Pesticide Laws and Regulations

Federal Laws and Regulations

Pesticides provide important benefits when used correctly. However, they can cause serious harm if used improperly. The **Federal Insecticide, Fungicide, and Rodenticide Act (*FIFRA*)** is the most important law regulating the registration, distribution, sale, and use of pesticides in the US. It gives the Environmental Protection Agency (EPA) the authority to oversee the sale and use of pesticides. Commercial applicators can be fined as much as $5,000 for FIFRA violations. Criminal penalties can be as much as $25,000 and/or 1 year in prison. In addition, Kentucky can enact legal requirements that may be more restrictive than federal law.

FIFRA also gives EPA the authority to:

- Impose civil and/or criminal penalties on anyone who misuses a pesticide or commits any other listed unlawful acts. Fines can be up to $1,000 for each offense. However, you have the right to ask for a hearing in your own city or county.
- Stop the sale or use of any pesticide.
- Issue removal orders and seize products to keep them out of the market if it determines the products pose an unreasonable risk.
- Reevaluate older pesticides to ensure that they meet more recent safety standards.
- Protect agricultural workers and pesticide handlers from occupational pesticide exposure.

Exceptions to FIFRA

Unless the label specifically prohibits it, you can apply a pesticide

- To control a pest that is not on the label as long as the specific crop or site is listed
- By any method that is not prohibited. For example, some pesticides cannot be applied by air.
- At a lower dosage, concentration, or less frequently than specified on the label
- In a pesticide-fertilizer mixture.

All pesticides are classified according to their potential hazards under the circumstances in which they are to be used. The two main classifications are Restricted Use (RUP) and unclassified or general use. The EPA has officially classified very few pesticides as general use. Most that might be expected to fit into the general-use category currently are unclassified. Normally, general-use pesticides have a lower toxicity than RUPs so they are less likely to harm humans or the environment. The general public can buy general-use pesticides without special permits or restrictions.

Kentucky Laws and Regulations

The Division of Environmental Services of the Kentucky Department of Agriculture (KDA) regulates federal and state pesticide laws and regulations, including the Kentucky Fertilizer and Pesticides Storage, Pesticide Use and Application Act of 1996 (KRS 217b). It is responsible for regulating the registration, sale, distribution, proper use, storage, disposal, and application of pesticides in the Commonwealth. The Division strives to

educate the pest control industry and consumers about the proper use of pesticides through education and training programs.

KDA personnel give exams to certify and license qualified citizens who wish to apply or to sell pesticides. Field inspectors from the Agricultural Branch inspect facilities of the businesses which sell and/or apply pesticide and review their records. They can impose fines on businesses and/or individuals who neglect to follow federal and state laws concerning the proper storage, containment, sale, distribution, application, record keeping, or disposal of federally registered pesticides. They also investigate pesticide potential application complaints and violations.

You are responsible for learning about and complying with pesticide laws and regulations before making any applications. In addition, you are responsible for any consequences of actions that result from an application. ***Ignorance of the law is never an excuse for noncompliance or violations.***

Recordkeeping Requirements

KRS 217b requires that applicator keep records of applications of general and restricted use pesticides.

Record the information **within 14 days** from the date of treatment and keep the records for **3 years** and give the customer a copy **within 30 days**. USDA and/or KDA representatives have legal access to the records.

Required records must include the following information:

- ☑ Name and address of person receiving services
- ☑ Brand or product name of pesticides applied
- ☑ Date of application
- ☑ Purpose of application
- ☑ Size of area treated
- ☑ Crop, commodity, or type of area treated
- ☑ Name and certification number of applicator
- ☑ EPA registration number of the product
- ☑ Location of the application
- ☑ Total amount of each pesticide applied

Pesticide applications records:

- are invaluable documentation in the event of a complaint or lawsuit.
- can help determine which pesticide treatments work, which do not work, and why
- help you to plan purchases so that you buy only the amount needed
- provide information needed by medical staff
- document the steps taken to protect farmworkers and the environment
- are used for federal and state surveys

Important Definitions

- **Pests** - any animals (insects, snails, slugs, rodents, etc.); plant pathogens (nematodes, fungi, viruses, bacteria, or other microorganisms) or plants normally considered to be a pest, or which are declared to be a pest by the KDA.
- **Pesticide** - any substance or mixture of substances intended to:
    - prevent, destroy, control, repel, attract, or mitigate any pest;
    - be used a plant regulator, or a spray adjuvant, after being mixed with an EPA registered product;
    - be used as a plant regulator, defoliant, or desiccant.
- **Restricted Use Pesticide** -any pesticide classified as such by the EPA administrator, or by administrative regulation of the KDA. Only certified applicators can purchase and use them. Generally, the EPA classifies a pesticide as restricted use if:
    - it exceeds one or more human health toxicity criteria,
    - it meets certain criteria for hazards to non-target organisms or ecosystems,
    - the EPA determines that a product (or class of products) may cause unreasonable harm to human health and/or the environment without such restriction.
    - The restricted-use classification designation must appear prominently on the top of the front panel of the pesticide label.
- **Certification** - recognition by the KDA that a person has demonstrated a minimum level of competence by examination and continuing education units and is authorized to use or supervise the use of pesticides in his or her area of certification.
- **Commercial Pesticide Operator** - owns or manages a business that applies pesticides on the lands of another for hire. Operators must be certified in the appropriate category and must have a valid license issued by the KDA. A licensed commercial pesticide operator also must be registered as a pesticide dealer or must be employed by a registered dealer. The annual operator license expires on December 31, the license fee is $25.
- **Commercial Pesticide Applicator** - any individual employed by an operator to apply pesticides. Applicators must be certified in the appropriate category and must have a valid license issued by the KDA. The annual applicator license expires on December 31, the license fee is $10.
- **Noncommercial Applicator** - an employee of a golf course, municipal corporation, public utility, or other governmental agency certified and licensed to apply pesticides to lands owned, occupied, or managed by his or her employer. The annual non-commercial applicator license expires on December 31, there is no license fee.

- **Dealer** - stores bulk fertilizer or a restricted use pesticide for redistribution or direct resale, OR is in the business of applying any pesticide to the lands of another.
- **Trainee** - an individual employed by a dealer and working under the direct on-the-job supervision of a licensed operator or applicator.
- **Direct on-the-job supervision** - when a licensed operator or applicator is physically on site and is directly supervising or training an individual to apply a pesticide.
- **License renewal** - There is a 25% fine for license holders who do not file a renewal before March 1. ***The licensee must take a new certification examination if the license is not renewed before June 1***.

Certification and Licensing

Commercial and non-commercial pesticide applicators must be both certified and licensed. Both are accomplished by passing a written test (minimum score 70%) administered by the KDA.

Evidence of Financial Liability

Pesticide dealers who apply pesticides to the lands of others must show evidence of financial responsibility. This can be a surety bond or a liability insurance policy of at least one million dollars ($1,000,000) that would protect persons who may suffer legal damages as a result of the applicant.

Registration and Inspection of Equipment

The Kentucky Department of Agriculture (KDA) requires an annual fee of ten dollars ($10) for each piece of ground equipment to be registered, in the business of applying pesticides to the lands of another within the state. All registered equipment must be identified by a license plate or decal furnished by the KDA which must be put on the equipment as indicated by the department.

The KDA may inspect any equipment used for application of pesticides and may require repairs or other changes before it can be used. The registration of any equipment that fails to pass inspection may be revoked or suspended.

Penalties

Anyone who uses a pesticide in a manner inconsistent with its labeling directions and restrictions may be subject to civil and/or criminal penalties. Generally, any applicator in violation of FIFRA may be assessed a civil penalty. However, the EPA may issue a warning instead of assessing a penalty. An intentional violation by a private applicator is a misdemeanor and will result in a fine and/or up to 30 days imprisonment. You must use all pesticides exactly according to labeling directions—the label is the law!

How To Remain Certified

1. Return the annual license renewal form before March 1. There is a 25% fine for license holders who do not file a renewal before March 1. *You must take a new certification examination if your license is not renewed before June 1.*
2. Pay any required fees.
3. Earn Continuing Education Units (CEUs) in educational meetings approved by the KDA. Twelve (12) CEU credits (9 general units and 3 category specific units) must be earned before December 31 of the final year of your certification period. The Kentucky Cooperative Extension Service provides training materials and educational programs for certification and continuing education of commercial and non-commercial applicators through the Pesticide Safety Education Program.

Pesticide Labels and Labeling

Labels and labeling provide essential directions for the sale and responsible use of these chemicals. Pesticide users are required by law to follow all the instructions and directions for use in pesticide labeling.

Pesticide label is the information printed on the product container. All labels, which are essentially the manufacturer's license to sell, provide the important facts about Distribution, Storage, Sale, Use, Disposal, and Safety Measures Required for the Pesticide.

Pesticide labeling refers to any information printed on, attached to, or accompanying your purchase. This may include brochures, leaflets, and other information handed out by the dealer.

Major Types of Pesticide Registrations

The Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) has several types of registrations and exemptions that enable pesticides to be used. You are responsible for applying only pesticides registered or exempted from registration by EPA and the state of Kentucky.

