid high pressures. Higher pressure creates a finer spray that is more subject to drift. The maximum pressure for flat fan, even fan, and flooding nozzle tips should be 40 psi. For maximum drift control with flooding nozzle tips, operate within the 8–20 psi range. Consult the nozzle sizing chart for the recommended pressures for the nozzle being used.

Use a flooding or drift reduction nozzle where practical. They produce larger droplets and operate at lower pressure than the equivalent tapered fan nozzle. Special low-drift hollow cone, flat fan, and flooding nozzles are claimed to greatly reduce the number of fine particles.

Numerous drift-reducing spray additives are available, although their effectiveness generally has not been thoroughly tested. Foams and invert emulsions also have potential, although special equipment is usually required.

Table 4:
Variables affecting physical drift

Helps reduce drift <	Variable	> Causes more drift
Lower	Boom height	Higher
Lower	Windspeed	Higher
Larger	Droplet size	Smaller
Lower	Pressure	Higher
Larger	Orifice size	Smaller
Low-pressure flat fan	Nozzle type	Flat fan or cone
Flooding	Nozzle type	Flat fan or cone
Raindrop	Nozzle type	Flat fan or cone
Higher	Relative humidity	Lower
Higher	Viscosity	Lower
Lower	Volatility	Higher

Calibration

Learning objectives:

- **Define the term "calibration."**
- **Explain the purpose and importance of calibration.**
- **Identify the factors that affect calibration.**
- **Explain how to calculate the size of the application area.**

Calibration is simply a process to adjust application equipment to apply the desired rate of pesticide. This process is needed to ensure that each pesticide is applied as directed on the label. Too much pesticide is dangerous; too little will not do a good job controlling pests.

Accurate calibration is the only way to know how much chemical is being applied.

Failure to calibrate a sprayer can injure crops, create hazardous situations, and cost money in wasted chemicals. In addition to calibrating the sprayer at the start of the season, it should be recalibrated every few days of use. Tests have shown that wettable powders can wear nozzle tips enough to increase the discharge rate by 20 percent after spraying for only 10 hours. Also, some brand-new nozzles show a tendency to "wear in" and increase discharge by a few percent during the first hour or two.

Before calibrating, check the sprayer carefully. Be sure nozzle tips are clean. Is pressure holding constant?

When the sprayer is operating properly, proceed to calibrate. There are many techniques for calibrating a sprayer, but all are based on determining the volume of chemical applied to a measured area. The choice between calibration methods will depend on the type of equipment to be calibrated as well as personal preference. Use these or any other method but be sure to calibrate.

Lawn and Garden Equipment

Before applying a pesticide, completely read the label on the pesticide container and follow its recommendations and safety precautions. Check the mechanical condition of the application equipment for tight connections and cleanliness.

Calibration of liquid hand sprayers may be accomplished with relative ease. When spraying, either hold the nozzle at a steady, constant height and spray back and forth in swaths or swing the nozzle back and forth at a uniform speed in a sweeping, overlapping motion. Maintain a uniform walking speed during application.

This calibration procedure is only for spraying ground areas. When spraying trees, shrubs, bushes, etc., use the recommended concentration (i.e., tablespoons per gallon) and spray until foliage is wetted.

1. Measure and mark an area of known size on a concrete or asphalt surface (such as 10 ft × 10 ft = 100 ft^2 or 20 ft × 25 ft = 500 ft^2). Using water, practice spraying the area. Observe the evaporating water. Areas of excessive or deficient application rates will be apparent. By adjusting the spraying technique, you should be able to obtain a uniform distribution over the marked area.

2. Fill the sprayer with water to a marked level, spray the area using the refined technique from step 1, and measure the amount of water that must be added to return the water to the marked level. Then compute the application rate.

Example:

measure area = 20 ft × 25 ft = 500 ft^2;
water sprayed = 0.75 gallon
application rate = 0.75 gallon/500 ft^2
or 1.5 gallon/1,000 ft^2

3. Recommendations on the label are sometimes given only in pounds (or quarts) of product per acre rather than in ounces per 1,000 ft^2, so the following conversions may be useful:

   dry products - oz/1,000 ft^2 = recommended lb/acre × 0.37

   liquid products - oz/1,000 ft^2 = recommended qt/acre × 0.73

4. Determine the proper amount of pesticide and add it to the water in the tank by:

$$oz\ pesticide/tank = \frac{GT\ x\ OP}{G/1{,}000\ ft^2}$$

Where:
GT = gallons per tankful
OP = oz pesticide per 1,000 ft^2
G/1,000 ft^2 = gallons applied per 1,000 ft^2

The oz pesticide/tank represents the amount of pesticide formulation to mix with a full sprayer tank.

Example:
For a 3-gallon tank capacity, application rate from step 2 above of 1.5 gallons per 1,000 ft^2 and a recommended rate of 4 lbs dry material per acre.

First:
oz/1,000 ft^2 = lb/acre × 0.37
= 4 × 0.37 = 1.5 oz/1,000 ft^2

Then:

$$oz\ pesticide/tank = \frac{GT\ x\ OP}{G/1{,}000\ ft^2}$$

$$= \frac{3\ gal\ x\ (1.05\ oz/1{,}000\ ft^2)}{1.5\ gal/1{,}000\ ft^2}$$

$$= 3\ oz/tank$$

Avoid spraying near sensitive plants. Check weather conditions and spray when wind speed is low to prevent drift. Do not use a higher pressure than needed. If you have a surplus pesticide for any reason, dispose of it according to label directions. After application, clean the sprayer thoroughly.

Calibration of granular applicators is also possible but is less safe, as we must use the chemical to be applied in the calibration process. Except for the orifice or metering gate setting, ground speed is the most significant factor affecting the application rate. To obtain the most uniform application, cover the area twice with the second application at right angles to the first.

1. Read the pesticide label to determine the application rate, and set the machine as recommended by the operator's manual for a starting setting. Set gate openings from one direction only, such as from "closed" to "open," to eliminate variation in setting.

2. Fill the hopper with the pesticide to an easily determined level designated by a mark drawn across the tank with a rule and marking pen.

3. Apply to a known area within the total acreage to be treated.

4. Refill the hopper to the mark, weighing container before and after filling to determine the amount used.

5. Calculate the application rate.

Example:
swath area = 5 ft wide × 100 ft long = 500 ft^2
amount applied = 1 lb
application rate = 1 lb/500 ft^2 or 2 lbs/1,000 ft^2

Or if the recommendation is given in pounds per acre, use the following example:

Example:
swath area = 5 ft wide × 100 ft long = 500 ft^2
amount applied = 1 lb
1 acre = 43,560 ft^2

First:

$$\frac{distance\ traveled\ (ft)\ x\ swath\ width\ (ft)}{43{,}560\ ft^2/acre}$$

$$= \frac{5\ ft\ x\ 10\ ft}{43{,}560}$$

$$= 0.011\ acre$$

Then:

$$application = \frac{amount\ used\ (lbs)}{acres\ covered}$$

$$= \frac{1\ lb}{0.011\ acre}$$

$$= 91\ lbs/acre$$

6. If the application rate determined in step 5 is not the desired rate, adjust the applicator setting and repeat steps 2 through 5 until the desired rate is obtained.

Granular formulations may differ in density, granule size, carrier used, etc. Be sure that you calibrate for each different formulation and be alert to changes in application rate. A good practice is to mark off the hoppers in a specific measure, such as quarts, and check the amount used at each filling against the area covered.

Field Sprayers

To apply a pesticide evenly and accurately, the sprayer must move at a constant speed and operate at a constant pressure. Each nozzle must be clean and at the right height. All nozzles must be of the correct type and size for the job. Each nozzle in the system must deliver its rated amount.

Measured Course and Banding

1. Measure a distance of ⅛ mile (660 feet or 40 rods). It is best to run the test in the field that will be sprayed, since sinkage in a soft field can change travel speed.

2. Start with a full spray tank, and be sure to eliminate air pockets in the pump, lines, and tank. Water (or the usual carrier) will usually do for calibration, but if you are using a chemical that changes the viscosity of the carrier, you should use the chemical as it will be sprayed.

3. Spray the ⅛-mile strip using the gear and throttle setting that you will use while spraying. You should run the engine well into the governed rpm range so that the governor can hold the speed constant.

4. Measure carefully the amount of water needed to refill the tank. Again, be sure to eliminate air pockets in the tank.

5. Calculate the application rate as follows:

Broadcast:

$$\frac{Gallons\ used\ x\ 66}{Swath\ width\ in\ ft} = Gallons\ per\ treated\ acre$$

Banding:

$$\frac{Gallons\ used\ x\ 66}{Band\ width\ in\ ft\ x\ number\ of\ bands}$$

$$= Gallons\ per\ treated\ acre$$

6. Divide tank capacity by gallons per acre (GPA) determined in step 5. This gives the number of acres covered by one tankful of spray.

7. To determine the amount of chemical to add to each tank, multiply the recommended rate of application by the number of acres covered per tankful.

Calibration Jar

1. With the unit stationary, operate the sprayer at the same pressure that will be used in the field. Use clean water for calibration unless you are using a chemical that changes the viscosity of the water. Hold a 1-quart jar under each nozzle and measure the number of seconds needed to fill the jar.

2. Calculate the flow rate of each nozzle by the formula:

$$GPM = \frac{15}{S}$$

Where:

GPM = gallons per minute delivered by nozzle
S = number of seconds needed to fill quart jar

Large nozzle tips with high flow rates may require use of a 5-gallon bucket in place of the quart jar. If using a 5-gallon bucket, the formula in step 2 becomes:

$$GPM = \frac{300}{S}$$

Where:

GPM = gallons per minute
S = number of seconds needed to fill 5-gallon bucket

3. Average the nozzle flow rates as determined in step 2. Compare the flow rate of each individual nozzle tip with the average. Any tip that has flow rate more than ±5 percent different than the average should be replaced. If the average flow rate differs from the factory specifications for new tips by more than ±5 percent, then the entire set of nozzle tips should be replaced.

4. Measure 176 feet and time the tractor over that distance while operating at the same gear and rpm that will be used in the field. If possible, do this in the actual field to be sprayed so the sinkage will be constant.

5. Determine the speed of the unit in miles per hour from the formula:

$$MPH = \frac{120}{T}$$

Where:

MPH = speed of tractor in miles per hour
T = number of seconds needed to travel 176 ft

Some examples are in the table below.

Table 5. Field speed determination

Time required to drive 176 ft (seconds)	Speed (miles per hour)
60	2
40	3
30	4
24	5
20	6
17	7

6. Now, determine the application rate from the formula:

$$GPA = \frac{GPM \times 5{,}940}{MPH \times W}$$

Where:

GPA = application rate in gallons per acre (treated area)
GPM = gallons per minute delivered by nozzle
MPH = speed in miles per hour
W = width
(a) For broadcast spraying, W is nozzle spacing in inches
(b) For band spraying, W is bandwidth in inches

7. Divide tank capacity by the GPA determined in step 6. This gives the number of acres covered by one tankful of spray.

8. To determine the amount of chemical to add to each tank, multiply the recommended rate of application by the number of acres covered per tankful.

Note: For a more thorough discussion of sprayer components, nozzle selection, and calibration, refer to Extension Bulletins MF2894, "Calibrating Boom Sprayers," and MF3178, "Agricultural Spray Nozzle: Selection and Sizing."

Adjusting Your Sprayer

If the sprayer is delivering more or less spray than the label directs, you can change the rate three ways:

1. **Change the pressure.** Lower pressure means less spray delivered; higher pressure means more spray delivered. This is not a good method, because a pressure change may change the nozzle pattern and droplet size. Pressure must be quadrupled or increased by four times to double the output.

2. **Change the speed of your sprayer.** Slower speed means more spray delivered; faster speed means less spray delivered. This method is practical for small changes in delivery rate. If you drive half as fast, you double the delivery rate.

3. **Change the nozzle tips to change the amount delivered.** The larger the hole in the tip, the more spray delivered. This is the best method for making major changes in the delivery rate of sprayers. Always select proper nozzles for the job. Use the manufacturer's performance charts to make your selection.

After making a change, recalibrate to make sure the rate is correct.

Determining the Correct Dosage

Next, the correct amount of pesticide to put in the tank to apply the correct dosage must be determined. To do this, you need to know two more facts:

1. How much the sprayer tank holds.
2. The amount of formulation to be used per unit of area. This will be given on the label.

Suppose the tank holds 200 gallons of spray. The directions say to apply 1 pint of formulation on each acre, and the sprayer applies 20 GPA. First find the number of acres one tank load will spray. Divide 200 gallons by 20.

$$\frac{200\ gallons\ per\ tankful}{20\ gallons\ per\ acre}$$

$$= 10\ acres\ per\ tankful$$

To find the amount of formulation to add to the tank for spraying 10 acres with 1 pint per acre, multiply 1 pint by 10.

$$1\ pint\ per\ acre\ x\ 10\ acres\ per\ tankful$$

$$= 10\ pints\ per\ tankful$$

Suppose the formulation of a pesticide is a 50 percent wettable powder and you want to apply ½ lb of active ingredient per acre. In this example the tank will cover 10 acres.

Find how many pounds of formulation are needed to apply ½ lb of active ingredient per acre. There is ½ lb of active ingredient in 1 lb of 50 percent wettable powder formulation. So, 1 lb of formulation is needed for each acre your sprayer will cover.

$$1\ lb\ per\ acre\ x\ 10\ acres\ per\ tankful$$

$$= 10\ lbs\ per\ tankful$$

Add the 10 lbs of wettable powder to a small amount of water in a clean bucket. Stir until it is mixed well and add this mixture (called a slurry) to the partly filled tank. Remember to operate the sprayer's agitator while adding the slurry and filling the tank.

Granular Application Calibration

Granular chemicals for weed or insect control must be applied with precision. This is particularly true of preemergence herbicides and soil insecticides.

Both herbicides and insecticides may be broadcast before planting or applied after planting. It is common, however, to apply those chemicals in a band over the row by attaching applicators to the planter. This reduces the amount of material used, thus lowering costs.

Check and Maintain Ground Speed

Speed should be checked carefully in the field where the chemicals will be applied. One method is to set markers 176 feet apart and check the time (in seconds) required to drive between them. Make each check with a running start. To determine the speed in MPH, divide 120 by the traveling time in seconds. Some examples are given in Table 5 on the left.

Once the field speed has been established and checked, keep the speed uniform during the application.

Even though granular applicators use a rotating agitator that varies with ground speed, the flow of the granules through the outlet hole is not necessarily proportional to speed. It is not uncommon to find a 100 percent variation in the application rate with a speed change of 1 MPH.

The factors that affect application rate can vary from one day to the next or from one field to another. For this reason, check the application rate often so you can make the necessary adjustments to obtain the proper application rate.

Field Check of Application Rate

Once the applicators have been set according to the operator's manual, make a field check for each hopper. This can be done in several ways. One method is to make a round or two in the field with the seed boxes removed from the planter. Paper, plastic, or cloth bags can be used for collecting the granules from each hopper. The granules collected can be weighed or checked with a calibrated measure. Repeat this process until the desired rate is obtained from each hopper.

Another method that is less accurate but acceptable is to proceed with the planting and check the exact amount dispensed through each hopper. The disadvantage of this method

is the possibility of not having the proper application rate on the calibrating rows.

Table 6 below shows the number of feet of row in 1 acre, and the pounds per acre to equal 1 ounce per 1,000-foot row. The table can be used to check calibration.

Table 6. Checking calibration

Row spacing	Feet of row in 1 acre	Lbs/acre to equal 1 oz per 1,000 ft of row
40	13,068	0.82
36	14,520	0.91
30	17,424	1.09
24	21,780	1.36
20	26,136	1.63

Example 1

An operator wants to apply a granular insecticide with units mounted on a 6-row 30-inch planter. The insecticide calls for 6–8 oz per 1,000 ft of row. Four passes were made across a quarter section, and the operator refilled all the hoppers. Refilled, they held a total of 20 lbs of insecticide. Is this within the allowable range?

Solution:

The total row length covered is:
4 passes × 6 rows × 2,650 ft = 63,600 ft, so the application rate is:

$$\frac{20\ lbs\ x\ 16\ oz/lb}{63{,}600\ ft} = 5.03\ oz/1{,}000\ ft$$

The result, 5.03 oz/1,000 ft, is below the 6 to 8 oz per 1,000 ft rate for the insecticide. The application rate is too low, so the applicator should be readjusted.

Example 2

An applicator refilled the granular hoppers after finishing a 9-acre field and found that 75 lbs of granules had been applied. The label calls for 5–7 oz per 1,000 ft of row, and the applicator is using 24-in. rows. Is this within the allowable range?

Solution:

The application rate in lbs/acre is:

$$\frac{75\ lbs}{9\ acres} = 8.33\ lbs/acre$$

From Table 6, 1 oz/1,000 ft = 1.36 lbs/acre, so the row application rate was:

$$\frac{8.33\ lbs/acre}{1.36\ lbs/acre} = 6.125\ oz\ /\ 1{,}000\ ft$$

The result, 6.125 oz/1,000 ft, is within the 5–7 oz per 1,000 ft rate for the insecticide. The application rate was acceptable.

Example 3

A patch of weeds about 80 ft in diameter needs to be treated for a noxious weed. The granular herbicide being used should be applied at the rate of 2 lbs per square rod. How much should be broadcast on this area?

Solution:

1 rod = 16.5 ft, so one sq. rod
= 272 sq. ft
The area of a circle is:
A = 3.14 × r × r, where r is the radius of the circle.
In this case, r = 40 ft, so:
A = 3.14 × 40 × 40 = 5,024 ft^2, or

$$\frac{5{,}025\ ft^2}{272\ ft^2/sq.rd.} = 18.5\ sq.rd.$$

So, the total amount applied should be:
2 lb/sq. rod × 18.5 sq. rod = 37 lbs

Volume and Area Determinations

Determining Volume

Volume of a cylinder = 3.1416 × radius × radius × length
Volume of a cone = 1.0472 × radius × radius × height (for a round hopper bottom).
Volume of a pyramid = length of base × width of base × ⅓ of the height (for a square hopper bottom).

Volume Conversion Factors

1 gallon = 231 cubic in.
7.48 gallons = 1 cubic ft
62.4 lbs of water = 1 cubic ft
8.336 lbs of water = 1 gallon
1 gallon = 0.1337 cubic ft
27 cubic ft = 1 cubic yard

Determining Field Areas

Area of a rectangle = length × width
Area of right triangle = ½ × length × width
Area of a circle = 3.14 × radius × radius

Area Conversion Factors

Acres = $ft^2/43{,}560$
Miles = ft/5,280
Miles = rods/320
Rods = ft/16.5

Useful Conversions

$$MPH = \frac{ft/minutes}{88}$$

$$Acres/hour = \frac{MPH\ x\ swath\ width\ (ft)}{8.25}$$

$$Acres/minute = \frac{MPH\ x\ swath\ width\ (ft)}{495}$$

Example:

A 20-foot sprayer traveling 6 MPH covers 14.5 acres/hour. A 100 MPH airplane with a 50-foot swath covers 10.1 acres/minute.

Liquid Volume Conversion Factors

3 teaspoons = 1 tablespoon
2 tablespoons = 1 fluid oz
8 fluid oz = 1 cup
2 cups = 1 pint
2 pints = 1 quart
4 quarts = 1 gallon
1 pint = 473 milliliters
1 gallon = 3,785 milliliters
1 lb = 0.454 kilograms
1 liter of water weighs 1 kilogram
1,000 milliliters = 1 liter
1,000 grams = 1 kilogram

How much is in the tank?

Cylindrical spray tanks are often mounted horizontally, but unless the tank has a capacity scale taped to it, it is hard to calculate how much liquid is left in the tank.

The first question is "What is the total capacity of the tank?" The volume of a cylindrical tank is:

V = 3.1416 × r × r × L

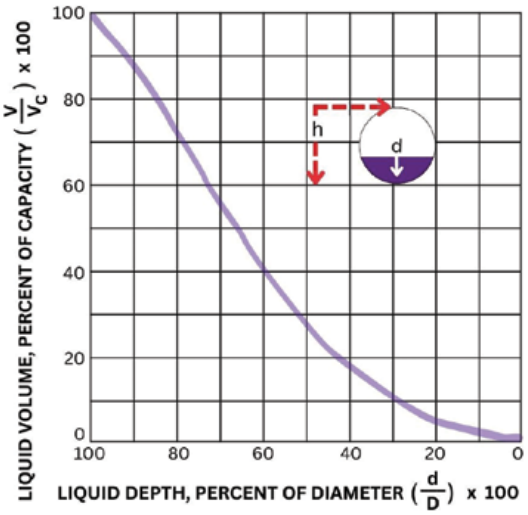
This assumes the end of the tank is square, not oval or spherical. For example, if the tank diameter is 36 in. and the length is 48 in., the volume is:

V = 3.1416 × 18 × 18 × 48 = 48,858 cubic in.

Since 1 gallon contains 231 cubic in., the tank capacity in gallons is:

$$\frac{48{,}858\ cubic\ in.}{231\ cubic\ in.} = 211.5\ gallons$$

Now, if the tank is only partially filled, how much does it contain? To determine this, with the tank level, measure the depth of the liquid, then consult the graph below. Considering the same tank (36 in. × 48 in.) as above, assume the liquid depth is 9 in. Then, d/D × 100 becomes 9/36 × 100, or 25. Reading up from the bottom axis, then over, the graph indicates that the tank is 20 percent full; 20 percent × 211.5 gallons equals 42.3 gallons.



Depth-volume relationship for a cylindrical tank

Example 1

An operator filled a 300-gallon spray tank and started spraying a half section. He ran out in the middle of the second round. Swath width is 30 ft. How many GPA are being applied?

Calibration example 1

Solution:

First, calculate the area sprayed. In this case, the top and bottom strips are 5,280 ft long, while the end strips are 2,640 - 90 = 2,550 ft long.

Thus, the areas sprayed are:

Top:	30 ft × 5,280 ft =	158,400
Bottom:	60 ft × 5,280 ft =	316,800
Left:	60 ft × 2,550 ft =	153,000
Right:	30 ft × 2,550 ft =	76,500
TOTAL		704,700 ft^2

Now to convert ft^2 to acres:

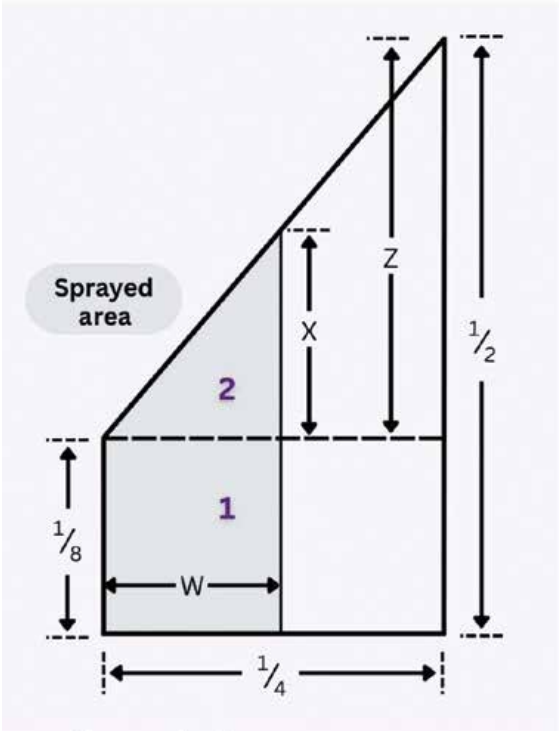
$$\frac{704{,}700\ ft^2}{43{,}560\ ft^2/acre} = 16.18\ acres$$

So, the application rate is:

$$\frac{300\ gallons}{16.18\ acres} = 18.5\ gallons/acre$$

Example 2

A creek runs through an 80-acre field, cutting off a large corner. The east and west boundaries are ½ mile and ⅛ mile long, and the south fence is ¼ mile long. The creek is nearly straight. A 25-ft-wide sprayer makes 30 passes, starting at the west edge, and about 340 gallons of spray is used. What is the application rate?



Calibration example 2

Solution:

To solve the problem, first divide the sprayed area into two regions, a rectangle and a triangle.

Rectangle (Region 1)
Area = 30 passes × 25 ft × 660 ft = 495,000 ft^2
(⅛ mile = 660 ft)

Triangle (Region 2)
Area = ½ × W × L
Now, Z = ½ – ⅛ = ⅜ mile = 1,980 ft
W = 750 ft

Since the creek is nearly straight, L is the same proportion of Z as W is to ¼ mile. Thus,

$$L = \frac{W\ x\ Z}{1/4\ mile}$$

or:

$$L = \frac{750\ x\ 1{,}980}{1{,}320} = 1{,}125\ ft$$

So, area = ½ × 750 × 1,125 = 421,875 ft^2 and the total area sprayed is:

495,000 + 421,875 = 916,875 ft^2

or

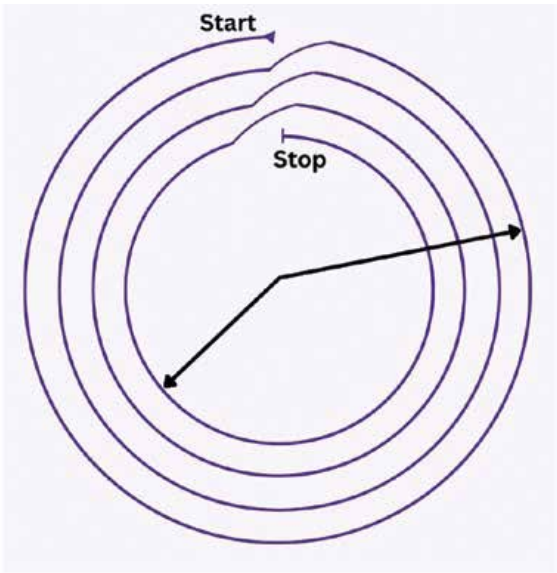
$$\frac{916{,}875\ ft^2}{43{,}560\ ft^2/acre} = 21.0\ acres$$

Since 340 gallons were used, the application rate is:

$$\frac{340\ gallons}{21.0\ acres} = 16.2\ gallons/acre$$

Example 3

A sprayer with a 30-ft boom starts spraying a quarter-section-sized center pivot irrigated field. At the end of the third round, about 320 gallons of spray have been used. What is the application rate?