- **Section 3 (Federal label)** is the most common registration. An approved and registered product will have an official EPA registration number on the label.
- **Section 18 (Emergency Exemption)** allows the sale and use of a registered pesticide product for a specific non-registered purpose during a specified time period. EPA can issue an emergency exemption at the request of the state for a public health concern or other pest crisis. There are three conditions for these exemptions:
    - No effective registered pesticides are available
    - No feasible alternative control practices are available
    - The situation involves the introduction of a new pest, will present significant risks to human health or the environment, or will cause significant economic loss.
- Regulations impose strict controls and require recordkeeping for all emergency uses. An Emergency Exemption is considered as restricted use and must be applied by certified applicators, even if it a general use pesticide. The Kentucky Department of Agriculture prescribes application rates, safety precautions, and other vital application information. Applicators must have a copy of the Section 18 approval on hand to legally use the product.
- **Section 24(c) (Special Local Needs)** allows states to expand or limit the uses of certain registered pesticides within their jurisdictions. For instance, some SLNs allow uses of pesticides for crops or sites not listed on the label. Others limit the uses of certain pesticides to address local concerns. Manufacturers must provide supplemental labeling for each SLN registration. **You must have SLN labeling in your possession to use a pesticide for that purpose.**
- The registration numbers of special local need labeling include the SLN number and code for the state issuing the registration. These registrations are legal only in the region, state, or local area specified in the labeling. **It is illegal to apply a pesticide that has an SLN registration from other states or regions.**

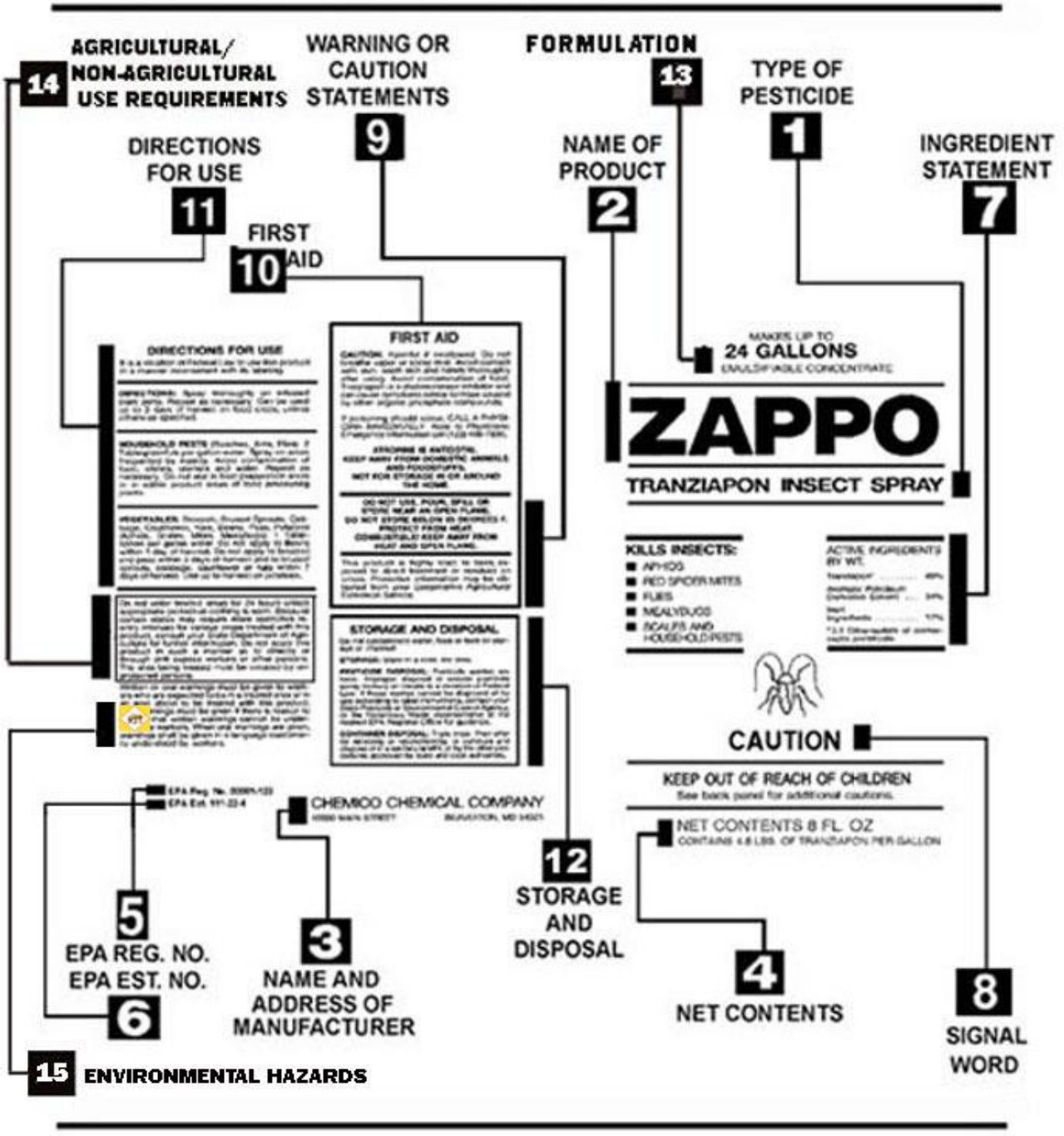
Read and understand all labeling before buying, using, storing, or disposing of a pesticide.

Read the Label First!

- Make sure the product is registered for your intended use. Confirm that there are no restrictions or other conditions that prohibit using this pesticide at the application site. Find out what PPE and special application equipment you will need.
- Determine what precautions to take to prevent exposure to people and non-target organisms. Learn what first aid and medical treatments are necessary should an accident occur. Be certain the product's use is suitable for weather conditions at the time of application. Also, be sure it controls the appropriate life stage of your pest.
- Find out how to store the pesticide properly. Understand any special precautions to prevent fire hazards
- Learn how to prevent environmental contamination and hazards to people. Check with the KDA for any disposal restrictions and requirements. Find out whether your state has pesticide container recycling and waste disposal programs.

The Pesticide Label

A pesticide label contains basic information that helps users clearly identify the product. Some of these items will be on the front panel of every label according to EPA requirements. The information on a pesticide label usually is grouped under headings to make it easier to find.



Restricted-Use Designation

A box at the top of the front panel identifies Restricted Use pesticides. A statement may describe the reason for the classification: groundwater and surface water concerns OR high acute toxicity. Another statement may describe the category of the certified applicator who can buy and use the product. General use pesticides have no designation on the product label.

RESTRICTED USE PESTICIDE
(Ground and surface water concerns)

For retail sale to and use only by certified applicators or persons under their direct supervision and only for the uses covered by the Certified Applicators Certification. This product is a restricted use herbicide due to ground and surface water concerns. Users must read and follow all precautionary statements and instructions for use in order to minimize potential for this product to reach ground and surface water.

Examples of other restrictive wording include:

For Pest Management Professionals and Commercial Use Only

OR

Intended For Use by Commercial Applicators Only

Brand or Trade Name

The brand or trade name shows up plainly on the front panel of the label and is used in advertising. Beware of choosing a pesticide product by brand name alone. Some companies use the same basic name with only minor variations to designate entirely different pesticides. Always read the ingredient statement to determine the active ingredients in a product.

Type of Pesticide

Usually listed on the front panel, there may be a short statement of what pests the product will control. For example,

2,4-D Amine Weed Killer
For selective broadleaf weed control
in certain crops, turf, and non-crop areas

Active and Inert Ingredients

Pesticides contain both active and inert ingredients. The active ingredient (sometimes more than one in a product) controls the pest. The common name and/or official chemical name for each active ingredient must be listed along with the amount or percentage present in the product.

Active Ingredient: *Dimethylamine salt of 2,4-Dichloro-phenoxyacetic acid 47.2%
Inert ingredients 52.8%

By purchasing pesticides according to the common or chemical names, you will always be sure to get the right active ingredient. Inert ingredients do not need to be named but the label must show their percent. Not all pesticides with the same active ingredient are labeled for the same uses or rates.

Net Contents

Tells how much is in the container in dry or liquid units. Liquid formulations also may list the pounds of active ingredient per gallon of product. For example:

*** Equivalent to 38.6% 2,4-D acid or 3.74 pounds per gallon**

EPA Registration Number

Specific for each pesticide. The two sets of numbers, separated by a hyphen, identify the manufacturer and the specific product. The registration number is used in recordkeeping. For example,

EPA Reg. No. 1386-43-72693

Pesticide Mode of Action Classification Number

appears on the front panel of some pesticides. This provides growers, advisors, consultants, and crop management professionals with a guide to selection of pesticides for use in resistance management strategies. Pesticides with the same classification number have similar modes of action. Group 3 herbicides are dinitroanaline herbicides which inhibit cell division in roots. Resistance is the result of repeated use of one or more similar pesticides over a number of years. See the chapter on pesticide resistance for more information.

Formulation

may be named or the label may show an abbreviation, such as F for flowable, G for granule, or WDG for water dispersible granule.

Precautionary Statements

Example from a 2,4-D amine product label:

Corrosive
Causes irreversible eye damage. Harmful if swallowed. Do not get in eyes or on clothing. Avoid breathing spray mist.

Physical or Chemical Hazards

Tells of any special fire, explosion, or chemical hazards the product may pose: e.g. if the product is flammable or corrosive.

Signal Words and Symbols

Most pesticide labels must include a signal word. The signal words Danger, Warning, or Caution - appear in large letters on the front panel of the pesticide label. They indicate the acute toxicity of the product to humans. The statement Keep out of reach of children must be present, also.

Poison/Skull and Crossbones - All highly toxic pesticides will carry the word POISON printed in red and the skull and crossbones symbol. PELIGRO, the Spanish word for DANGER, must also appear on the label. The signal word is based on the active ingredient and the contents of the formulated product including carriers, solvents, or inert ingredients.

Danger - signal word for a toxic pesticide that is **very likely** to cause acute illness from mouth, skin, or breathing exposure, or to cause severe eye or skin irritation. Products that have the signal word DANGER due to potential skin and eye irritation will not carry the word POISON or the skull and crossbones symbol.

Warning – **moderately likely** to cause acute illness from oral, dermal, or inhalation exposure or it is likely to cause moderate skin or eye irritation. AVISO, the Spanish word for WARNING, must also appear on the label.

Caution –the product is **slightly toxic** or relatively nontoxic. It has only slight potential to cause acute illness from oral, dermal, or inhalation exposure. Skin or eye irritation also is likely to be slight.

The EPA has determined that signal words are not required on the labels of pesticides identified under FIFRA section 25B as exempt or minimum risk. A few new products such as the caterpillar-specific insecticide, chlorantraniliprole, also do not have signal words.

Statement of Practical Treatment (First Aid)

First aid measures, may include instructions to seek medical help.

- ***Hazards to humans and domestic animals*** - warns of possible poisoning to humans and animals. Special precautions, including necessary protective equipment, appear here. The proper poison treatment is listed if the product carries serious risk.
- ***Acute effects*** – indicates routes of entry (mouth, skin, eyes, lungs) to protect and specific action needed to avoid acute effects from exposure.
- ***Delayed effects*** - warns of the potential to cause problems such as tumors or reproductive problems in laboratory animals.
- ***Allergic effects*** – indicates the potential to cause allergic effects: skin irritation, asthma. Sometimes the labeling refers to allergic effects as "sensitization."

Personal Protective Equipment Statements

Gives the minimum protection needed when using the pesticide. The statements may require different equipment for different pesticide handling activities. For example, an apron may be required only during mixing, loading or equipment cleaning. Wear the specified personal protective equipment even though you may be risking only your own safety by not wearing it.

Agricultural Use Requirements Section

If a pesticide label has an Agricultural Use Requirements box, then some or all of its uses are subject to the federal Worker Protection Standard. This section contains required statements on restricted entry interval (REI), early entry personal protective equipment, and notification-to-workers. The **restricted entry interval** is the period immediately following a pesticide application during which entry into the treated area is restricted.