Calibration example 3

Solution:

A 90-ft-wide strip was sprayed around the outside of the circle, so we can calculate the total area of the circle, then subtract the area that has not yet been sprayed.

Total area of circle:
A = 3.14 × 1,320 × 1,320 = 5,471,136 ft^2 or

$$\frac{5{,}471{,}136\ ft^2}{43{,}560\ ft^2/acre} = 125.6\ acres$$

Area not yet sprayed
r = 1,320 - 90 = 1,230 ft
A = 3.14 × 1,230 × 1,230 = 4,750,506 ft^2
or

$$\frac{4{,}750{,}506\ ft^2}{43{,}560\ ft^2/acre} = 109.1\ acres$$

So, the area that has been sprayed is 125.6 - 109.1 = 16.5 acres, and the application rate is:

$$\frac{320\ gallons}{16.5\ acres} = 19.4\ GPA$$

It is important to remember that as pesticide application systems become increasingly automated that calibration is still essential—even with advanced GPS-controlled sprayers. Technology can fail in simple ways, and not all systems manage pesticide output the same. Some monitor and control each nozzle individually and alert the operator to issues, while others only monitor sections or the entire boom. In those cases, a single malfunctioning nozzle might go unnoticed without manual inspection. And if you don't check, you can end up with streaks of poor control (or over-application).

Laws and Regulations

Learning objectives:

- **Explain how and why pesticides are regulated in the United States.**
- **Describe applicator responsibilities for pesticide applications.**
- **Identify recordkeeping components.**

Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA)

The U.S. Congress enacted legislation that regulates the production, transportation, sale, use, and disposal of pesticides. The Federal Insecticide, Fungicide and Rodenticide Act (FIFRA) was enacted in 1947. The EPA administers this statute.

Both state and federal laws regulate pesticides. Certification as it exists today was first created in 1972 when Congress amended FIFRA. This law covers the registration of all pesticides, including their classification as restricted use. FIFRA requires that applicators meet certain competency requirements to use RUPs. It also provides for civil penalties up to $5,000 for each offense and criminal penalties up to $25,000, one year in prison, or both for persons who do not obey the law. Use of a pesticide inconsistent with the label is a violation of FIFRA.

In general, all pesticides must be registered by the EPA. FIFRA and related rules and regulations set forth the requirements for registration. These requirements are quite complex and need not be discussed here other than to point out that EPA will not register a pesticide unless the agency is satisfied that the use of the pesticide as specified by the label will not cause undue harm to people or the environment. Pesticides must be reregistered periodically, and EPA follows the same evaluation procedure for reregistrations as for original registrations. EPA may cancel the registration of a pesticide if information becomes available to show that the material poses an undue risk to human health or the environment.

There are some exceptions to the registration requirement, but those exceptions generally do not affect the availability or use of a pesticide in agriculture. An unregistered pesticide may be made available for (1) experimental use under a temporary permit, especially if the experimental use is needed to develop information to support an application for registration; and (2) emergency use upon application by the KDA for a Section 18 permit.

Pesticide Business License

In Kansas, a pesticide business must be licensed. Any individual, business, association of persons, or corporation that applies pesticides for compensation on or to the property of another or is subcontracted by a licensed pesticide business to apply pesticides on the property of another is required to obtain a Kansas Pesticide Business License. It is unlawful to advertise, offer for sale, sell or perform any service for the control of a pest on the property of another or apply a pesticide on the property of another within this state without a pesticide business license. Pesticide businesses must employ a commercial applicator who is certified in each category and subcategory in which application work is performed prior to becoming licensed. State, federal, and other governmental agencies shall have government authorization to make applications in the state of Kansas.

Required Records

The Kansas Pesticide Law requires each pesticide business to maintain certain kinds of records of all (both RUP and general use pesticides) commercial applications. These requirements as stated in the law are as follows.

(a) Each pesticide business shall present to each customer for whom he or she performs a pest control service involving the application of pesticides a written statement of services or contract setting forth the following information:

1. Business name, address, and license number of the pesticide business licensee;
2. Name and address of the customer (all addresses should include the street address or rural route);
3. The name of each pest to be controlled;
4. Date, location, and start and end time of the application of the pesticide;
5. Complete brand or product name of each pesticide used;
6. EPA registration number;
7. Quantity of pesticide used;
8. Total area to which the pesticide is applied;
9. The concentration or rate of pesticide applied, when applicable;
10. Signature and applicator certification number of the individual who performed or supervised the application, when applicable;
11. Wind direction and velocity, when applicable;
12. Expiration date of all guarantees, if any are given; and
13. If the pesticide was applied at less than label rate, this must be clearly stated.

(b) Whenever the service involving the application of pesticides is performed for the purpose of controlling termites, powder post beetles, wood borers, wood rot fungus, or any other wood-destroying pest, the following information shall be included in addition to that required under subsection (a):

(1) The conditions under which retreatments, if any are to be made;
(2) The approximate date or dates of inspection, for any to be made after the original application of the pesticides; and
(3) A diagram of the structure to be treated, showing the location of visible evidence of active and inactive infestations by any wood-destroying pest or pests for which the treatment is proposed; where a partial or spot treatment is to be made, this diagram shall also show the area or areas of the structure which are to be treated.

- The required statement of services or contract for services involving the application of pesticides may be incorporated into any business form used by the pesticide business licensee.
- The statement of service or contract shall be presented to the customer in paper format, unless the customer agrees to receive all or part of the statement of service in electronic format.
- The pesticide business licensee shall present the statement of services or contract to the customer within 30 days of when the pest control services were provided and prior to the due date for payment of the services, if the services are not a prepaid agreement. Upon the customer's request, the statement of services or contract shall be presented to the customer no later than the close of business on the business day following the request.
- Upon request of the Secretary of Agriculture or the secretary's designee, a duplicate of the statement of services or contract provided to the customer shall be made available within two business days to the Secretary of Agriculture or the secretary's designee.
- Any pesticide business licensee using aerial methods of applying pesticides may present such information at any time prior to the time payment is accepted.
- The statement of services or contract may be signed using the legible printed names of the individuals who performed and, when applicable, supervised the performance of the pest control service or the application of pesticide.
- The pesticide business licensee shall retain a copy of each statement of services or contract in such licensee's files for a period of three years from the expiration date of any statement of services or contract.
- Each pesticide business licensee shall faithfully carry out the stipulations set

forth in any statement of services or contract prepared by such licensee or any of its representatives.

- Each pesticide business licensee shall make available to the Secretary of Agriculture upon request, a copy of any statement of services or contract, records of all pesticide applications during any specified period, records of all employees who performed any service involving, or in conjunction with, the application of pesticides and any other requested information pertinent to the administration of this act or any rule or regulation adopted hereunder by the secretary.

Commercial Applicator Categories

Commercial applications of pesticides have, for certification purposes, been separated into the following categories and subcategories.

1. **Agricultural pest control** in the production of agricultural plants and animals.
   a. Agricultural plant pest control in producing agricultural crops and on grasslands and non-crop agricultural lands.
   b. Agricultural animal pest control of animals and to places on or in which animals are confined. (Doctors of Veterinary Medicine engaged in the business of applying pesticides for hire, engaged in large-scale use of pesticides, or publicly holding themselves out as pesticide applicators, are included in this category).
   c. Agricultural wildlife damage control for the management and control of wildlife in rangeland and agricultural areas.

2. **Forest Pest Control** in forests, forest nurseries, and forest seed-producing areas.

3. **Ornamental and turf pest control** to control pests in the maintenance and production of ornamental trees, shrubs, flowers, turf, and interior landscape pest control.

4. **Seed treatment**.

5. **Aquatic pest control** purposefully applied to standing or running water, excluding applicators engaged in public health-related activities included in category 8 below.

   5S. Sewer root control in sewer lines and septic systems

6. **Right-of-way pest control** in the maintenance of public roads, electric powerlines, pipelines, railway right-of-way, or other similar areas, excluding applicators engaged in regulatory activities included in category 9.

7. **Industrial, institutional, structural, and health-related pest control** in, on, or around food-handling establishments; human dwellings; institutions such as schools and hospitals; industrial establishments, including warehouses and grain elevators; and any other structures and adjacent areas, public or private; and for the protection of stored, processed, or manufactured products.
   a. Wood-destroying pest control in the control of termites, powder post beetles, wood borers, wood rot fungus, and any other wood-destroying pest.
   b. Non-soil fumigation and stored products pest control of pests in stored grain and food products and to fumigate anything other than soil.
   c. Industrial pest control of pests in industrial areas.
   d. Health-related pest control for the management and control of pests having medical and public health importance.
   e. Structural pest control of pests in structures including human dwellings, institutions, schools, hospitals, and industrial establishments (applications not covered by wood-destroying or stored product pest control).
   f. Wood preservation and wood products to extend the life of wooden poles, posts, crossties, and other wood products to preserve or protect them.

8. **Public health pest control:** Federal, state, or other governmental employees in public health programs for the management and control of pests having medical and public health importance.

9. **Regulatory pest control:** Federal, state, or other governmental employees who use or supervise the use of RUPs in the control of federal or state regulated pests.
    a. Noxious weed control of weed pests regulated under the Kansas Noxious Weed Law.
    b. Regulated pest control of federal or state regulated pests not covered in subcategory (a) above.

10. **Demonstration and research pest control** of:
    a. individuals who demonstrate to the public the proper use and techniques of application of RUPs or supervise such demonstrations; or
    b. persons conducting field research with pesticides and, in doing so, use or supervise the use of RUPs.

11. **Sodium cyanide predator control** to use or supervise the use of sodium cyanide in a mechanical ejection device. This category is limited to use by governmental agencies only.

12. **Aerial pest control:** Use of pesticides applied by fixed or rotary aircraft.

13. **Soil fumigation:** Use of pesticides to fumigate soil.

Responsibilities of Certified Applicators

1. Certified applicators must have their certificate or pocket card (an electronic copy is acceptable) in possession when applying or supervising the use of a pesticide.

2. Certified commercial applicators are required to notify KDA of any change in mailing address, phone number or email address. Such notification is to be made within 30 days.

3. Certified commercial applicators who are not employed by or otherwise acting for a licensed business are required to prepare a statement of work performed for each application of RUPs made by themselves or under their supervision. This statement can be written or in electronic format. Each such statement must set forth the following:
    a. Name and address of commercial applicator;
    b. Name and address of owner or operator of property treated;
    c. The name of each pest to be controlled;
    d. Date and location of the application of the pesticide;
    e. Complete brand or product name of each pesticide used;
    f. EPA Registration number;
    g. Quantity of pesticide used;
    h. Total area to which the pesticide is applied;
    i. The concentration or rate of pesticide applied, when applicable;
    j. Signature of the individual who performed or supervised the application;
    k. Wind direction and velocity, when applicable;
    l. Expiration date of all guarantees, if any are given;
    m. If the pesticide was applied at less than label rate, this must be conspicuously stated; and
    n. For additional requirements, see (b) under the Required Records section above.

Such records must be maintained for three years after such application of the pesticide and shall be available upon request of KDA.

4. A noncertified person (i.e., uncertified applicators and registered pest control technicians) applying an RUP must be under the supervision of a certified commercial applicator. This supervision requires that both persons are stationed at and work from the same business address and that the certified commercial applicator provide the noncertified applicator with detailed instructions in the handling and application of the pesticide being used. The certified commercial applicator must be available to the noncertified applicator by telephone, two-way radio or other comparable means of communication during the time the RUP is being applied. The certified commercial applicator shall be physically present, when such presence is required by the pesticide label. The certified commercial applicator shall be prepared to verify that the requirements were met, if

requested to do so by an authorized representative of the KDA. Uncertified applicators in wood-destroying, structural, or ornamental and turf pest control may not commercially apply any pesticide unless they are registered pest control technicians or if either a certified applicator or registered pest control technician is physically present.

Prohibited Actions

All pesticides must have a label. The label includes instructions for use, storage and disposal of containers. The label, together with any literature to which it refers, has the force of law. It is unlawful to detach, alter, deface, or destroy the label.

The following is a partial list of Unlawful Acts specified under the Kansas Pesticide Law. It shall be unlawful for any person to:

- Except as provided for in K.S.A. 2-2470, use pesticides in a manner inconsistent with such pesticide's label or labeling;
- Discard or store any pesticide or pesticide container in such a manner as to cause injury to humans, vegetation, crops, livestock, wildlife, pollinating insects, or waterways and wildlife therein; or
- Fail to comply with any other provision of this act or any rule or regulation adopted pursuant thereto.

Penalties

Civil Penalties

Violations of the provisions listed above regarding pesticide business licenses and pesticide dealers may incur a civil penalty in an amount not less than $100 nor more than $5,000 for each violation and, in the case of a continuing violation, every day such violation continues may be deemed a separate violation. In the case of a continuing violation, the maximum civil penalty shall not exceed $10,000.

Any person who holds a license, certification, registration or permit or is required to hold such license, certification, registration, or permit and violates any provisions of the Kansas Pesticide Law or any rules or regulations adopted may incur a civil penalty in the amount fixed by rules and regulations of the secretary in an amount not less than $100 nor more than $500 per violation, and in the case of a continuing violation, every day such violation continues may be deemed a separate violation. In the case of a continuing violation, the maximum civil penalty shall not exceed $2,500.

Criminal Penalties

Willful violation of FIFRA provisions is a Class A misdemeanor. Each separate violation shall constitute a separate offense. Upon conviction, a private applicator is subject to a fine of up to $1,000 and/or 30 days in prison, a commercial applicator is subject to a fine of up to $25,000 and/or up to 1 year in prison; and a producer is subject to a fine up to $50,000 and/or up to 1 year in prison.

Remember, you must use all pesticides according to the label directions.

Related Regulations

Shipment of pesticides and other dangerous substances across state lines is regulated by the Federal Department of Transportation (DOT).

If you haul pesticides between states, you should know that:

- They must be in their original packages. Each package must meet DOT standards.
- The vehicle must have a correct sign. Manufacturers must put the correct warning signs on each package.
- The pesticides may not be hauled in the same vehicle with food products.

You must contact DOT immediately after each accident:

- when someone is killed,
- when someone is injured badly enough to go to a hospital, or
- when damage is more than $50,000.

You must tell DOT about all spills during shipment.

State and local laws may require you to take additional precautions. Specific Fish and Game laws govern the use of such pesticides as sodium cyanide, fumigants, and others used in vertebrate damage control.

Disposal of pesticide waste is regulated in Kansas by the Kansas Department of Health and Environment (KDHE). To avoid the expense and regulatory problems associated with pesticide waste, every effort should be made to avoid producing it. Excess pesticide solutions and diluted rinse solutions should be collected and appropriately used in subsequent spray mixtures. Liquid pesticide containers

should be properly rinsed (use the triple rinse method or equivalent) so they can be disposed of as solid waste or recycled.

For regulatory purposes, pesticide wastes are classified as hazardous, small quantity hazardous, or non-hazardous. What must be done with pesticide waste depends upon its classification. Questions concerning the classification and required disposal methods for certain kinds of waste should be directed to KDHE. Applicators are responsible for determining whether they produce hazardous waste. Basically, the EPA considers a waste to be hazardous if it is ignitable, reactive, corrosive, or toxic, or if it is listed among 400 or more substances the agency has determined to be hazardous.

Residues and Tolerances

Pesticide that remains in or on raw farm products or processed foods is called a residue. EPA sets residue tolerances under regulations authorized by the Federal Food, Drug, and Cosmetic Act (FD&C Act). A tolerance is the maximum pesticide residue limit that may legally remain on or in treated crops and animals or animal products sold for food or feed. Residues in processed foods are considered food additives and are regulated as such.

Tolerances are expressed in parts per million (ppm). One ppm equals one part (by weight) of pesticide for each million parts of farm or food product. Using pounds as a measure, 50 ppm would be 50 pounds of pesticide in a million pounds of the product. The same pesticide may have a different tolerance on different products. It might be 5 ppm on grapes and 25 ppm on apples. If too much residue is found on a farm or food product, the product may be seized or condemned.

The label will tell you how many days before harvest the pesticide may be applied. Follow the label exactly to be sure you are not breaking the law and to be sure dangerous levels of pesticide residues are not consumed.

Common Pesticide Misuses

The common misuses involving pesticides start with poor planning. The "more is better" syndrome has no place in choosing the rate to apply. Adherence to pesticide label rates specified for the crop, soil, and pesticide combination provides higher probability that the pesticide will work as desired without causing crop damage, illegal residues, or environmental hazards. Improper mixes of different pesticides are sometimes chosen to "kill two birds with one stone." Unless the pesticide label has instructions for a specific mix, the applicator assumes responsibility. Common errors include using excessive rates in the combination, using an improper carrier, incompatibility of formulations, and inappropriate timing of application for a component pesticide.

Pesticide misuse commonly results from poor management decisions in spray application, use of inadequate safety equipment, and use of improperly maintained or designed sprayer equipment. Use of pesticide products inconsistent with their individual labels is a violation of the pesticide law.

Pesticide Safety

Learning objectives:

- **Define the terms "risk," "toxicity," and "exposure."**
- **List the four routes through which pesticides can enter the body.**
- **Describe typical symptoms of pesticide exposure in humans.**
- **Define "restricted-entry interval (REI)."**
- **Explain the features that make personal protective equipment (PPE) effective.**
- **Outline how to properly select and wear PPE.**
- **Describe first aid procedures used in cases of dermal, oral, inhalation, and eye exposure.**

Pesticides are designed to be toxic to living organisms, so the control of unwanted pests (plants, insects, rodents, fungi, bacteria, etc.) can be achieved. Unfortunately, this means that pesticides also can be hazardous to people. Pesticides can cause both short-term and long-term effects in humans. Pesticide applicators and their families are exposed regularly to greater than normal contact with pesticides. Therefore, it is important to do everything possible to keep exposure to an absolute minimum.

Workers and other people also should be protected from pesticide injuries. Most pesticide accidents result from careless practices or lack of knowledge about safe handling of pesticides. The time you spend to learn about and use safe procedures is an investment in the health and safety of yourself, your family, and others.

Protecting Your Body

Some pesticides are so highly toxic that accidental exposure without proper protection can sicken or kill humans. Other pesticides are much less toxic; large exposures to these poisons would be necessary to cause illness. **Hazard** or risk is the potential for harm (injury, illness, or allergy) to occur because of product toxicity or human exposure. **Toxicity** refers to the ability of a pesticide to cause short-term (acute) or long-term (chronic) injury. Even slightly toxic pesticides can irritate the nose, throat, eyes, and skin of some people. Knowing how to protect yourself, your workers, and others from harmful exposure to the pesticides you are applying is important.

Exposure occurs when pesticides get onto or into the body though the mouth (orally), through the skin or eyes (dermally), or through the lungs (inhalation). Product formulations differ greatly in the exposure risk they present. People may be poisoned without realizing the seriousness of the exposure—especially if pesticides enter through the skin and lungs.

Oral exposure can be caused by:

- not washing hands before eating, drinking, smoking, vaping, or chewing tobacco;
- mistaking the pesticide for food or drink;
- accidentally applying pesticides to food; or
- carelessly splashing pesticide into the mouth.

Dermal or ocular exposure can be caused by:

- not washing hands after handling pesticides or their containers;
- splashing or spilling pesticides on unprotected skin or eyes;
- wearing pesticide-contaminated clothing (including boots and gloves);
- applying pesticides in windy weather or above your head;
- wearing inadequate protective clothing and equipment during mixing or application; or
- touching treated plants, soil, or livestock.

Inhalation exposure can be caused by:

- prolonged exposure to pesticides in closed or poorly ventilated spaces;

- accidentally breathing vapors from fumigants and other toxic pesticides;
- breathing fumes, dust, or mist during application without appropriate protective equipment;
- inhaling fumes present immediately after a pesticide is applied (reentering the area too soon); or
- not having a good seal on your respirator or using an old or inadequate cartridge or canister.

People can be exposed to pesticides in two major ways: Acute exposure and chronic exposure.

Acute exposure is a single, one-time exposure to a pesticide. Usually, the symptoms of poisoning begin quickly and leave little doubt about the cause of the illness. Acute exposure is usually due to an accident such as:

- splashing a pesticide into the mouth,
- spilling or spraying a pesticide onto your clothing, or
- being contaminated with pesticides from broken equipment.

Chronic exposure is repeated exposure to pesticides over a prolonged period. Chronic exposure may go unnoticed since some pesticides may persist in the body for a long time without any obvious signs or symptoms of poisoning. If you continue to be exposed to these pesticides, residues in your body may increase, thus creating additional risk that even low-level chronic exposure may lead to serious illness. Chronic exposure most often occurs in the workplace because of:

- faulty or inadequate protective clothing or equipment,
- early reentry,
- inadequate cleanup of clothing and body, or
- contaminated working conditions.

What You Should Wear

To prevent pesticides from entering the body, you must wear personal protective equipment (PPE). You should follow all advice on protective clothing or equipment from the pesticide label. However, the lack of any statement or the mention of only one piece of equipment does not rule out the need for additional protection. No safety recommendations can cover all situations. Your common sense and knowledge of pesticide toxicity should help you assess the hazard and select the kind of protection you need. Remember that PPE reduces exposure but does not necessarily eliminate it. Always read the pesticide label to see if it states what materials are resistant to the pesticide product.

Protective Clothing

Body Covering

Protective clothing should be clean, dry, free of holes and tears, and cover as much skin as possible. Always wear long-sleeved coveralls or long-sleeved shirts and pants. Tuck shirts into pants, and cover the waist area with an apron for added protection.

Clothing should be made from tightly woven fabric and have collars and cuffs that fit snugly when buttoned. The protection offered depends on the fabric and design features. Waterproof and/or disposable coveralls are available and offer good protection.

Wear pant legs outside to prevent pesticides from seeping into boots or shoes. Wear long sleeves outside gloves, but if you are working above your head, tuck sleeves inside.

Gloves

The majority of pesticide handlers' exposure comes from their hands and forearms. Wear gloves when handling concentrated or highly toxic pesticides. For liquid formulations, liquid-proof neoprene gloves are best. They should be long enough to protect the wrist. Gloves should not be lined with a fabric because the lining absorbs chemicals and is hard to clean. For most jobs, sleeves should be outside of the gloves to keep pesticides from running down the sleeves and into the gloves, but if you will be working with your hands and arms overhead, put the gloves outside of the sleeves.

Hat

Wear something to protect your head and neck from overhead exposure. A wide-brimmed hat will help keep pesticides off your neck, eyes, mouth, and face. Most special coveralls have an attached protective hood. Hats should not have a cloth or leather sweatband. They should be easy to clean or disposable. When you will be exposed to liquid pesticides, wear a liquid-proof hat. Plastic hard hats with plastic sweatbands are liquid-proof and are cool in hot weather.

Footwear

Sturdy shoes and socks are sufficient for some pesticide applications. Neoprene or rubber boots are a wise precaution with many pesticide applications because canvas, cloth, and leather shoes can readily absorb pesticides. If you will be handling liquid concentrates or highly toxic pesticides (those with DANGER on the label), neoprene or rubber boots are necessary. Wear unlined boots with trouser legs outside the boots so the pesticide will not run down the leg and collect in the boot.

Goggles or Face Shield

Wear goggles or a face shield when there is any chance of getting pesticide in your eyes. Eyes readily absorb pesticides, and the temporary blindness caused by an accident may delay or prevent self-treatment. You can wear goggles alone or with a respirator.

Protective Clothing for Fumigant Application

When handling or applying fumigants, be sure to check the label for directions on how to best protect yourself. If the label does not give specific instructions, then you should wear at least gloves, shoes or boots, and a long-sleeved shirt and long-legged trousers made from tightly woven fabric. Some fumigants readily penetrate rubber, neoprene, and leather. These fumigants may be trapped inside the gloves, boots, or liquid-proof suit and cause severe skin irritation or lead to poisoning through skin absorption. The labels on these fumigants will specify the appropriate protective clothing to be worn while handling them.

Care of Clothing

Laundering Clothing Contaminated with Pesticides

Always wash pesticide-contaminated items separately from the family laundry. Otherwise, pesticide residue may be transferred to the other laundry and harm you or your family. Be sure that the people who clean and maintain your PPE and other work clothes know they could be harmed by touching these pesticide-contaminated items. Instruct them to wear gloves and an apron, work in a well-ventilated area if possible, and avoid inhaling steam from the washer or dryer. Know what pesticide was used, its toxicity level, and its formulation so the appropriate treatment can be used. One machine washing may be sufficient to remove some diluted, water-soluble, less toxic pesticides. Certain formulations like emulsifiable concentrates are more difficult to remove. Discard clothing contaminated with highly toxic, concentrated chemicals.

Use the following procedure for washing non-chemical resistant items such as cotton, cotton/polyester, denim, canvas, and other absorbent materials and for most chemical-resistant items.