For example:

AGRICULTURAL USE REQUIREMENTS
Use this product only in accordance with its labeling and the Worker Protection Standard. This standard contains requirements for the protection of agricultural workers on farms, forests, nurseries, or greenhouses and handlers of agricultural pesticides.
Do not enter or allow worker entry into treated areas during the restricted entry interval (REI) of 48 hours.
PPE required for early entry to treated areas that is permitted under the Worker Protection Standard that involves contact with anything that has been treated, such as plants, soil, or water is:
Coveralls over short sleeved shirt and short pants
Chemical-resistant gloves made of any water proof material
Chemical-resistant footwear plus socks
Protective eyewear
Chemical resistant headwear for overhead exposure

Pesticide handlers: mix, load, or apply agricultural pesticides; clean or repair pesticide application equipment; or assist with the application of pesticides.

Agricultural workers: perform tasks related to growing and harvesting plants on farms or in greenhouses, nurseries, or forests.

Workers include anyone employed for any type of compensation (including self-employed) doing tasks such as carrying nursery stock, repotting plants, or watering, or other tasks directly related to the production of agricultural plants on an agricultural establishment.

Dual use pesticides have separate boxes for Agricultural Use and Non-agricultural Use requirements. In this example, entry into the area is allowed once the spray has dried.

NON-AGRICULTURAL USE REQUIREMENTS
The requirements in this box apply only to uses of this product only that are NOT in within the scope of the Worker Protection Standard for agricultural pesticides. … The WPS applies when this product is used to produce agricultural plants on farms, forests, nurseries, or greenhouses. Do not enter or allow people (or pets) to enter the treated area until sprays have dried.
NOTE: For application to turf being grown for sale for commercial use as sod, follow AGRICULTURAL USE REQUIREMENTS ON THE LABEL.

Environmental Hazards

Indicates precautions for protecting the environment when using the pesticide. Most labels warn you not to contaminate water when applying the pesticide, cleaning equipment, or disposing of pesticide wastes. The label will contain specific precautionary statements if there is a specific hazard to the environment.
Example: *Most cases of groundwater contamination involving phenoxy herbicides have been associated with mixing/loading and disposal sites*.

Many pesticides are highly poisonous to honey bees and other pollinators. A bee icon appears on a pesticide label to signal that the product is potentially hazardous to bees. Look for requirements under the "Directions for Use" section of the label. Example warning:

Do not apply this product while bees are foraging. Do not apply this product until flowering is complete and all petals have fallen unless the following condition has been met.

Directions for Use

Explains correct use of the product, lists pests controlled, application sites, when and how much to apply, and harvest restrictions. The use directions and instructions are requirements. Below it is the statement "It is a violation of Federal Law to use this product in a manner inconsistent with its labeling."

Examples from different pesticide labels:

Observe pre-harvest interval of 28 days.
Limited to 2 applications per season.
Apply at 7 to 14 day intervals as necessary.
Maximum allowed per crop season: 11.2 fl oz – 0.088 lb ai per acre.

Storage and Disposal

All pesticide labels contain some instructions for storing the pesticide. Example:

Do not store below temperature of 25°F

Labels also contain some general information about how to dispose of excess pesticide and the pesticide container in ways that are acceptable under federal regulations. State and local laws vary, however, so the labeling usually does not give exact disposal instructions.

Pesticide Formulations – Chapter 3

Using Pesticide Formulations

Pesticide formulations are a combination of one or more **active ingredients (a.i.),** which control pests, and several inert ingredients. Many a.i.s are not soluble in water. Some may be toxic or unsafe to handle. Others may be unstable during storage. The inert ingredients are included in a formulated product to solve these problems. Some **inert ingredients** pose health risks to pesticide handlers or applicators so their characteristics, along with those of the active ingredient, determine the signal word that appears on the product label. For example:

4L = 4 pound per gallon Liquid
80 WP = 80% wettable powder
4L = 200 SL = 200 grams/liter (1.67 pounds/gal) soluble liquid

Pesticide products sold as **concentrates** must be mixed with water, or some other carrier, before being applied. The amount of active ingredient (a.i.) and the kind of formulation may be listed on the product label.

Concentrated formulations are very economical when treating large areas but it may be hard to measure amounts needed for small areas. Also, the handling, mixing, need for specialized spray equipment, and clean-up time may make the use of concentrates inconvenient or impractical.

Ready-to-Use formulations may be more appropriate for small areas. They contain small amounts of active ingredient (often 1% or less a.i. per unit volume). Some contain petroleum-based solvents; others are water-based. RTU formulations are already diluted and may be sold in containers that serve as applicators. Example RTU formulations include aerosols (A), granules (G), and most baits (B).

Most pesticide formulations are liquid or dry materials. Some pesticides are available in more than one. Cost is always a consideration but **safety and pest management concerns should come first**. Choose the formulation best suited for the job based on:

- Legal, labeled uses
- Signal word
- Applicator safety
- Environmental safety
- Pest biology
- Site characteristics
- Target (surface to be treated)
- Application equipment

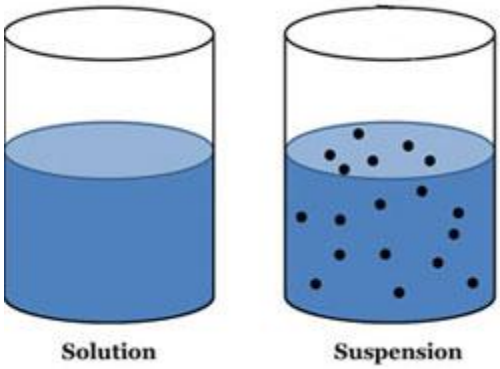
Answering these questions can help with the decision:

- Is the intended use and site listed on the product label?
- Do I have the necessary application equipment?
- Can the formulation be applied appropriately under the conditions in the application area?
- Will the formulation reach the intended target and stay in place?
- Is the formulation likely to damage the surface or foliage being treated?
- Would a less hazardous formulation be as effective?

Liquid Formulations

Most liquid formulations are diluted with water to make a finished spray. However, some labels direct users to mix the product with another solvent such as crop oil or other light oil as a carrier.

The three main types of liquid formulations are solutions, suspensions, and emulsions:



A **solution** is made by dissolving a substance in a liquid. A true solution is a mixture that cannot be separated by a filter or other mechanical means. Normally, it will not separate or "settle out" into distinct parts after being mixed. Light can penetrate most solutions.

A **suspension** is an even mixture of very small solid particles throughout a liquid. A suspension that has been on a shelf for some time must be shaken well to mix the liquid and solid portions evenly before pouring it into the spray tank. Water is added to make a finished spray. There must be enough agitation to keep the product evenly distributed in the spray tank during application. Most suspensions are cloudy or opaque; light cannot pass through them.

An **emulsion** is a mixture of droplets of one liquid in another liquid. Each ingredient keeps its unique properties and identity.

In an emulsion, the active ingredient is dissolved in an oil-based solvent. An emulsifier allows the active ingredient and the solvent to mix evenly with water before application. Some agitation may be necessary to keep an emulsion from separating. As a rule, emulsions have a "milky" appearance.

Common Liquid Formulations

Emulsifiable Concentrate (E or EC)

EC formulations usually contain an oil-soluble liquid active ingredient, a petroleum-based solvent, and an emulsifier (mixing agent). The emulsifier allows the active ingredient in the solvent to mix with water, these form an emulsion. ECs are versatile formulations that can be applied with many types of sprayers.

Formulation	Advantages	Disadvantages
E or EC	Easy to handle and measure; Little agitation is required; Will not separate; Little visible residue on the plant; Do not wear sprayer parts or plug screens or nozzles; Seldom leaves visible residue	Easily absorbed through skin; High concentration; Easy to over-treat or under-treat through mixing or calibration errors; May burn tender plant foliage; May soften rubber or plastic hoses, gaskets, and pump parts; May be corrosive to eyes or skin

Solutions (S, CS)

Some pesticide active ingredients dissolve readily in a liquid solvent, such as water or a petroleum-based diluent. When mixed, they form a solution that does not settle out or separate. Formulations of these pesticides usually contain the active ingredient, solvent (carrier or diluent), and one or more other ingredients. No emulsifier is required. Solutions are suitable for any type of sprayer and are registered for many sites.

Formulation	Advantages	Disadvantages
S or CS	Easy to handle and measure; No agitation required; Little visible residue on the plant; Does not wear sprayer parts or plug screens or nozzles; Seldom leaves visible residue	Limited availability; Spills and splashes difficult to clean-up or decontaminate

Emulsions in Water (EW)

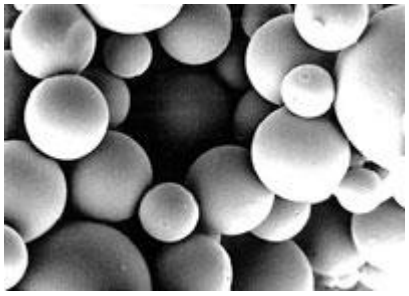
An emulsion in water formulation is the dispersion of a liquid active ingredient in water. These formulations have reduced dermal toxicity and lower potential for harming the environment. EWs are less likely to damage tender plant foliage because they do not contain the solvents found in emulsifiable concentrates.

Flowables (F, L, or SC)

Some active ingredients will not dissolve in either water or oil so they are impregnated in a dry carrier, such as clay, which is ground into a fine powder. The powder is suspended in a small amount of liquid to make the thick liquid formulation. Abbreviations used include “F” for flowable, "L" for liquid, and "SC" for suspension concentrate. The abbreviations 4F or 4L mean 4 pounds of the a.i. per gallon. They are considered to be liquids because the end use product is a thick liquid. Flowables are often used for the same types of pest control operations as ECs.

Formulation	Advantages	Disadvantages
F, L, or SC	Easy to handle and measure; Seldom burns plant foliage; Easy to tank mix; No dust exposure for applicator	Low absorption into skin; Will settle, requires moderate agitation; May leave a visible residue; May wear spray nozzles

Microencapsulated Pesticides (M or ME)



These are dry particles or liquid droplets surrounded by a plastic, starch or other material coating. They are mixed with water and applied as sprays. After application, there is a “timed” or slow release of the a.i. Depending on the physical properties of the coating, release may be weather-dependent. If the release is slower than normal (for example, due to dry or cool weather), residues may remain on treated plants or surfaces longer than expected. As a result, some microencapsulated products have relatively long restricted-entry or pre-harvest intervals.