Procedures for washing contaminated PPE

1. **Discard clothing contaminated with highly toxic, concentrated chemicals in a secured plastic bag and take it to a household hazardous waste collection site.**
2. **Always prerinse contaminated clothing before washing. Options include hosing garments down outdoors, soaking in a suitable container, or using the prerinse cycle on a washing machine. Prerinsing is especially helpful in removing wettable powder formulations.**
3. **Wash no more than three to four pieces of clothing at a time so there is plenty of agitation and water for dilution.**
4. **Use recommended amounts of a heavy-duty liquid laundry detergent, increasing amounts as necessary if your washing machine exceeds a 16-gallon water fill.**
5. **If using a washing aid, never mix bleach and ammonia.**
6. **Wash using the highest water level setting for a regular 10- to 12-minute cycle with hot water (140°F) and two rinse cycles.**
7. **If necessary, wash contaminated clothing two or three times to thoroughly flush fabric.**
8. **After washing contaminated clothing, run a complete hot water cycle containing detergent afterward to eliminate any remaining pesticide in the washing machine and avoid contaminating subsequent loads.**
9. **Line drying laundry is recommended to avoid pesticide residue in the dryer. An added benefit is that many pesticides break down when exposed to sunlight.**

Protective Equipment: Respirators

The respiratory tract, including the lungs and other parts of the breathing system, is much more absorbent than the skin. The product formulation, toxicity and type of application will influence what type of respirator is needed. You must wear an approved respiratory device when the label directs you to do so. Even if the label does not require it, you should always wear a respiratory protective device:

- if the pesticide you are mixing or applying has a label precautionary statement such as "do not breathe vapors or spray mist," or "harmful or fatal if inhaled;"
- during calibration and adjusting of equipment if you are using pesticides with the above precautionary statements;
- if you will be exposed to a pesticide for a long time; or
- if you are working in an enclosed area.

If you have trouble breathing while wearing a respiratory device, see your physician to find out whether you have a respiratory problem.

Chemical Cartridge Respirator (TC-23C)

Wear this kind of respirator when you will be intermittently exposed to a pesticide. The inhaled air is drawn through both a fiber filter pad and a cartridge to absorb pesticide vapors. The cartridge must be appropriate for the particular contaminant (organic, vapor, phosphine, etc.) Most harmful vapors, gases, and particles are removed. Chemical cartridge respirators come in both half-facemask and full-facemask styles.

Canister Respirator (Gas Mask, TC-14G)

Wear this kind of respirator when you will be continuously exposed to a pesticide. The canister respirator has longer lasting absorbent material and filters than the cartridge respirator. Gas masks usually provide full-face protection. Neither cartridge nor canister respirators will protect you from high concentrations of vapor, and neither is effective when the oxygen supply is low; for example, during fumigation inside buildings, railroad cars, holds of ships, or grain bins.

Supplied-Air Respirator (TC-19C)

You may use this kind of respirator when mixing or applying pesticides:

- when the oxygen supply is low, or
- when you are exposed to high concentrations of highly toxic pesticides.

Because this type of respirator works by pumping clean air through a hose to the full-face mask, you must work close to a supply of clean air.

Self-Contained Breathing Apparatus (TC-13F)

Wear this kind of respirator under the same conditions as the supplied-air respirator. It does about the same thing, but the difference is that you carry cylinders of air or oxygen with you, usually on your back. This lets you move more freely and over a wider area than you can with a supplied-air respirator. Seek training from competent instructors before using self-contained breathing equipment. These devices contain a limited air supply that may be used up quickly in high temperatures or with excessive exertion.

Positive-Pressure Respirator

Both chemical cartridge and chemical canister respirators rely on the wearer's ability to draw air through the filters in normal breathing. To be effective, these "negative-pressure" respirators must be tightly sealed to the face. A positive-pressure respirator uses a lightweight blower to draw the contaminated air through the filter. It forces the clean air into a loose-fitting helmetlike head covering. The outflow prevents contaminants from entering the helmet. The filtered air circulates over the head, neck, and upper body of the applicator, providing some cooling.

Positive-pressure respirators are available as lightweight backpacks, or they may be mounted on or in application equipment where the power is supplied by the vehicle's electrical systems. Some vehicle-mounted units provide cool filtered air to the applicator.

Respiratory Devices for Use with Fumigants

Fumigants are gases. They pose the greatest hazard of poisoning through inhalation. Exposure to even small concentrations of the fumigant as a gas can cause severe injury and death. Special precautions are necessary during

handling and application. Use a supplied-air respirator, or at least a canister respirator with an organic vapor canister. Wear a respirator during application and reentry if any exposure to the fumigant gas is likely. In closed areas such as bins, vaults, and chambers, oxygen levels may be insufficient to sustain life. Use supplied-air respirators or a self-contained breathing apparatus and never work alone.

Selection and Maintenance

Use only respirators carrying a seal of approval for pesticide use from the National Institute for Occupational Safety and Health (NIOSH). To ensure the respirator is the right size for the user, a fit test must be conducted by a trained professional. Pesticide product labels often specify the type of respirator required by listing its TC number. In addition, filters are classified based on oil degradation and filter efficiency. Read the manufacturer's instructions on the use and care of any respirator and its parts before you use it.

When to fit test

- **After subject is medically cleared for respirator use and annually thereafter**
- **Before the subject wears the respirator in the workplace**
- **When facial changes occur**
- **After significant weight changes**
- **When respirator size, make, or model changes**
- **Whenever employee reports a problem with fit**

Factors affecting respirator seal

- **Facial hair**
- **Facial bone structure**
- **Dentures**
- **Facial scars**
- **Eyeglasses**

A negative-pressure respirator must fit the face well. Long sideburns, a beard, dentures, facial scars, or glasses may prevent an adequate seal. Every time you put on a respirator, conduct a fit check or user seal check to be sure the respirator forms a complete seal around your face and air cannot leak in or out along the edges. See Table 7 for additional information on fit testing.

When applying pesticides, change filters, cartridges, or canisters if you have trouble breathing, if you smell pesticides, or after a maximum of 8 hours of use. Remove and discard filters, cartridges, and canisters and wash the facepiece with detergent and water, rinse it, and dry it with a clean cloth. Store it in a clean, dry place away from the pesticides.

The useful life of a cartridge or canister depends on:

- the amount of absorbent material it contains,
- the concentration of contaminants in the air,
- the breathing rate of the wearer, and
- the temperature and humidity.

Operation and maintenance requirements for positive-pressure respirators are similar to those for cartridge and canister respirators. The filter has a longer working life than those in cartridges or canisters, but it should be replaced after about 150 hours of use or when the amount of air being supplied to the applicator drops noticeably. The exposed parts of these respirators also need to be washed and dried after each use.

Table 7. Qualitative vs. quantitative fit testing

	Qualitative fit test (QLFT)	Quantitative fit test (QNFT)
Applicability	Negative-pressure, air-purifying respirators (hazard is less than 10x permissible exposure limit)	Any tight-fitting respirator
Test result type	Pass/fail based on user's sensory skills or reflexes	Instrument measures a numerical "fit factor" result based on leakage measurement
Test agents	Use one of four of OSHA-accepted test agents: 1. Isoamyl acetate (banana smell); only for testing respirators with organic vapor cartridges 2. Saccharin (sweet taste): can test respirators with particulate filters of any class 3. Bitrex® (bitter taste); can also test respirators with particulate filters of any class 4. Irritant smoke (involuntary cough reflex); only for testing respirators with level 100 particulate filters	Not applicable
Test protocols	Seven exercises performed for 1 minute each: 1. Normal breathing 2. Deep breathing 3. Turning head side to side 4. Moving head up and down 5. Talking 6. Bending over (or jogging in place if fit test doesn't permit bending) 7. Normal breathing again	Uses the same test protocols as QLFT, plus an additional "grimace" test where the user smiles or frowns for 15 seconds
Fit factor requirement	Not applicable	At least 100 for half-mask regulators; 500 for full-face pieces
Measurement equipment	None; relies on user's senses	Instruments required: Generated aerosol Condensation nuclei counter Controlled negative pressure
Suitability	Limited to specific conditions (hazard must be less than 10x the permissible exposure limit)	Suitable for any tight-fitting respirator regardless of conditions
Test chamber requirement	Not required	Required for generated aerosol method; not required for condensation nuclei counter

Special Handling Precautions

- If possible, clothing worn when applying pesticides should be saved for only that purpose.
- If clothing gets contaminated when working with pesticides, change immediately. Don't wait until you've finished the job.
- Always wear rubber gloves when handling and rinsing clothes contaminated with pesticides.
- Wash hats, gloves, and boots daily. Always wear clean clothes daily.
- Empty pockets and cuffs of any pesticide granules outdoors, discarding them in a safe manner. Granules left in clothing could dissolve into the wash water and not be completely resolved during the wash cycle.
- Keep contaminated clothing in containers separate from the regular family laundry and always wash separately.
- Test gloves for leaks by filling them with water and gently squeezing.
- Wash contaminated clothing as soon as possible after each wearing. The longer they stand, the harder it is to remove the chemicals.
- Wash goggles and face shield at least once a day.
- If clothes have become contaminated with concentrated, highly toxic pesticides, dispose of them as hazardous waste. Washing will not make them safe to wear.

Personal Cleanup

Anytime you spill a pesticide on yourself, wash immediately. When you finish working with pesticides or pesticide-contaminated equipment, take a shower. Wash your body and hair thoroughly with detergent and water. Work clothing should be changed daily. Place used clothing away from your other clothes and away from the family laundry. The pesticides remaining on your work clothes could injure people who touch them. Do not allow children or pets to play in them. Do not wash contaminated gloves, boots, respirators, or other equipment in streams or ponds. The pesticides could poison aquatic life or harm people, livestock, or wildlife.

Reentering Treated Areas

Unprotected people should not enter an area immediately after a pesticide application. The waiting period is called the **reentry interval**. Workers not wearing proper protective clothing must always wait at least until sprays have dried or dusts have settled before entering an area treated with any pesticide. Some highly toxic carbamate and organophosphate pesticides have specific reentry times set by law, and those times are listed on the pesticide label.

If you oversee a pesticide application, you should warn workers and other people that an area has been treated with pesticides. The only exceptions are mosquito abatement and related public pest control programs, and livestock and other animal treatments.

Transportation, Storage, and Security

Transportation of Pesticides

You are responsible for the safe transport of pesticides in your possession. The safest way to haul pesticides is in the back of a truck. Careless handling of containers, incorrectly maintained equipment, and unforeseen accidents can lead to pesticide leaks and spills during transport. Secure all containers to prevent breakage and spillage. Keep the pesticides away from food, feed, livestock, pets, and passengers. Pesticides should be transported only in correctly labeled containers. Be sure to keep paper and cardboard packages dry. If any pesticide is spilled in or from the vehicle, clean it up right away using correct cleanup procedures. Do not leave pesticides unattended, as you are responsible if accidents occur.

Pesticide Storage

As soon as pesticides arrive, store them in a designated place. The storage area should be in a cool, dry, well-ventilated, and well-lighted room or building that is insulated to prevent freezing or overheating. Be sure that the area is fireproof, with a non-porous floor, such as sealed cement, glazed ceramic tile, or no-wax sheet flooring. Keep the area locked to prevent entry by children, unauthorized persons, or stray animals, and post warning signs on doors and windows.

Post "No Smoking" warnings, as pesticides are highly flammable.

The storage area should be supplied with detergent, hand cleaner, and water; absorbent materials, such as absorbent clay, sawdust, and paper to soak up spills; a shovel, broom, and dustpan; and a fire extinguisher rated for ABC fires.

The storage building or area should be located away from where people and animals live to avoid or minimize harm to them in case of fire or flooding. Carefully consider soil and land surface characteristics when selecting a storage site to prevent potential contamination of surface or groundwater.

Store all pesticides in the original containers with the labels in plain sight. Do not store them near food, feed, seed, or animals. Store paper containers off the floor. Check every container for leaks or breaks. If one is leaking, position the containers so the hole is on the top or place the entire damaged container into a suitable larger container. Then transfer the contents to a container that has held exactly the same pesticide and has an intact label. If one is not available, use a clean container of similar construction, remove the label from the damaged container, and place it on the new container. This container may not be offered for sale or redistributed. In cases where paper containers are punctured, place them in a heavy, clear-plastic bag. Clean up any spills. Keep an up-to-date inventory of the pesticides you have and copies of their labels.

Mixing and Loading Pesticides

Studies have shown that pesticide applicators are most often exposed to harmful amounts of pesticides when handling concentrates.

Handlers involved in mixing and loading undiluted, highly toxic pesticides are exposed to a high risk of accidental poisoning. Pouring concentrates from one container to another is the most hazardous activity.

Safety Guidelines

Observing some simple precautions reduces the risks involved in mixing and loading. It is important to keep livestock, pets, and people out of the mixing and loading area. Do not work alone when using highly toxic pesticides. Choose a place with good light and ventilation. Be particularly careful not to mix or load pesticides at night or indoors unless lighting and ventilation are adequate.

Before handling a pesticide container, put on protective clothing and equipment. Each time you use a pesticide, read the directions and make sure you do this before you open the container. It is important to note that directions, including amounts and methods, often change.

Do not tear paper containers to open them. Use a sharp knife. Clean the knife afterward, and do not use it for other purposes. When pouring a pesticide from the container, keep the container and pesticide below eye level. This will help avoid a splash or spill on your goggles or protective clothing.

If you splash or spill a pesticide while mixing or loading, stop right away and remove contaminated clothing. Immediately wash thoroughly with detergent and water, then clean up the spill.