Some microencapsulated pesticide products contain highly toxic materials with coatings to increase handler safety. Others are microencapsulated to reduce staining or odor or to protect the active ingredient from breakdown by sunlight.**Microencapsulated insecticides may be very hazardous to bees if the particles do not break down quickly and are the same size as pollen grains.**Foraging bees may collect them and carry them back to the hive. Later, when the coatings break down and release the pesticide, the colony may be poisoned. Some microencapsulated soil-applied products may be more prone to leaching into groundwater.

Formulation	Advantages	Disadvantages
M or ME	Safer handling; Longer residual control; Reduced plant injury (burn)	Pollen size particles are a bee hazard; Require agitation; Slower breakdown may cause higher residue at harvest

Aerosol (A)

These formulations contain one or more active ingredients and a solvent. Most aerosols contain a low percentage of active ingredient. There are two types of formulations.

- **Ready-to-use (RTU) aerosol formulations** are usually small, self-contained units that release pesticide when the nozzle valve is triggered. An inert pressurized gas pushes the pesticide through a fine opening when the gas is released, creating fine droplets. These products are effective in greenhouses, in small areas inside buildings, or in localized outdoor areas. Commercial models, which hold 5 to 10 pounds of pesticide, are usually refillable.
- **Smoke or Fog Generator formulations** are used in machines that use a rapidly whirling disk or heated surface to produce and distribute very fine droplets. These formulations are used mainly for insect control in structures such as greenhouses, barns, and warehouses and for outdoor mosquito and biting fly control. Both provide easy ways to treat confined spaces but have high inhalation hazards and aerosols have a high risk of fire/explosion.

Dry Formulations

The active ingredient is on the surface of a solid carrier, such as talc, clay, or ground corncobs.

Granules (G)

Granules are ready-to-use formulations. The active ingredient either coats the outside of the granules or is absorbed into small particles of clay, talc, or similar carrier. The amount of active ingredient is relatively low, usually ranging from less than 1% to 15%. The carriers in many granular formulations absorb moisture so humidity affects their flow rate during application. Also, different "batches" of the same formulation may differ slightly in size or shape and density. Therefore, it is important to calibrate granular application devices often.

After application, the active ingredient is slowly released. Rainfall or watering usually is needed to activate the product. Granular formulations are mostly used to apply chemicals to the soil to control weeds, nematodes, or soil insects. Granular formulations are used to deliver systemic pesticides which are taken up by plant roots. They also are used in aquatic situations to control mosquito larvae and aquatic weeds.

Formulation	Advantages	Disadvantages
G	Carries the formulation to target; May break down more slowly	Needs moisture for activation; Potential bird ingestion hazard

Wettable Powders (WP or W)

Active ingredients are applied to finely ground talc or clay particles. Most WP formulations also include wetting and/or dispersing agents. Usually, they are mixed with water to form a suspension and applied as a spray. They will settle quickly without constant agitation. To prepare a spray suspension, you must form a slurry by mixing the WP with a small amount of water, then dilute this slurry mixture further.

Wettable powders are effective for most pest problems and in most types of spray equipment where agitation is possible. They have excellent residual activity and usually do not harm treated surfaces. When you apply a WP spray suspension to a target, most of the pesticide remains on the surface. This is true even for porous materials, such as concrete, plaster, and untreated wood. In such cases, only the water carrier penetrates the porous material. Wettable powder particles remain on the treated surface.

Formulation	Advantages	Disadvantages
W or WP	Low skin absorption; Low potential to burn foliage	High inhalation hazard when pouring and mixing; Requires good agitation in spray tank; Abrasive to nozzles and sprayer parts (not SP)

Soluble Powder (SP or S)

These formulations look like wettable powders. However, when mixed with water, soluble powders dissolve readily in water and form a true solution. After a thorough mixing, no additional agitation is necessary. The amount of active ingredient in soluble powders ranges from 15% to 95%; it usually is more than 50%. Soluble powders have all the advantages of WPs but only one of the disadvantages: inhalation hazard during mixing. The insecticide acephate is one of the few pesticides available in this formulation because very few active ingredients dissolve in water.

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

These are WP formulations that have been compressed into dust-free, granule-sized particles. Most come with product-specific measuring devices. The dry ounce (or pound) increment marks on them are based on product density (weight per unit volume).These formulations readily pour out of their containers and are are easier to measure and cleaner to handle than WPs. They too are mixed with water and applied as a spray suspension. Once in water and agitated, the granules break apart into fine powder. The label may contain specific instructions to make mixing more effective. These formulations require constant agitation to keep them suspended in water.

WDGs share the advantages and disadvantages of WPs. However, WDGs have one added benefit: reduced handler exposure risk. A label for an 80 WDG indicates that this dry product contains 80% by weight of active ingredient and is formulated as a water-dispersible granule.

Formulation	Advantages	Disadvantages
WDG or DF	Low skin absorption; Low potential to burn foliage	High inhalation hazard when pouring and mixing; Requires good agitation in spray tank; Abrasive to nozzles and sprayer parts

Water-Soluble Bags/Packages (WSB)

An increasing number of pesticide products are available in water-soluble bags (WSBs). A special film packages a precise amount of wettable powder, soluble powder, or gel containing the pesticide active ingredient(s). When added to water in a spray tank, the bag dissolves and releases the contents that then are suspended or dissolved. This packaging method reduces handler exposure risk. It also simplifies measuring.

Water-soluble packaging will not dissolve in organicsolvents or undiluted ECs. As a result, mixers and loaders must follow label instructions when preparing a spray mixture. Store water-soluble products in a dry place, and do not handle them with damp or wet gloves. Packets contain amounts of pesticide for specific spray volumes, such as 100 gallons of water.

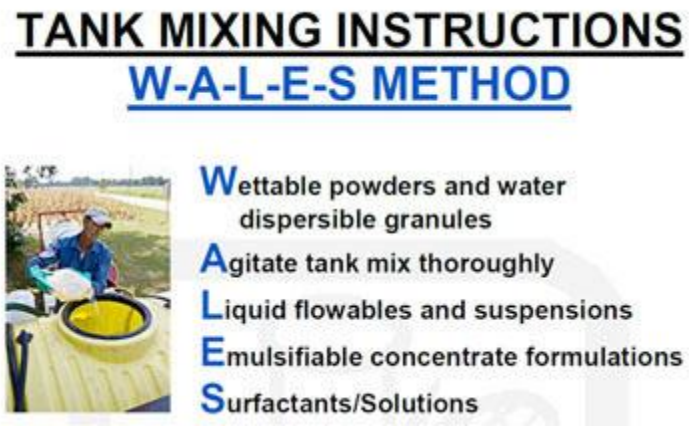
Formulation	Advantages	Disadvantages
WSB or WSP	Safe handling; Precise pre-measured amounts	Suitable for specific volumes only; Packets may deteriorate or tear.

Baits (B)

These are RTU formulations containing an active ingredient mixed with food or another attractive substance. The bait either attracts the pests or is placed where the pests will find it. Application may require specialized equipment and treatment costs may be too great for problems such as slug control in no-till corn or soybeans.

Pesticide Tank Mixtures

Combining two or more pesticides in a tank mix can be convenient and cost-effective, saving time, labor, fuel, and equipment wear. Combined applications also reduce soil compaction and the risk of mechanical damage to crops or treated areas. Situations appropriate for tank mixing include combining a fungicide and insecticide to treat fruit trees or field crops or to combine two (2) or more herbicides to increase the number of weed species controlled (broadened control spectrum).



Manufacturers may combine two or more pesticides, commonly applied at the same time, in premix packages. If a desired premix is not available, Federal law allows you to combine two or more pesticides unless the labeling of one or more of the intended products specifically prohibits it. For example, some sample tank mix warnings might include:

In a tank mixture, observe all restrictions, directions for use, crop/sites, use rates, dilution ratios, precautions and limitations that appear on the tank mix product label.

*****

Do not exceed labeled dosage rate and follow the most restrictive label precautions and limitations. This product must not be mixed with any product that prohibits such mixing.

*****

Tank mixtures or other applications of products referenced on this label are permitted only in those states in which the referenced products and uses are registered.

Compatibility of Pesticide Mixes

Pesticides must be compatible in order to provide effective pest control. If the labels do not give mixing instructions but do not prohibit it, then you are responsible for

- determining compatibility by "jar testing" the combinations. **AND**
- checking for phytotoxicity (plant injury) by testing the mixture on a small number of plants.

Pesticides can be incompatible for one of two main reasons:

- **physical** - they gel, curdle, foam, or stay in separate layers when mixed.
- **chemical** - their pest control activity changes when they are mixed.

Antagonism and synergism are the main types of chemical incompatibility. Antagonism occurs when the pest control effectiveness of one or both mixed products is reduced. Synergism occurs when mixing increases the activity of one or more products. This can produce more effective pest control in some cases but in other cases, the result can be crop damage.

Additives / Adjuvants

Additives / adjuvants are chemicals that may improve the action of a pesticide OR change the characteristics of a pesticide formulation or a spray mixture. Before using any adjuvant, consult the pesticide product label. Some products have very specific recommendations or prohibitions for adjuvants. If a label instructs you to use an adjuvant, use the type called for at the directed rate. Many products already contain those adjuvants that the manufacturer or formulator feels are necessary or useful. Adding others may actually decrease efficacy or result in unintended and possibly undesirable effects.

Adjuvants alone have no pesticidal activity so the EPA does not register them. As a result, there are no standards for composition, quality, or performance. Contact the manufacturer if you have questions about an adjuvant.

Types of Adjuvants

Antifoaming (defoaming) agent reduces excessive foaming of spray mixtures that may result from using some surfactants and/or from vigorous agitation.

Buffer or pH modifier allows pesticides to mix with diluents or other pesticides of different acidities or alkalinities. A buffer should be added first and mixed well. The water must be pH neutral or slightly acidic before adding pesticides or other adjuvants.

Compatibility agent helps to combine pesticides (or pesticides and fertilizers) effectively; they can reduce or eliminate mixing problems.

Dift control additive (deposition aid) increases average droplet size and/or lower the number of “fines” (very small droplets) produced.

Extender or sticker keeps pesticides active on a target for an extended period or on waxy foliage.

Plant penetrant allows pesticides to entered treated foliage. Certain plant penetrants may increase movement into leaves of some but not all plant species.

Safener reduces the toxicity of a pesticide formulation to the pesticide handler or to the treated surface.

Spreader allows a pesticide to form a uniform layer over a treated surface.

Sticker allows pesticides to stay on a treated surface longer. Some stickers help to hold solid particles to treated surfaces. This reduces the amount that washes off due to rain or irrigation. Others reduce evaporation and/or slow breakdown by sunlight.

Thickener increases viscosity (thickness) of spray mixtures. They may reduce drift and/or slow evaporation.

Wetting agent allows WP formulations to mix with water.