When mixing pesticides, measure carefully and ensure that no tank mixture can back-siphon into a water source. Use only the amount called for on the label and mix only the volume you plan to use. Mix pesticides in areas where any spills, leaks, or overflows cannot flow toward a drain or into water sources.

When loading pesticides, stand so the wind does not blow them toward your body. To prevent spills, close containers after each use.

Closed Handling Systems

Closed handling systems can reduce the applicator's exposure to concentrated pesticides. A closed handling system is a series of interconnected equipment that allows the applicator to remove a pesticide from its original container, rinse the empty container, and transfer the pesticide and rinse solution to the spray tank without contacting the pesticide.

Closed-system handling has several advantages and disadvantages.

Advantages:

- Increased applicator safety.
- Less need for protective clothing and equipment (waterproof clothing and respirators can be uncomfortable, especially in hot weather).
- Reduction of spills.

- More accurate measurement, which reduces overdosing and underdosing and may result in cost savings.

Disadvantages:

- Equipment may be cumbersome.
- Equipment is not usable with all pesticide containers because of variations in drum openings, shapes, and sizes.
- Many steps involved in the system.
- All steps must be done in proper sequence.

The systems now available are designed to remove the pesticide concentrate from the original container in one of two ways: by gravity or by suction.

Gravity systems are sometimes called punch-and-drain systems. The unopened pesticide container is inserted into a chamber, which is then sealed. A punch cuts a large opening in the container, allowing all the material to drain into the mixing tank. A water nozzle attached to the punch sprays the inside of the container to rinse it thoroughly. The rinse water also drains into the mixing tank. The rinsed container is then removed for disposal. A limitation of this system is that only full container quantities can be used. It is not possible to use part of the pesticide in a container and store the rest.

Suction systems use a pump to remove the pesticide through a probe inserted into the container. Some containers are equipped with built-in probes. The pesticide is transferred to the mixing tank by hose and pipe. When the container is empty, it and the transfer system are rinsed with water. The rinse water is added to the mixing tank.

To allow the use of only part of the pesticide in the container, the system must have a way to measure the amount of pesticide suctioned into the mixing pan, and it must allow the probe to remain in the container until all the pesticide is used and the container and probe can be rinsed. Some probes have a breakaway head, which allows the head to stay and the probe to be withdrawn and reused.

In some systems, it is not possible to reseal partially emptied containers. Another disadvantage of suction systems is that highly viscous pesticides (those which pour like molasses) are difficult to move by suction.

Two techniques have been developed for handling dry concentrates. One is a closed handling system similar to those used for liquid formulations. The other is soluble packaging. Soluble bags or containers allow an applicator to put the entire package (pesticide and container) into the tank. The container dissolves in the solvent inside the tank. Disadvantages of soluble packaging include the risk of releasing the concentrate if the packaging is exposed to water during shipping and the possibility of "splashback" as containers are added to the tank.

Pesticide Application

The safety of yourself and others should be a major concern during any pesticide application. Follow all label directions carefully and observe these basic safety guidelines.

Wear the correct protective clothing and equipment. Wear waterproof clothing if you will be working in drift, spray or runoff. Do not wipe your gloves on your clothing, as this will contaminate your clothing and may soak through to your skin. Never eat, drink, smoke, vape, or chew tobacco while handling or applying pesticides. Wash your face and hands thoroughly first. If you feel ill, do not try to finish the job. Get out of the area quickly and get help.

If you will be working outdoors, choose application equipment, formulations, and additives that will minimize drift and runoff. Do not apply pesticides during or just before expected high winds or heavy rains. Try to spray downwind from sensitive areas such as beehives, residential areas, waterways, and nontarget crops and livestock.

If you are working indoors, be sure you have adequate ventilation or wear a supplied-air respirator. Be sure that nontarget food and feed, toys, and pets are removed from the area to be treated. Failure to do this is a misuse of the pesticide. Choose application techniques, equipment, and formulations that minimize exposure to people and nontarget animals who may have to reenter treated areas to live or work.

To prevent spillage and possible poisonings, check all application equipment for leaking hoses, pumps, or connections and for plugged, worn, or dripping nozzles. Do not blow out clogged nozzles, hoses, or lines with your mouth. Do not allow children, pets, or unauthorized persons to touch application equip-

ment or pesticide containers or to enter storage areas. Correctly calibrate your equipment before use. Try to use all the pesticide in your tank or hopper. If you have some left over, use it for other labeled uses.

Before application, you must clear the area of all unprotected people. By law, the application of a pesticide—either directly or through drift—must not expose workers or others.

Cleaning Equipment

Never leave pesticide equipment at the application site. When the tank or hopper is empty, return the equipment to the area designated for equipment cleanup. Mixing, loading, and application equipment must be cleaned as soon as you finish using it. Clean both the inside and outside, including nozzles and hopper openings. Only trained individuals wearing the correct protective equipment should do this job.

Have a special procedure for cleaning equipment. A designated cleaning location should have a wash rack or concentrate apron with a sump to catch contaminated wash water. Pesticide residues in a spray tank may corrode metal, plug hoses, or damage pumps and valves unless they are removed immediately after use.

If possible, reuse sump collections when mixing compatible spray solutions. If necessary, contaminated sump collections should be disposed of as you would dispose other pesticides. Do not allow rinsates to flow into water systems, including sinks and floor drains, storm sewers, wells, streams, lakes, or rivers.

Equipment sometimes must be repaired before it is completely cleaned. Warn the person doing the repairs of the potential hazards.

Disposal

Pesticides

The best way to solve the problem of pesticide waste disposal is to simply avoid producing any waste. Excess pesticides should be properly collected, labeled, and temporarily stored for use in another spray mixture. Rinse solutions also should be collected and used as diluent in subsequent tank mixes if they are labeled for use on the target site where the new mixture is applied. Never dispose of rinsate on a site the pesticide product label does not allow.

To minimize disposal amounts, do not mix more pesticide than you will use according to the labeled application rates. Pesticide inventories should be carefully managed so old or useless pesticide products do not accumulate. All pesticides or pesticide solutions should be stored according to label directions. Pesticide container regulations require the pesticide label to identify the container as nonrefillable or refillable and provide instructions on how to handle and clean the container.

Containers

Do not leave pesticides or pesticide containers at the application site. Never give pesticide containers to children to play with or adults to use. Leftover pesticides should be kept in tightly closed containers in your storage facility.

Always triple=rinse empty containers of liquid pesticides as follows.

1. Empty the container into the tank. Let it drain from the empty pesticide container for 30 seconds.
2. Fill approximately 20 percent of the container volume with water.
3. Replace the closure and rotate the container. Invert the container so the rinse reaches all inside surfaces.
4. Drain the rinse water from the container into the tank. Let the container drain for 30 seconds.
5. Repeat steps 2 through 4 at least two more times for a total of three rinses. Remember to empty each rinse solution into the tank.

Refillable Containers

Refillable containers are intended to be refilled and reused more than once to sell or distribute pesticides. The containers can be returned to the manufacturer or distributer for reprocessing with the pesticide product.

Nonrefillable Containers

A container that is not refillable and that is designed for a one-time use is referred to as nonrefillable. It is not intended to be filled again with a pesticide for sale or distribution. Always refer to the current pesticide label Storage and Disposal requirements for each product and ensure the container is properly

disposed of according to state and federal laws. Recycle the containers if a recycling program is available. Small quantities of hazardous and non-hazardous wastes can be disposed of at the county sanitary landfill, but this disposal option depends on the quantity and type of pesticide.

Cleanup of Pesticide Spills

Minor Spills

Keep people away from spilled chemicals by roping off the area and placing flags to warn people. Do not leave unless someone is there to confine the spill and warn of the danger. If the pesticide was spilled on anyone, wash it off immediately.

Confine the spill. If it starts to spread, dike it up with sand or soil. Use absorbent material such as soil, sawdust, or an absorbent clay to soak up the spill. Shovel all contaminated material into a leak-proof container for disposal. Dispose of it as you would a pesticide waste. Do not hose down the area, because this spreads the chemical. Always work carefully and do not hurry.

Do not let anyone except those who are properly trained enter the area until the spill is completely cleaned up.

Major Spills

The cleanup of a major spill may be too difficult for you to handle, or you may not be sure of what to do. In either case, keep people away, give first aid if needed, and confine the spill. Then call Chemtrec, the local fire department, KDHE, and state pesticide authorities for help. The spiller is responsible for reporting spills that impact the soil and waters of the state.

Chemtrec stands for Chemical Transportation Emergency Center, a public service of the Manufacturing Chemicals Association. Its offices are in Washington, DC. Chemtrec provides immediate advice for those at the scene of emergencies.

Chemtrec operates 24 hours a day, seven days a week, to receive calls for emergency assistance. For help in chemical emergencies involving spills, leaks, fire, or explosions, call toll-free 800-424-9300 day or night. This number is for emergencies only.

If a major pesticide spill occurs on a highway, have someone call the highway patrol or the sheriff for help. (Carry these phone numbers with you.) Do not leave until responsible help arrives.

Cleanup Notification of Pesticide Spills

Minor Spills

A minor spill is one involving 1 quart or approximately 2 lbs or less of pesticide concentrate. However, common sense must be used in determining how much action you as an individual take regarding pesticide spills. For example, 1 quart of a highly toxic insecticide requires more expertise and precautions in handling cleanup and disposal than 1 quart of low-toxicity herbicide.

Keeping the product toxicity in mind, a general procedure for cleaning up a minor spill would be to use an absorbent, such as pet litter, cover with bleach, and scrub the area with detergent. Then follow label statements for disposal, or telephone KDHE at 785-291-3333 for further instructions on disposal.

Before authorities arrive, get a copy of the pesticide label, and, if possible, determine the toxicity of the pesticide involved. Information from the label can be helpful to the doctor.

Major Spills

Pesticide spills caused by commercial spray rigs, aerial spray planes, and large pesticide containers may be too big to be handled by one person. Follow correct procedures to notify the proper authorities.

If people have been exposed to the spilled pesticide, notify the local poison control center. Make every effort made to keep other people from being exposed to the spill until local authorities can assume responsibility at the site. Report all spills by telephone to the Kansas Division of Emergency Management at 785-291-3333. If contact cannot be made, call 911 to notify the local authorities such as the police department and fire department.

First Aid and Pesticide Poisoning Recognition

First Aid

Get medical advice quickly if you or any of your fellow workers have unusual or unexplained symptoms starting at work or later the same day. Do not let yourself or anyone else get dangerously sick before calling your physician or going to a hospital. It is better to be too cautious than too late.

First aid is the initial effort to help a victim while medical help is on the way. If you are alone with the victim, make sure the victim is breathing and is not being further exposed to the poison before you call for emergency help. Apply artificial respiration if the victim is not breathing.

Read the first aid instructions on the pesticide label, if possible. Follow those instructions. Do not become exposed to poisoning yourself while you are trying to help. Take the pesticide container or the product label to the physician. Do not carry the pesticide container in the passenger space of a car or truck. For different exposures, take the following actions.

Poison on Skin

- Act quickly to remove contaminated clothing and wash skin with water.
- Cleanse skin and hair thoroughly with detergent and water.
- Dry victim and wrap in blanket.

Chemical Burn on Skin

- Wash with large quantities of running water.
- Remove contaminated clothing.
- Cover burned area immediately with loose, clean, soft cloth.
- Do not apply ointments, greases, powders or other drugs in first aid treatment of burns.

Poison in Eye

- Wash eye quickly but gently.
- Hold eyelid open and wash with gentle stream of clean running water or eye wash solution.
- Wash for 15 minutes or more.
- Do not use chemicals or drugs in the wash water. They may increase the extent of injury.

Inhaled Poison

- Carry victim to fresh air immediately.
- Open all doors and windows so no one else will be poisoned.
- Loosen any tight clothing.
- Apply artificial respiration if breathing has stopped or if the victim's skin is blue. If patient is in an enclosed area, do not enter without proper protective clothing and equipment. If proper protection is not available, call for emergency equipment from your local fire department.

Poison in Mouth or Swallowed

- Rinse mouth with plenty of water.
- Give victim large amounts (up to 1 quart) of milk or water to drink. Consult the label and follow the instructions.
- Induce vomiting only if instructions to do so are on the label.
    - Position victim face down or kneeling forward. Do not allow victim to lie on his/her back, because vomit could enter the lungs and do additional damage.
    - Put finger or the blunt end of a spoon at the back of victim's throat or give syrup of ipecac.
    - Collect some of the vomit for the physician if you do not know what the poison is.
    - Do not use salt solutions to induce vomiting.
- Do not induce vomiting:
    - If the victim is unconscious or is having convulsions.
    - If the victim has swallowed a corrosive poison. A corrosive poison is a strong acid or alkali. It will burn the throat and mouth as severely coming up as it did going down. It also may get into the lungs and burn there.
    - If the victim has swallowed an emulsifiable concentrate or oil solution. Emulsifiable concentrates and oil solutions may cause severe damage to the lungs if inhaled during vomiting.

Pesticide Poisoning Recognition

Pesticides can poison humans as well as the target pests they intend to kill. Some pesticides are highly toxic to humans; only a few drops in the mouth or on the skin can cause

severe injury. Other pesticides are less toxic, but excessive exposure to them will cause injury. You should know the kinds of injury most likely to be caused by the pesticides you use to ensure the least possible exposure (Table 8).

A symptom is any bit of evidence that you are sick. It is something abnormal that you feel. Examples of symptoms are headache, dizziness, profuse sweating, weakness, and nausea. A sign is evidence of an abnormality or disorder as observed by a physician. Examples of signs are vomiting, salivation, fever, declining mental alertness, and convulsions. Symptoms reported by a patient and signs observed by the doctor are used in diagnosis of a pesticide poisoning.

Pesticides in the same chemical group cause the same type of poisoning. The illness may vary from mild to severe depending upon the pesticide, the amount of pesticide and length of time the pesticide is in contact with the body, and other factors. Pesticide poisonings may occur by accidental ingestion, skin contact and/or by inhalation. Contact your doctor immediately if you or your co-worker have symptoms or signs of pesticide poisonings, which occur after using a pesticide. Take the label of the pesticide with you when you go to the doctor.

Most chemical manufacturers are equipped to provide emergency information on their products. Consult the table below for signs and symptoms related to specific classes of pesticides. The National Pesticide Information Center or Chemtrec can provide additional information if the product is registered. The Recognition and Management of Pesticide Poisonings manual gives healthcare providers a quick reference related to toxicology and treatment. See the appendix for related contact information.

Table 8. Pesticide poisoning signs and symptoms

Chemical class/ agent	Examples	Site of toxicity	Signs and symptoms	Primary route of exposure
Herbicides				
Chlorophenoxy derivatives	2,4-D and 2,4-DB	Skin, eyes, respiratory and gastrointestinal (GI) tract	**Inhalation:** burning sensation in the nasopharynx and chest, dizziness **Ingestion:** vomiting, esophagitis, abdominal pain, diarrhea, muscle stiffness and twitching, metabolic acidosis	Inhalation, skin exposure, swallowing
Dipyrids	Diquat, paraquat	Injury to skin, nails, cornea, liver, kidney, and lining of GI and respiratory tract	**Ingestion early:** nausea, vomiting **48-72 hours after exposure:** jaundice, cough, dyspepsia, tachypnea, pulmonary edema, convulsions, coma	Inhalation, skin exposure, swallowing
Nitophenolic, nitrocresolic	Dinitrophenol, dinitrocresol, dinoseb	Liver, kidney, renal and nervous system	Sweating, thirst, fever, headache, confusion, malaise, restlessness, hypothermia, tachycardia	Inhalation, skin exposure, swallowing
Insecticides				
Organophosphates	Parathion, diazinon, malathion, chlorpyifos, methyl parathion	Irreversible inhibition of red blood cell cholinesterase, acetylcholinesterase, plasma cholinesterase	**Mild:** fatigue, headache, blurred vision, dizziness, numbness of extremities, nausea, vomiting, excessive sweating and salivation, tightness in chest **Moderate:** weakness, difficulty talking, muscular weakness, miosis **Severe:** unconsciousness, flaccid paralysis, respiratory difficulty	Inhalation, swallowing, skin exposure
Carbamates	Carbaryl, carbofuran, Aldicard	Reversible inhibition of red blood cell acetylcholinesterase and plasma cholinesterase	Diarrhea, nausea, vomiting, abdominal pain, profuse sweating, salivation, blurred vision, difficulty breathing, headache, paralysis of extremities	Inhalation, swallowing, skin exposure
Chlorinated hydrocarbons	Methoxychlor, lindane, toxaphene, chlordane	Neurotoxin: central nervous system, kidney, liver	Apprehension, excitability, dizziness, headache, involuntary muscle activity, behavior changes, disorientation, weakness, convulsions	Inhalation, swallowing, skin exposure
Phophine fumigants	Aluminum or zinc phosphide	Lungs, central nervous system, liver, kidney	Dizziness, headache, nausea, vomiting, pulmonary edema	Inhalation, skin exposure
Pyrthrins, pyrethroids	Bifenthrin, cyfluthrin, permethrin, delamethrin	Nervous system	Stuffy or runny nose, scratchy throat, wheezing, cough, difficulty breathing	Inhalation
Fungicides				
Dithiocarbamates, thiocarbamates	Thriam, ferbam, maneb, zineb	Skin, eyes, respiratory mucous membranes	Skin irritation, nausea, vomiting, diarrhea	Skin exposure, inhalation

Supervising Uncertified/ Noncertified Applicators

Learning objectives:

- **Detail the responsibilities of the certified applicator when supervising uncertified applicators.**
- **Explain when a certified applicator must be present during a pesticide application performed by uncertified applicators.**
- **Provide use-specific instructions to uncertified applicators using RUPs under the direct supervision of a certified applicator.**
- **Summarize recordkeeping requirements for uncertified applicator pesticide safety training.**

The State of Kansas allows certified applicators to supervise the application of RUPs by uncertified applicators, which includes uncertified applicators and registered pest control technicians. The terms "uncertified" and "noncertified" can be used interchangeably, but state and federal regulations may use different terms.

As the supervising certified applicator, you must:

- Be licensed to perform the type of application being performed, including any required categories or endorsements. For example, if you are supervising the use of a restricted-use product to control a pest in agricultural crops, you must be certified in agricultural plant pest control or a similar certification category.
- Be physically present at the site where the RUP is applied when required by the product labeling.
- Ensure that the uncertified applicator is at least 18 years old.
- Ensure that the uncertified applicator has PPE as specified on the label, that PPE is in proper operating condition, and that PPE is used properly for its intended purpose.
- Ensure that the uncertified applicator has access to the product's labeling at all times during the application.
- Ensure that all equipment can be used without risk of reasonably foreseeable harm to either the uncertified applicator, other people, or the environment.
- Ensure that immediate communication is possible between the supervising certified applicator and the uncertified applicator(s). Properly charged cell phones could meet this criterion if signal strength is sufficient and phones are continuously available.
- Ensure that the uncertified applicator has been instructed in the last 12 months of the safe and proper use of any equipment needed for the application. Training on application equipment must take place before the uncertified applicator makes any RUP application.
- Ensure that the uncertified applicator received sufficient pesticide safety training, as described in the following section.

Pesticide safety training for uncertified applicators under your supervision shall be presented either orally from written materials or audiovisually. The information needs to be presented in a manner that the uncertified applicator can understand, which may require translation. Uncertified applicators must receive pesticide safety training at least every 12 months. Certified applicators who a) aren't certified to perform that particular application or b) aren't certified within the jurisdiction where the application will take place will also need training.

The trainer must be qualified, and the content must be complete according to federal regulations. The trainer who conducts the training must either be currently certified as a commercial applicator; must be designated as a trainer of certified applicators or pesticide

handlers by EPA, the Secretary of Agriculture, or a state, tribal or federal agency having jurisdiction; or must be an applicator who has completed an EPA-approved pesticide safety train-the-trainer program.

The content of the training is specified by law and must include all information the uncertified applicator needs to protect themselves, other people, and the environment from harm.

- Potential hazards from toxicity and exposure that pesticides present to uncertified applicators and their families, including acute and chronic effects, delayed effects, and sensitization.
- Routes through which pesticides can enter the body.
- Signs and symptoms of common types of pesticide poisoning.
- Emergency first aid for pesticide injuries or poisonings.
- Routine and emergency decontamination procedures, including emergency eye flushing techniques. Uncertified applicators must be instructed that if pesticides are spilled or sprayed on the body, to immediately wash or to rinse off in the nearest clean water. Noncertified applicators must also be instructed to wash or shower with soap and water, shampoo hair, and change into clean clothes as soon as possible.
- How and when to obtain emergency medical care.
- After working with pesticides, wash hands before eating, drinking, using chewing gum or tobacco, or using the toilet.
- Wash or shower with soap and water, shampoo hair and change into clean clothes as soon as possible after working with pesticides.
- Potential hazards from pesticide residues on clothing.
- Wash work clothes before wearing them again and wash them separately from other clothes.
- Do not take pesticides or pesticide containers used at work to your home.
- Potential hazards to children and pregnant women from pesticide exposure.
- After working with pesticides, remove work boots or shoes before entering your home, and remove work clothes and wash or shower before physical contact with children or family members.
- How to report suspected pesticide use violations to the appropriate state or tribal agency responsible for pesticide enforcement.
- Format and meaning of information contained on pesticide labels and in labeling applicable to the safe use of the pesticide, including the location and meaning of the restricted-use product statement, how to identify when the labeling requires the certified applicator to be physically present during the use of the pesticide, and PPE information.
- Need for, and appropriate use and removal of, PPE.
- How to recognize, prevent, and provide first aid treatment for heat-related illness.
- Safety requirements for handling, transporting, storing, and disposing of pesticides, including general procedures for spill cleanup.
- Environmental concerns such as drift, runoff, and wildlife hazards.
- RUPs may be used only by a certified applicator or by an uncertified applicator working under the direct supervision of a certified applicator.
- The certified applicator's responsibility to provide to each uncertified applicator instructions specific to the site and pesticide used. These instructions must include labeling directions, precautions, and requirements applicable to the specific use and site, and how the characteristics of the use site (such as surface and groundwater, endangered species, local population, and risks) and the conditions of application (such as equipment, method of application, formulation, and risks) might increase or decrease the risk of adverse effects. The certified applicator must provide these instructions in a manner the noncertified applicator can understand.
- The certified applicator's responsibility to ensure that each uncertified applicator has access to the applicable product labeling at all times during its use.
- The certified applicator's responsibility to ensure that where the label of a pesticide product requires that PPE be worn for mixing, loading, application, or any other

use activities, each uncertified applicator has clean, label-required PPE in proper operating condition and that the PPE is worn and used correctly for its intended purpose.

- The certified applicator's responsibility to ensure that before each use, equipment for mixing, loading, transferring, or applying pesticides is in proper operating condition as intended by the manufacturer and can be used without risk of reasonably foreseeable adverse effects to the uncertified applicator, other people, or the environment.
- The certified applicator's responsibility to ensure that a means to immediately communicate with the certified applicator is available to each uncertified applicator using RUPs under his or her direct supervision.

In addition to the training concepts listed above, the trainer is also responsible for providing use-specific instructions to the uncertified applicator for the RUP and explaining any federal, state, or tribal regulations pertinent to the application. These pesticide safety training requirements can be met through various approved training resources.

Certified applicators also will need to ensure that all required records are kept if they are supervising an uncertified applicator using an RUP. This will include detailed documentation of the safety training provided to the uncertified applicator. It is the trainer's responsibility to create or verify the existence of the training record before allowing the uncertified applicator to use RUPs. Training records must include the uncertified applicator's printed name and signature, the date the training was completed, the name of the trainer, and the title and description of the training provided. If WPS training is used to meet the requirements, the record must contain the EPA approval number and the trainer's qualifications to train.

Ensuring Safe Pesticide Use: Professional Conduct

Learning objectives:

- **Know why it is important for a pesticide applicator to communicate effectively with the public.**
- **Identify what is needed to present a professional image.**
- **Understand the importance of maintaining chemical and pesticide security.**
- **Learn appropriate pesticide stewardship.**

The use of pesticides can be a source of anxiety or public controversy and can cause a conflict of opinions. The professionalism exhibited by pesticide applicators affects how the public views pesticides and their application. Applicators must do their work in a professional manner and not take shortcuts that may harm customers, the public, or the environment.

Professionalism

Professionalism refers to the skill, good judgement, and behavior exhibited by trained applicators. The public expects that applicators treat customers fairly, respect others, and are an asset to the community they serve. An applicator or supervisor needs expertise and good judgement to make decisions on issues affecting security, safety, health, or the environment not addressed by regulations or the pesticide label. It is important to stay current on industry related laws and regulations. The ability to answer questions from customers, neighbors, and others about the work you do will create a positive impression of the pest control industry. Good public relations between the applicator and others (bystanders, customers, concerned people, etc.) result in improved public trust and professional credibility.

Professionalism is demonstrated through a good working knowledge of pesticides and a positive attitude. An applicator should use pesticides responsibly and make sure they follow the pesticide label. Do not use pesticides when bystanders are present. Professional training on topics such as IPM is important, as it helps to guide sound pest management decisions, identifies when pesticides should be used, and helps to protect sensitive plants, organisms, and sites from harm.

Security of Pesticides

Pesticides must be stored in a well-marked, locked area when they are not in use. Warning signs should be posted to alert others that pesticides are stored inside. Non-employees and untrained individuals should be restricted from having access to these storage areas. Pesticides should be stored in their original, labeled containers with a legible and intact label. Pesticides should not be stored in areas that are prone to flooding, and the floor should be impervious to help contain any spills. Storage of mini-bulk and bulk tanks require additional containment measures.