Surfactants are commonly used as adjuvants to alter the dispersal, spreading, and wetting properties of spray droplets. These products physically change the surface tension of a spray droplet. In order to perform well, some pesticide sprays must be able to wet treated foliage thoroughly and evenly. Surfactants that reduce surface tension enable droplets to spread out instead of "beading up". This results in better coverage and increases the odds that the pest will contact the pesticide. Surfactants are particularly helpful when treating plants with waxy or hairy leaves.

Surfactants are classified by how they split apart into charged atoms or molecules, called ions.

- **Anionic surfactants** have a negative (-) charge. They are most often used with contact pesticides, which control the pest by direct contact instead of being absorbed into it systemically.
- **Cationic surfactants** have a positive (+) charge. Do not use them as "stand-alone" surfactants—often, they are phytotoxic.
- **Nonionic surfactants** have no electrical charge. They are often used with systemic products to help pesticides to penetrate plant cuticles. They are compatible with most pesticide products. A pesticide can behave very differently in the presence of an anionic, cationic, or nonionic surfactant. For this reason, you must follow label directions when choosing one of these additives. Selecting the wrong surfactant can reduce efficacy and damage treated plants or surfaces.

The terms used with pesticide additives can be confusing. People sometimes use the words “adjuvant” and “surfactant” interchangeably. However, an adjuvant is ANY substance added to modify properties of a pesticide formulation or finished spray. A surfactant is a specific kind of adjuvant—one that affects the interaction of a spray droplet and a treated surface. All surfactants are adjuvants but not all adjuvants are surfactants. For example, drift control additives and safeners are not surfactants.

Choosing an Adjuvant

- Read and follow the label. Is an adjuvant recommended? If so, what type? Do not make substitutions. Some product labels may recommend an adjuvant for one type of use or site but prohibit any kind of adjuvant for another labeled use or site. Many end-use formulated products already have adjuvants, and adding adjuvants “on the fly” can decrease efficacy. Suppose, for example, that a certain product is formulated with a wetting agent. If you add another wetting agent when you mix and load a foliar-applied spray, the product may not give better spreading and coverage. Instead, the extra adjuvant may increase runoff, reduce deposition, and even damage the target plant.
- Use only those adjuvants manufactured for agricultural or horticultural uses. Do not use industrial products or household detergents in pesticide spray mixes.
- No adjuvant is a substitute for good application practices.
- Be skeptical of adjuvant claims such as “improves root uptake” or “keeps spray equipment clean” unless a reliable source can provide research-based evidence to support them. Only use adjuvant products that have been tested and found effective for your intended use.
- Test spray mixes with adjuvants on a small area before proceeding with full-scale use.

Summary

The components of a formulated pesticide include both active and inert ingredients. The active ingredient controls the pest. Inert ingredients include carriers or diluents and adjuvants. The type of formulation may be provided in the identifying information on the front panel of the label. Learn what formulations are available for the pesticide active ingredients you will use. To decide which formulation is best for a specific site and situation, you must know the properties—and be able to evaluate the pros and cons—of various formulation types. You must be familiar with formulation types and active ingredient properties in order to understand the characteristics of the products you use and apply them properly.

Most end-use pesticide products contain adjuvants. Although adjuvants themselves lack any direct pesticidal activity, they are added to pesticide formulations to improve product performance. You should know when and how to use an adjuvant.

You must consider several factors when choosing a pesticide formulation. These include

- the risks and benefits associated with the options available,
- the practicality of using a specific formulation in a particular site to control the target pest, and
- whether the formulated product will provide effective control.

Understanding the properties of common formulations before choosing a pesticide will help you avoid problems and apply your product in an effective and efficient manner.

Pesticide Hazards and First Aid

Toxicity, Exposure, and Hazard

Pesticides are chemicals designed to be toxic to certain groups of organisms so that they can control pest species effectively. Use them very carefully to avoid harming yourself, others, and non-target organisms.

Pesticides can have **acute (short-term)** and **chronic (long-term)** health effects. The **signal word** on the product label and the information contained in the ***Hazards to Humans and Domestic Animals*** part of the **Precautionary Statements** section of the label indicate the toxicity concerns and list the **minimum personal protective equipment** (PPE) and precautions needed to reduce risk when using the product. Pesticides also can pose additional physical and chemical hazards by being explosive and/or combustible. Information on physical or chemical hazards of products is included in the Precautionary Statements section. In addition, the **Safety Data Sheet** (SDS) has much more information on toxicity and precautions.

Toxicity is a measure of the ability of a pesticide to cause acute or chronic injury or illness. It is a combination of its chemical properties and concentration or amount.

Exposure occurs when pesticides get on or into the body through the skin, lungs, mouth, or eyes. There is great risk of exposure when: opening and handling containers; mixing and loading concentrates; working around or repairing contaminated application equipment; making applications; cleaning up spills; and re-entering a recently treated area before the spray has dried.

Hazard or risk is the potential or probability for harm (injury, illness, or allergy) to occur from the combination of the product's toxicity and the level of exposure to it. Product formulations differ greatly in their exposure risk. As an applicator, you can **reduce your risk** by choosing a less-toxic product or formulation, by reducing exposure, or both. In situations when a different product cannot be used, you can still reduce the hazard by taking steps to reduce your exposure.

Hazard = Toxicity x Exposure

The **greatest exposure hazard usually occurs while <u>mixing and loading concentrated pesticides</u>**. Hazards associated with the actual application are frequently much lower when diluted pesticides are handled or applied. The hazards may still be substantial, however, in the case of a single high exposure (such as when an accident occurs) or when many smaller exposures occur over an extended period.

The best way to reduce or avoid the risks of pesticides is to understand the products that you are using and know how to handle and apply them safely. Read the label carefully and follow its instructions. Your attitude is most important. If you assume that you know exactly how to use a pesticide without reading the product label or do not bother to take the precautions indicated on the label, then you are more likely to experience excess exposure.

When handling pesticides, you have a legal and moral obligation to protect both your health and that of others. Besides protecting yourself, you must be aware of other people, wildlife, or pets that may be in or near the treatment area. They could be exposed to the pesticide during or after application. By following good safety practices you reduce the chance of exposure.

The pesticide registration process requires manufacturers to do risk assessment studies. They then develop product labels that provide instructions on minimizing exposure. The labels specify personal protective equipment (PPE), engineering controls, symptoms of overexposure, first aid, and post-application restricted-entry intervals (REIs).

Potential Harmful Effects of Pesticides

The two broad **types of effects from pesticide exposure are: local or contact and systemic**.

<u>Local effects</u> may occur to the area of contact with skin, eyes, or respiratory tract. They are referred to as contact symptoms or effects. Examples of local (contact) effects:

- **Skin irritation or injury; itching, redness, rashes, blisters, burns, and discoloration.** Many herbicides and fungicides cause dermatitis. Fumigants can cause severe blisters.
- **Eye irritation or injury: swelling, stinging, and burning.** Herbicides, fungicides, insecticides, and fumigants may cause eye irritation or injury through contact, sometimes resulting in irreversible damage.
- **Nose, mouth, or throat irritation or injury: Swelling, stinging, and burning**. Permanent respiratory damage occurs less often.

Systemic effects may occur once the substance is absorbed and distributed throughout the body. They may be acute or chronic. These effects depend on the toxicological profile of the chemical itself, the amount absorbed, and the individual's ability to detoxify and eliminate the chemical. Examples of systemic effects are:

- Damage to nerves.
- Reduced ability of blood to clot.
- Some cancers.
- Reproductive problems.
- Impaired metabolism (the body's ability to use energy).
- Hormonal effects.
- Damage to various organ systems, such as the kidneys or liver.

The U.S. Environmental Protection Agency (EPA) considers local and systemic effects when deciding whether to register a chemical. They are also used to set label restrictions, such as limiting the method, timing, or rate of application; to determine appropriate levels of PPE; or to establish restricted entry intervals (REIs) in combination with exposure factors.

Allergic effects are harmful effects that occur in some people after exposure to certain substances. An allergy to a chemical contained in a product formulation may cause skin irritation, blisters, or hives. Occasionally, more serious problems, such as asthma or even life-threatening shock can develop.

Pesticide allergy symptoms include red and/or itchy eyes, respiratory discomfort, and asthma-like effects. Unfortunately, there is no way to predict which people will develop allergies to a particular product. Having an allergic reaction does not predict whether someone would also be more sensitive to other effects of the pesticide, such as chronic or delayed effects. These types of effects depend on different chemical reactions within the body.

Exposure -- How Pesticides Get Into the Body

Pesticide exposure occurs when pesticides get onto or into the body. The four primary routes of exposure are:

- skin (dermal),
- eyes (ocular),
- lungs (inhalation), and
- mouth (oral).

Skin or Dermal Route

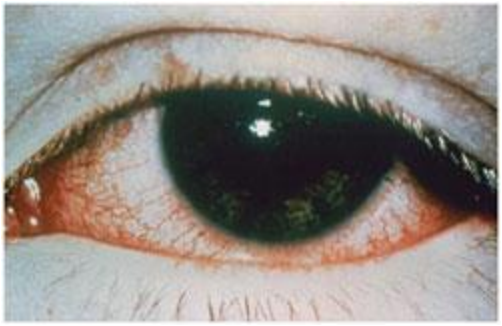
Usually, the skin is the main route of entry onto or into the body. Up to 97% of all body exposure to pesticides during a spraying operation is by skin contact. Dermal absorption or contact injury may occur from airborne dust, splashes, spills, or spray mist when mixing, loading, applying, or disposing of pesticides. Skin exposure may also result from contact with pesticide residues on treated surfaces or contaminated equipment during cleaning, adjustment, or repair.

Once a pesticide contacts the body, absorption, penetration, and distribution depend on: *chemical properties of the pesticide product, *the area of contact and rate of absorption, and *the body's own detoxification and elimination capabilities. Some products that cause systemic injury are just as toxic when absorbed through the skin as when they are when swallowed.

Parts of the body differ in their ability to absorb pesticides. **Warm, moist areas, such as the groin, armpits, head, neck, backs of the hands, and tops of the feet, tend to absorb more than the palms and forearms. However, palms and forearms must still be protected because they get the most exposure.** Cuts, abrasions, and skin rashes can increase absorption. The rate of absorption (i.e., how quickly the pesticide can get into the body) differs depending on the area contacted but entry also depends on time. **The longer a pesticide (or any other chemical) remains in contact, the more will be absorbed.** Skin protection is important even if the area of the body most likely to contact a pesticide has a low absorption rate.