Employees must be trained in security and emergency procedures related to pesticides and their storage. They can provide early warnings if something seems out of place, or something is of concern. A spill cleanup kit should be on hand at each location. An emergency response plan must be in place to address how employees should respond to fire, theft, pesticide spills, and other incidents. At a minimum, employees should receive training on pesticide inventory control, security of storage facilities and application equipment, and emergency response. Schedule daily and weekly preventative maintenance inspections of equipment. Each applicator needs to be familiar with the equipment before using it and play a role in keeping it clean and well maintained. Post telephone numbers for emergency response agencies in prominent locations.

Communication with the Public

Effective communication with the public is a skill that you can practice. Pesticide applicators can better communicate when they use simple, direct language rather than providing technical terminology. Provide the facts and communicate as clearly and effectively as you can. It is important to listen to public concerns and to try to understand conflicting viewpoints. Be proactive and reach out to neighbors, customers, and others who may have concerns about sensitive sites where pesticides may be applied. Be prepared to explain what it means to be a certified applicator and learn how to communicate the benefits and risks of pesticide use with customers, employees, and the public. Involve your customers in decisions that can directly affect them. As an applicator, be informed about your company's policy about talking to customers, neighbors, or the media.

Keep accurate records of all pesticide applications. Good records provide the facts about the application and demonstrate the professionalism of the applicator. If there is a complaint or legal action following an application, this documentation reaches a new level of importance and may become a valuable defense. If records are not recorded or insufficient, this creates additional scrutiny of the applicator and the company. Being an effective applicator requires good judgement, professional behavior, and the skills and knowledge to conduct a safe application.

Pesticide Stewardship

Pesticide stewardship refers to the responsibility of applicators to protect the environment from unnecessary pesticide applications. The use of pesticides in an IPM program minimizes negative impacts and enhances sustainability. An IPM program includes:

- Weed, pest, and disease identification;
- Preventative cultural, mechanical, and biological controls;
- Weed, pest, disease scouting and monitoring;
- Evaluation of pest problems through analysis of economic thresholds when appropriate;
- Use of forecasting models for pests and disease when available; and
- Selection of the most appropriate pesticides based on the specific situation.

Limiting pesticide use to needed applications is important to help minimize environmental impacts. IPM allows applicators to identify when it is appropriate to use pesticides and maximize the benefits of an application. This helps to reduce or limit the development of resistance by weeds, diseases and insects and minimize impacts to pollinators and natural enemies. It also minimizes the health and safety concerns to workers, customers, and the public that are associated with pesticide use.

Other Terms Used in Pest Control

Some of these words have several meanings. Those given here are the meanings that relate to pest control.

Abiotic Plant Disorder: Physiological disorders or environmental stresses that can resemble plant diseases.

Abrasion: The process of wearing away by rubbing.

Abscission: The separation of fruit, leaves, or stems from a plant.

Absorption: The process by which a chemical is taken into plants, animals, or minerals. Compare with adsorption.

Activator: A chemical added to a pesticide to increase its activity.

Adherence: Sticking to a surface.

Adsorption: The process by which chemicals are held on the surface of a mineral or soil particle. Compare with absorption.

Adulterated: Any pesticide whose strength or purity falls below the quality stated on its label. Also, a food, feed, or product that contains illegal pesticide residues.

Aerobic: Living in the air. The opposite of anaerobic.

Aerosol: An extremely fine mist or fog consisting of solid or liquid particles suspended in air. Also, certain formulations used to produce a fine mist or smoke.

Agitation: The process of stirring or mixing in a sprayer.

Alkaloids: Chemicals present in some plants. Some are used as pesticides.

Anaerobic: Living in the absence of air. The opposite of aerobic.

Animal Sign: The evidence of an animal's presence in an area.

Antagonism: The loss of activity of a chemical when exposed to another chemical.

Antibiotic: A substance used to control pest microorganisms.

Antidote: A practical treatment for poisoning, including first aid.

Aqueous: A term used to indicate the presence of water in a solution.

Arsenicals: Pesticides containing arsenic.

Aseptic: Free of disease-causing organisms.

Bait Shyness: The tendency for rodents, birds, or other pests to avoid a poisoned bait.

Bipyridyliums: A group of synthetic organic pesticides that includes the herbicide paraquat.

Botanical Pesticide: A pesticide made from plants. Also called plant-derived pesticides.

Broadleaf Weeds: Plants with broad, rounded, or flattened leaves.

Brush Control: Control of woody plants.

Carbamate: A synthetic organic pesticide containing carbon, hydrogen, nitrogen, and sulfur.

Carcinogenic: Can cause cancer.

Carrier: The inert liquid or solid material added to an active ingredient to prepare a pesticide formulation.

Causal Organism: The organism (pathogen) that produces a specific disease.

Chemosterilant: A chemical that can prevent reproduction.

Chlorinated Hydrocarbon: A synthetic organic pesticide that contains chlorine, carbon, and hydrogen. Same as organochlorine.

Chlorosis: The yellowing of a plant's green tissue.

Cholinesterase: A chemical catalyst (enzyme) found in animals that helps regulate the activity of nerve impulses.

Concentration: The amount of active ingredient in a given volume or weight of formulation.

Contaminate: To make impure or to pollute.

Corrosion: The process of wearing away by chemical means.

Crucifers: Plants belonging to the mustard family, such as mustard, cabbage, turnip, and radish.

Cucurbits: Plants belonging to the gourd family, such as pumpkin, cucumber, and squash.

Deciduous Plants: Perennial plants that lose their leaves during the winter.

Deflocculating Agent: A material added to a suspension to prevent settling.

Degradation: The process by which a chemical is reduced to a less complex form.

Dermal: Of the skin; through or by the skin.

Dermal Toxicity: Ability of a chemical to cause injury when absorbed through the skin.

Diluent: Any liquid or solid material used to dilute or carry an active ingredient.

Dilute: To make thinner by adding water, another liquid, or a solid.

Dispersing Agent: A material that reduces the attraction between particles.

Dormant: State in which growth of seeds or other plant organs stops temporarily.

Dose, Dosage: Quantity of a pesticide applied.

Emulsifier: A chemical that aids in suspending one liquid in another.

Emulsion: A mixture in which one liquid is suspended as tiny drops in another liquid, such as oil in water.

Fungistat: A chemical that keeps fungi from growing.

GPA: Gallons per acre.

GPM: Gallons per minute.

Growth Stages of Cereal Crops: (1) Tillering—when additional shoots are developing from the flower buds; (2) Jointing—when stem internodes begin elongating rapidly; (3) Booting—when upper leaf sheath swells due to the growth of developing spike or panicle; and (4) Heading—when seed head is emerging from the upper leaf sheath.

Hard (water): Water containing soluble salts of calcium and magnesium and sometimes iron.

Herbaceous Plant: A plant that does not develop woody tissue.

Hydrogen-Ion Concentration: A measure of acidity or alkalinity, expressed in terms of the pH of the solution. For example, a pH of 7 is neutral, 1–7 is acid, and from 7–14 is alkaline.

Immune: Not susceptible to a disease or poison.

Impermeable: Cannot be penetrated. Semipermeable means that some substances can pass through and others cannot.

Lactation: The production of milk by an animal, or the period during which an animal is producing milk.

LC_{50}: The concentration of an active ingredient in air that is expected to cause death in 50 percent of the test animals so treated. A means of expressing the toxicity of a compound present in air as dust, mist, gas, or vapor. It is generally expressed as micrograms per liter (µg/L) as a dust or mist, but in the case of a gas or vapor, it is expressed as parts per million (ppm).

LD_{50}: The dose of an active ingredient taken by mouth or absorbed by the skin that is expected to cause death in 50 percent of the test animals so treated. If a chemical has an LD_{50} of 10 milligrams per kilogram (mg/kg), it is more toxic than one having an LD_{50} of 100 mg/kg.

Leaching: Movement of a substance downward or out of the soil as the result of water movement.

Mammals: Warm-blooded animals that nourish their young with milk. Their skin is more or less covered with hair.

Miscible Liquids: Two or more liquids that can be mixed and will remain mixed under normal conditions.

MPH: Miles per hour.

Mutagenic: Can produce genetic change.

Necrosis: Localized death of living tissue such as the death of a certain area of a leaf.

Necrotic: Showing varying degrees of dead areas or spots.

Nitrophenols: Synthetic organic pesticides containing carbon, hydrogen, nitrogen, and oxygen.

Noxious Weed: A plant defined as being especially undesirable or troublesome.

Oral: Of the mouth; through or by the mouth.

Oral Toxicity: Ability of a pesticide to cause injury when taken by mouth.

Organic Compounds: Chemicals that contain carbon.

Organochlorine: Same as chlorinated hydrocarbon.

Organophosphate: A synthetic organic pesticide containing carbon, hydrogen, and phosphorus; parathion and malathion are two examples.

Ovicide: A chemical that destroys eggs.

Pathogen: Any disease-producing organism.

Penetration: The act of entering or ability to enter.

Phytotoxic: Harmful to plants.

Pollutant: An agent or chemical that makes something impure or dirty.

PPB: Parts per billion. A way to express the concentration of chemicals in foods, plants, and animals. One part per billion equals 1 lb in 500,000 tons.

PPM: Parts per million. A way to express the concentration of chemicals in foods, plants, and animals. One part per million equals 1 lb in 500 tons.

Predator: Any animal that destroys or eats other animals.

Propellant: Liquid in self-pressurized pesticide products that forces the active ingredient from the container.

PSI: Pounds per square inch.

Pubescent: Having hairy leaves or stems.

RPM: Revolutions per minute.

Safener: A chemical added to a pesticide to keep it from injuring plants.

Seed Protectant: A chemical applied to seed before planting to protect seeds and new seedlings from disease and insects.

Soil Sterilant: A chemical that prevents the growth of all plants and animals in the soil. Soil sterilization may be temporary or permanent, depending on the chemical.

Soluble: Will dissolve in a liquid.

Solution: Mixture of one or more substances in another in which all ingredients are completely dissolved.

Solvent: A liquid that will dissolve a substance to form a solution.

Spreader: A chemical that increases the area a given volume of liquid will cover on a solid or on another liquid.

Sticker: A material added to a pesticide to increase its adherence.

Surfactant: A chemical that increases the emulsifying, dispersing, spreading and wetting properties of a pesticide product.

Susceptible: Capable of being diseased or poisoned; not immune.

Susceptible Species: A plant or animal that is poisoned by moderate amounts of a pesticide.

Suspension: Finely divided solid particles mixed in a liquid.

Synergism: The joint action of two or more pesticides that is greater than the sum of their activity when used alone.

Target Pest: The pest at which a particular pesticide or other control method is directed.

Tolerance: (1) The ability of a living thing to withstand adverse conditions, such as pest attacks, weather extremes, or pesticides. (2) The amount of pesticide that may safely remain in or on raw farm products at time of sale.

Toxicant: A poisonous chemical.

Trade Name: Same as brand name.

Vapor Pressure: The property which causes a chemical to evaporate. The lower the vapor pressure, the more easily it will evaporate.

Vector: A carrier, such as an insect, that transmits a pathogen.

Viscosity: A property of liquids that determines whether they flow readily. Viscosity usually increases when temperature decreases.

Volatile: Evaporates at ordinary temperatures when exposed to air.

Wetting Agent: A chemical that causes a liquid to contact surfaces more thoroughly.

Resources

Have a phone list for authorities available and accessible in case of problems, accidents, or incidents that occur. Fill in your local numbers for quick reference.

Pesticide Spill Phone Numbers

Local Poison Control Center:

County Extension Agent:

Local Police Department: City, County, State

Local Fire Department:

Civil Defense:

Kansas Division of Emergency Management:
785-291-3333

Kansas Department of Health and Environment:
785-291-3333

Kansas Department of Agriculture:
785-564-6688

U.S. Environmental Protection Agency Region VII Spill Reporting:
913-281-0991

ChemTrec:
800-262-8200

Pesticide Regulatory Agency Contact Information

Kansas Department of Emergency Management:
785-646-2000

Kansas Department of Health and Environment:
785-291-3092

Kansas Department of Agriculture:
785-564-6688

U.S. Environmental Protection Agency Region VII Office:
800-223-0425

Recognition and Management of Pesticide Poisonings, 6th edition: https://www.epa.gov/sites/default/files/2015-01/documents/rmpp_6thed_final_lowresopt.pdf

Frannie L. Miller
Pesticide Coordinator, Kansas State University

Authors

Appreciation is expressed to the following for preparation of the material in this manual:

Raymond Cloyd
Extension Specialist**,** Entomology, Kansas State University
Megan Kennelly
Extension Specialist, Plant Pathology, Kansas State University
Drew Ricketts
Extension Specialist, Wildlife Management and Control, Kansas State University
Sarah Lancaster
Extension Specialist, Weed Science, Kansas State University

Acknowledgment

Appreciation is expressed to the following for cooperation in the Pesticide Applicator Training Program:
Sara Liming
Certification and Training Specialist, Pesticide and Fertilizer Program, Kansas Department of Agriculture
Kelly Navinsky-Wenzl
Program Manager, Pesticide and Fertilizer Program, Kansas Department of Agriculture
Terry Roberts
Training Support Specialist, IPM and Pesticide Safety Program, Kansas State University

KANSAS STATE UNIVERSITY
Extension

S12 | May 2026