Pesticide formulations penetrate the skin at different rates. In general, wettable powders, dusts, and granular pesticides do not enter easily. However, oil-based liquid formulations, such as emulsifiable concentrates, are readily absorbed. Application techniques may also affect exposure levels for applicators. Making overhead applications, using blower application equipment for mists and dusts, are application methods that often have high dermal exposure levels. Additionally, contaminated hands or gloves can transfer pesticides to other body parts. Be sure to wash your hands and gloves after each pesticide-handling activity.

Eyes or Ocular Route



Pesticides can be **absorbed quickly and easily into the blood vessels** that lie very close to the surface of the eye. In addition, **corrosive products can cause severe eye damage or even blindness**. Pesticides can get into your eyes as airborne dusts or particles, splashes or spills, broken hoses, spray mists, or from rubbing the eyes with contaminated hands or clothing

Breathing or Inhalation Route

Protect your lungs when mixing, loading, or applying pesticides, particularly in confined areas. In sufficient amounts, inhaled pesticides can cause **contact damage to sensitive tissues**. They can **enter the bloodstream very rapidly from the lungs**, eventually damaging other body organs (systemic illness). Also, petroleum solvents in emulsifiable concentrate formulations can enter the lungs while vomiting.

Swallowing or Oral Route

Oral exposure can occur **when liquid concentrates splash into the mouth** during mixing and loading of pesticides or while cleaning equipment. Never use your mouth to clear a spray line or to begin siphoning a pesticide. **Eating, drinking, or smoking without first washing your hands** may transfer product to your mouth. People are most likely to accidentally swallow pesticides that are improperly stored in the home or transferred into **unlabeled bottles or containers normally used for food or beverages**. Unfortunately, children are the most common victims of these mishaps.

Clearly mark all cups and containers used to measure pesticides and store them separately from devices used to measure food and beverages. Never store pesticides in drink or food containers. Practice good personal hygiene and wear proper protective equipment. Preventing exposure is key to the safe use of pesticides.

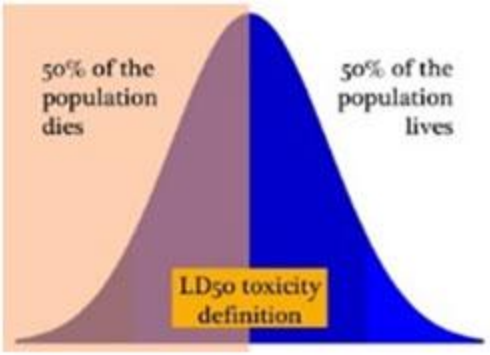
Product Toxicity and Health Concerns

Historically, the toxicity of pesticides has been determined by subjecting test animals (usually rats, mice, rabbits, or dogs) to various dosages of the active ingredients and to each formulated product. Acute and chronic toxicity from exposure is evaluated at a range of doses: those that cause no immediate effects, those that cause some immediate effects, those that cause delayed or long-term effects, and those that cause death.

Single doses are given to assess effects from a one-time exposure. Other tests involve dosing the animals over several years to simulate exposure to small amounts throughout a lifetime. These tests can detect many different types of toxic effects ranging from subtle changes, such as weight loss or gain (which could indicate underlying problems), to specific illnesses, to death. Today, agencies that regulate pesticides are developing tests that can identify and predict the same toxic endpoints as the

earlier tests required. The newer methods use mathematical models and techniques without animal testing.

Acute toxicity is the measure of harm (systemic or contact) caused by a single exposure event. Acute effects are determined after test animals have been exposed to a chemical through contact with their skin and eyes, through inhalation, or through ingestion. The harmful effects may be systemic or contact in nature (or a combination of both), depending on the product, formulation, dose, and route of exposure. Acute effects occur shortly after exposure, usually within 24 hours.



The common method used for comparing acute toxicity is the LD_{50}, or lethal dose 50%.

This is the **dose of a toxicant required to kill 50% of the population of test animals under a standard set of conditions.** For comparison purposes, LD_{50} values of pesticides are recorded in milligrams of toxicant per kilogram of body weight of the test animal (mg/kg). When the animal is exposed to material by feeding, the result is referred to as the oralLD_{50}. When the material is tested by skin exposure, the result is called the dermal LD_{50}.

Another commonly used measure of acute toxicity is the LC_{50}, or lethal concentration 50%. This is the concentration of a substance in air or water required to kill 50% of the test population. It is usually expressed in parts per million or milligrams per liter (mg/l). The LC_{50} is a common measure of lethal effects of chemicals on fish and other aquatic organisms. The LC_{50} values most directly applicable to human health are those expressing lethal concentration of chemicals in the air.

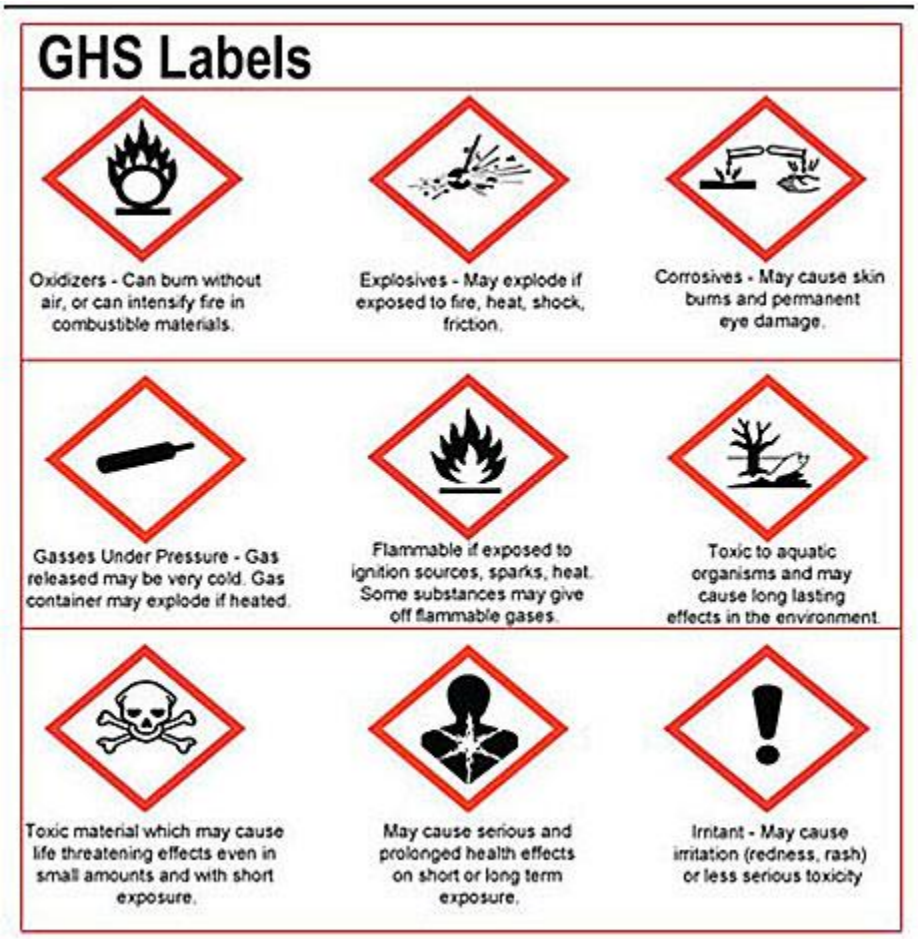
The LD_{50} and LC_{50} values are useful in comparing the systemic toxicity of different active ingredients as well as different formulations of the same active ingredient. The lower the LD50 value of a pesticide, the less it takes to kill 50% of the population of test animals and the greater the toxicity of the chemical. LD_{50} and LC_{50} values have limitations because they measure only one toxic effect — death. They do not indicate what dose may lead to other, less serious acute systemic effects or to other, possibly equally serious contact or delayed systemic effects. Also, they do not translate directly to humans because our body systems are different from those of test animals. Lastly, the LD_{50} and LC_{50} are measures of a single exposure, not the potential sequence of effects resulting from multiple exposures.

Some pesticides produce acute toxic effects because of their corrosive or irritant properties. These can result in respiratory, skin, or eye irritation or damage. Some can cause severe burns or permanent blindness. Chemicals with these irritant or corrosive properties require extra care and special PPE. Fungicides, herbicides, and some insecticides may cause contact injuries. Manufacturers list nonlethal systemic and contact effects in addition to the signal word. Systemic and contact acute toxicity concerns are indicated by the signal word. They are further explained in the "Precautionary Statements" portion of the product label under the "Hazards to Humans and Domestic Animals" section.

EPA and the manufacturer take into account both systemic and contact toxicity measures in assigning the signal word and toxicity category to a product. These are assigned on the basis of the greatest concern—be it oral, dermal, or inhalation systemic effects or skin, eye, or respiratory tract contact effects.

Signal Words and Skull and Crossbones Symbol

The Globally Harmonized System (GHS) for classification and labeling of chemicals is an international system for hazard communication. The goal is to improve and simplify hazard communication and alert users to the need to minimize exposure and risk. The system will identify more types of hazards than the current signal words on pesticide labels. For instance, separate pictograms and/or signal words will provide information about chronic toxicity as well as acute toxicity. This should result in safer transportation, handling, and use of chemicals.



This table summarizes the range of LD_{50} and LC_{50} values and their relationship to the different toxicity levels.

Signal Word & Symbol	Toxicity Level & Class	LD_{50} Oral (mg/kg)	LD_{50} Dermal (mg/l)	LC_{50} Inhalation (mg/kg)	Toxicity Concern
DANGER-POISON/ PELIGRO Skull & Crossbones	Highly toxic, Hazard Class I	Trace to 50	Trace to 200	Trace to 0.2	a few drops to 1 teaspoon could kill
DANGER/ PELIGRO	Highly toxic, Hazard Class I				Based on corrosive or irritant properties of the product
WARNING/ AVISO	Moderately toxic, Hazard Class II	50 to 500	200 to 2,000	0.2 to 2	*1 teaspoon to 1 ounce
CAUTION	Slightly toxic, Hazard Class III	500 to 5,000	2,000 to 20,000	2 to 20	*1 ounce to 1 pint or 1 pound
CAUTION or no signal word	Hazard Class IV	Greater than 5,000	Greater than 20,000	Greater than 20	Slight to none
* could cause death, illness, or skin, eye, or respiratory damage					

DANGER— POISON, DANGER, WARNING, and CAUTION, the four distinct signal words currently found on pesticide labels, are based on the acute toxicity of the product. Depending on their acute toxicity, pesticide products are categorized into several hazard classes. Some very low toxicity products (Hazard Class IV) are not required to have a signal word.

Danger—Poison plus a skull and crossbones

appears on pesticides classified as highly toxic. The lethal toxicity may be based on oral, dermal, or inhalation exposure, depending on the exposure route that presents the greatest risk for that product. Consult the precautionary statements that follow the signal word and symbol on the label

to learn more about the product's hazard to humans. Most fumigants, some insecticides and rodenticides, and a few herbicides are assigned the DANGER—POISON signal word.

Danger (without the word "poison" or the skull and crossbones symbol)

indicates the potential for permanent or severe damage to skin, eyes, or lungs from contact exposure. The contact effects of these pesticides are more dangerous than the acute systemic toxicity. Several carry warnings of concern about the products' ability to cause irreversible eye damage at low exposures. Consult the precautionary statements that follow the signal word on the label to learn more about the products' hazard for humans. Some herbicides, insecticides, and antimicrobials carry the DANGER signal word.

Warning

signal word alone does not indicate whether the concern is systemic, contact, or both. Consult the precautionary statements that follow the signal word on the label to learn about the product's specific contact or systemic hazard for humans.

Caution

Contact effects are generally irritation of eyes, skin, or respiratory tract. Consult the precautionary statements that follow the signal word on the label to learn about the product's contact or systemic hazard to humans.

Chronic Toxicity

The chronic toxicity of a pesticide is determined by subjecting test animals to long-term (usually 2 years) exposure to an active ingredient. The harmful effects that occur from small, repeated doses over time are termed chronic effects.

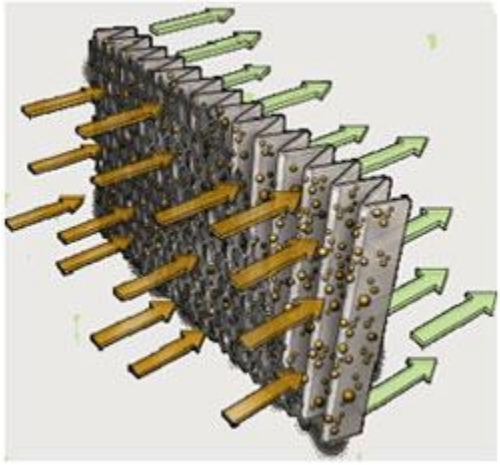
Chronic effects from pesticide exposure include genetic changes, noncancerous or cancerous tumors, reproductive effects, infertility, fetal toxicity, miscarriages, birth defects, blood disorders, nerve disorders, and hormonal or endocrine-mediated diseases. Each pesticide has its own characteristic pattern of diseases and adverse effects that it might cause. However, no single pesticide is likely to be able to cause the entire range of harmful effects. Minimizing the likelihood of chronic effects is one of the important reasons to follow all label directions and be cautious in handling and applying pesticides.

If a product causes chronic effects in laboratory animals, the manufacturer is required to include chronic toxicity warning statements on the product label. This information is also listed on the Safety Data Sheet. The chronic toxicity of a pesticide is more difficult to determine through laboratory analysis than the acute toxicity and cannot be expressed by a single measure.

Delayed Effects

Delayed effects are illnesses or injuries that do not appear immediately (within 24 hours) after exposure to a pesticide. They may be delayed for weeks, months, or even years. Whether you experience delayed effects depends on the pesticide, the extent and route of exposure(s), and how often you were exposed. The "Precautionary Statements" section of the label states any delayed effects that the pesticide might cause. It also tells you how to avoid exposures. Delayed effects may be caused by either an acute or a chronic exposure to a pesticide.

Factors Affecting Response



Humans have built-in mechanisms to reduce the risks of toxic substances and to eliminate them from the body. The **liver** is the primary organ that changes toxic substances to nontoxic or less-toxic forms. Its chemical breakdown processes help to make most of these substances more water-soluble so they can be eliminated.

The **kidneys** filter water-soluble unwanted chemicals out of the blood and into the urine. Those that cannot be made water-soluble are eventually are stored in fatty deposits throughout the body and in breast milk. Many of the pesticides in use today are more water-soluble than those used before 1970. Most are eliminated relatively quickly (hours to days instead of months to years) in urine.

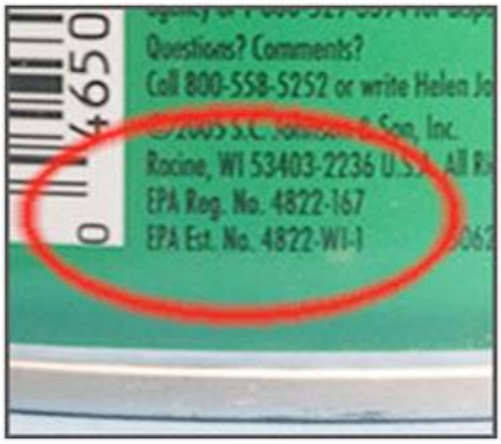
Some pesticides can cause changes, called mutations, to our DNA. DNA is the carrier of genetic information in our bodies. Some DNA mutations do not cause any effects. Others cause serious malfunctions and may lead to various types of illnesses or other problems, such as birth defects. Although our bodies constantly monitor and repair DNA mutations, over time our ability to repair the DNA decreases. Our bodies continually manufacture the enzymes we need to help detoxify pesticides and other toxic substances. However, continual or very frequent exposures may overwhelm the body's capacity for chemical breakdown and elimination. **Keeping your exposure low and having periods of non-exposure between applications of the same class of pesticide can reduce the chance that your body will be overwhelmed.**

Symptom Recognition

Symptoms can be correlated with certain groups of pesticides. For example, some fungicides irritate the skin, eyes, and mucous membranes of the respiratory system. Symptoms associated with synthetic pyrethroid insecticides include nausea, dizziness, weakness, nervousness, and eye and skin irritation. Chlorophenoxy herbicides, such as 2,4-D and some related products (dicamba, MCPA, and MCPP) irritate the skin and mucous membranes. They may also cause vomiting, headaches, diarrhea, and confusion.

First Aid for Pesticide Poisoning

Get medical advice immediately for unusual or unexplained symptoms that develop within 24 hours of a pesticide exposure. Be alert for the early symptoms of pesticide poisoning and contact (local) effects in yourself and others. Do not wait to call a physician until you or someone else gets dangerously ill. It is better to be too cautious than to act too late.



Take the pesticide label or EPA registration number with you to help medical personnel to treat you appropriately and quickly. The label is important because the medical professional needs to know the pesticide ingredients to determine the proper course of treatment. It is a good idea to print off extra copies of the label from the Internet. Place one copy in your service vehicle and one in your office in case of a medical emergency.

Keep in mind that symptoms commonly associated with certain pesticides are not always the result of exposure. Common illnesses (e.g., the flu, heat exhaustion or heatstroke, pneumonia, asthma, respiratory or intestinal infections, and even a hangover) can cause symptoms similar to those of many frequently used pesticides. Contact with certain plants, such as poison oak or poison ivy, may also produce skin effects like those resulting from pesticide exposure. However, it is best to take every precaution. **When symptoms appear after contact with pesticides, always seek medical attention immediately.**

General First Aid

First aid is the initial effort to assist a victim while medical help is on the way. If you are alone with the victim, **make sure he or she is breathing and exposure to the pesticide has stopped. Then call for help. Protect yourself from pesticide exposure** before and while giving assistance. Make sure you wear the appropriate PPE, including a respirator if indicated, before assisting someone in an enclosed area. Administer artificial respiration if the victim is not breathing and is not vomiting.

Immediate action can be a life-or-death matter in a pesticide poisoning. The product label is the primary source of information. Follow the label's specific first aid instructions carefully. Beyond the label, call the American Association of Poison Control Centers (AAPCC) (800-222-1222) or a physician for additional advice. It is very important to get the victim to a hospital, or contact 911 for emergency response, without delay. Post all emergency numbers near telephones and in service vehicles used by pesticide handlers.

Key points to remember when administering first aid during a pesticide emergency:

Oral or dermal exposure:

- Remove all contaminated clothing immediately.

- Rinse the exposed area with water to dilute the pesticide and to prevent skin absorption. Use the cleanest water available.
- Wash the affected area, including the hair, with water and soap. Then, rinse well. Showering is better than bathing to avoid prolonged contact with pesticide residues. Avoid harsh scrubbing, which could damage the skin and enhance pesticide absorption. Gently dry the affected area and wrap it in loose cloth or a blanket, if necessary.
- If the skin has chemical burns, cover the area loosely with a clean, soft cloth. Do not use ointments, greases, powders, and other medications unless instructed to do so by a medical authority.
- Never try to give an unconscious person anything by mouth.
- Do not induce vomiting unless the label tells you to.
- If inhalation exposure has occurred, get the victim to fresh air immediately.
- Become familiar with the proper techniques of artificial respiration. It may be necessary if a person's breathing has stopped or becomes impaired.
- If first responders are likely to be directly exposed to a pesticide, be sure they wear appropriate PPE.

Pesticide in the Eyes

- Because eyes readily absorb material, fast action is required.
- Hold the eyelid open and immediately begin gently washing the eye with drips of clean water. Do not use chemicals or drugs in the wash water unless instructed to do so by a medical professional or a poison control center.
- Drip the water across—not directly into—the eye, or use an eyewash dispenser.
- Continuously rinse the eye for 15 minutes. If only one eye is affected, be careful not to contaminate the other eye.
- Flush under the eyelid with water to remove debris.
- Cover the eye with a clean piece of cloth and seek medical attention immediately.

Inhaled Pesticide

- Immediately carry the victim to fresh air (do not allow him or her to walk).
- Do not attempt to rescue someone who is in an enclosed, contaminated area unless you are wearing appropriate PPE.
- Warn other people in the area of the danger.
- Have the victim lie down and loosen his or her clothing.
- Keep the victim warm and quiet. Do not allow him or her to become chilled or overheated.
- If the victim is convulsing, protect his or her head, turn the head to the side, and watch that breathing continues. Do not attempt to insert anything into the person's mouth during a seizure.
- Keep the person's chin up to ensure that air passages are open for breathing.
- Give artificial respiration if breathing stops or is irregular,.

Pesticide in the Mouth or Swallowed

- If pesticide is in someone's mouth but has not been swallowed, rinse the mouth with plenty of water. Then, give the victim large amounts (up to 1 quart) of milk or water to drink.
- If the pesticide is swallowed, one of the most critical first aid decisions is whether to induce vomiting. Induce vomiting only if the label instructs you to do so. Several pesticides cause more harm when vomited than if they remain in the stomach. To provide first aid for a swallowed pesticide, you must know the appropriate treatment. The decision to induce vomiting must be made quickly and accurately—the victim's life may depend on it.

Never induce vomiting if the victim:

- Is unconscious or having convulsions.
- Has swallowed a corrosive poison, such as a strong alkali or acid. The material burns the throat and mouth as severely coming up as it did going down. Also, it can be aspirated into the lungs and cause more damage.
- Has swallowed an emulsifiable concentrate or oil solution product, which is dissolved in petroleum solvents. Emulsifiable concentrates and oil solutions may be fatal if aspirated into the lungs during vomiting.

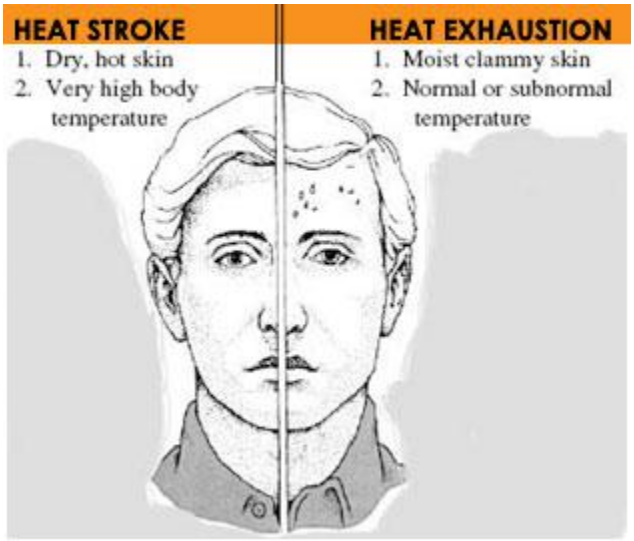
Heat Stress

Heat stress occurs when the body cannot cope with a certain level of heat. Heat stress may affect both pesticide handlers and other workers. **A person suffering from heat stress exhibits symptoms that closely resemble poisoning symptoms of some pesticides.**

PPE worn during handling or early-entry activities may increase the risk of heat stress. its protective qualities may restrict the evaporation of sweat, interfering with the body's natural cooling system. If you are under a physician's care, consult him or her before working in hot or humid conditions. Vests and headbands with special pockets for ice packs or other heat stress prevention devices may be worn with or beneath PPE. These will help maintain a cool body temperature.

Symptoms of Heat Stress

Mild forms of heat stress make people feel ill and impair their ability to do a good job. You may feel weak and get tired sooner than usual. You may also be less alert and less able to use good judgment.



Severe heat stress, also known as heatstroke, is life-threatening. The normal human body temperature ranges from about 97°F to 99°F, with an average of 98.6°F. With heatstroke, body temperature may exceed 105°F. Staggering, loss of consciousness or convulsions may result. **Lack of sweating is a common symptom of heatstroke.** Brain damage or even death may occur if the heatstroke victim is not cooled very quickly. More than 10% of severe heat stress victims die—including young, healthy adults. Sometimes victims remain highly sensitive to heat for months and cannot return to the same type of work.

Heat stress symptoms include:

- Fatigue, exhaustion, or muscle weakness
- Dizziness and fainting
- Clammy or hot, dry skin
- Altered behavior: confusion, slurred speech, quarrelsome or irrational conduct
- Headache, nausea, and chills
- Severe thirst and dry mouth
- Heavy sweating: eventually, this can progress to a complete lack of sweating as the body loses the ability to control its temperature

Act immediately to cool down if you suspect that you may be suffering from even mild heat stress. Drink plenty of water and take breaks in the shade throughout the workday. In hot conditions, watch for symptoms of heat stress in other workers as well.

Summary

Pesticide risk can be summarized by the equation hazard (risk) = toxicity x exposure.

Hazard = Toxicity x Exposure

"Toxicity" is the capacity of the pesticide to cause either short-term (acute) or long-term (chronic) injury or illness; "exposure" is the means by which the pesticide gets into or onto the body. These two factors determine the likelihood that harm (i.e., hazard) will come to a person who handles pesticides.

Harmful effects of pesticides may occur at the area of local contact or after uptake into the body (i.e., systemic effects). Pesticides can enter the body by any of four routes: through the skin (dermal), eyes (ocular), lungs (respiratory), or mouth (oral). Some adverse effects may occur within 24 hours after a

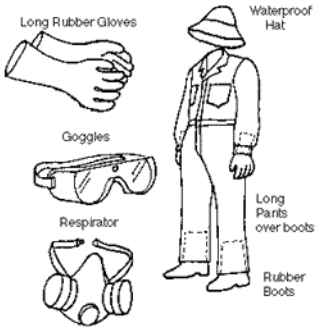
single (usually large) exposure (acute effects). Others may occur many years after exposure (delayed effects), typically from small exposures over a long period (chronic effects). **Pesticide handlers can minimize exposure—and reduce risk— by following label directions, using the proper application and handling procedures, and wearing appropriate personal protective equipment.**

The toxicity of a pesticide product is measured in test animals by the LD_{50} and LC_{50} values. These values determine the signal word that occurs on the pesticide label. Signal words— DANGER–POISON, DANGER, WARNING, and CAUTION—help the user recognize how acutely toxic the pesticide is and what precautions to take. Remember, however, that the signal word only provides information about the acute toxicity of the product. Chronic and delayed effects are often the result of different mechanisms and are not related to the substance's level of acute toxicity.

People who use pesticides routinely should have regular medical checkups to determine if they are experiencing any ill effects from pesticide use. Regular monitoring of blood cholinesterase levels can determine if certain insecticides are affecting an individual before symptoms appear.

Early recognition of pesticide poisoning symptoms is the key to preventing further injury. The label often provides important information on first aid procedures for the particular pesticide product. Make sure a copy of the label is readily available whenever you are using pesticides. Take the label to a medical professional if a poisoning incident occurs.

Personal Protective Equipment



The pesticide label provides handling precautions, minimal **personal protective equipment (PPE)**, and other safety measures to minimize your exposure while handling pesticides. PPE comprises the clothing and devices you wear to protect your body from contact with pesticides. Wearing PPE can reduce exposure and lower the chances of pesticide injury, illness, or poisoning. **Basic protective work clothing consists of: a long-sleeved shirt, long pants, closed toed shoes, and socks.**

The EPA defines PPE as: coveralls, apron, gloves, footwear, headgear, eyewear, and respirators.

All pesticide applicators and handlers must understand the protections and limitations of PPE. Proper PPE selection, use, and care are essential. **Although PPE may reduce your exposure to pesticides, it does not necessarily eliminate it.**

Good Work Practices

It is important to take basic steps to reduce exposure when you handle pesticides or work in pesticide-treated areas. Remember to use common sense—no guidelines cover all situations.

- **Avoid Mouth Exposure**

Never eat, drink, chew gum, use tobacco products, or handle cellphones while working with pesticides. Contaminated hands are a source of oral exposure to pesticides.

- **Avoid Skin Exposure**

Wash your hands before using the toilet—the groin area readily absorbs pesticide. Wear a minimum of a long sleeved shirt, long pants, and closed-toed shoes. Do not wipe contaminated gloves on your clothing—the pesticide may seep through.

- **Avoid Eye Exposure**

  Wear protective eyewear to protect from splashes, sprays, mists, fogs and aerosols.

- **Avoid Inhalation Exposure**

  Avoid breathing in dusts, spray droplets, or vapors. Wear a respirator when needed, even if the label does not require it.

- **Decontaminate Yourself and Your PPE**
  First, wash your gloves with soap and water. Then take them off and wash your hands and face. Immediately wash off any pesticide that gets directly on you. Remove and replace damaged or contaminated clothing or PPE. Have spare clothing available. Wash or replace contaminated PPE at the end of the day.

- **Shower Immediately After Work.** Wash your hair and scalp and under your fingernails. Put on a complete change of clothing.
- After work, **Launder Your Work Clothes Separately** from non-work and other clothes.

Protect Yourself from Pesticides

A pesticide label lists the **minimum** PPE that an applicator, handler, and early-entry worker must wear. **Wearing anything less is illegal and dangerous.** All pesticide handlers (e.g., applicators, mixers and loaders, and flaggers) are responsible for following the pesticide label, including wearing PPE.

Examples of PPE Requirements on the Product Label

PERSONAL PROTECTIVE EQUIPMENT
Some materials that are chemical resistant to this product are barrier laminate or butyl rubber or nitrile rubber or neoprene rubber or polyvinyl chloride (PVC) or viton.
Applicators using spray equipment mounted on their backs must wear: Coveralls over long-sleeved shirt and long pants. Chemical-resistant footwear plus socks, and Chemical-resistant gloves such as barrier laminate or butyl rubber or nitrile rubber or neoprene rubber, or polyvinyl chloride (PVC) or viton.
Mixers, loaders, all other applicators, and other handlers must wear long-sleeved shirt and long pants, chemical-resistant gloves, such as barrier laminate or butyl rubber or nitrile rubber or neoprene rubber, or polyvinyl chloride (PVC) or viton, shoes plus socks, and chemical-resistant apron, when mixing/loading, cleaning up spills, cleaning equipment, or otherwise exposed to the concentrate.
Follow manufacturer's instructions for cleaning/maintaining PPE. If no such instructions for washables exist , use detergent and hot water. Keep and wash PPE separately from other laundry. Discard clothing and other absorbent materials that have been drenched or heavily contaminated with this product's concentrate. Do not reuse them.

PPE requirements are typically listed under the "Precautionary Statements" section of the pesticide label. If you work in or on a farm, forest, nursery, or greenhouse, also look for additional PPE requirements listed in the "Agricultural Use Requirements" box on the label. Always check to see if state regulations are more restrictive than label requirements. Some states have more restrictive safety regulations for pesticide applicators. When a state or local regulation is more restrictive than federal pesticide laws, it must be followed.

Under EPA's Worker Protection Standard (WPS; 40 CFR Part 170), agricultural employers are legally required to provide PPE that is in good working order. They also must train pesticide handlers on the proper use and maintenance of label-required PPE. PPE label requirements vary, depending upon the toxicity, formulation, dilution, and route of exposure of the pesticide product and activity. For example, a single label may have one set of PPE requirements for applicators and a different set for agricultural early entry workers going into areas during the restricted-entry interval. Even very low hazard pesticides require that a long-sleeved shirt, long pants, shoes, and socks be worn.

Consider all work situations where using PPE may be hazardous. Be careful around moving equipment with parts that can catch apron strings. Protective clothing can restrict evaporation of sweat, interfering with the body's natural cooling system. This can cause heat-related illnesses, including heat stress (see Chapter 4, Pesticide Hazards and First Aid, for more information).

Protect Your Body

Different types of clothing, aprons, hats, boots, and gloves are not equally protective against all pesticides and under all conditions. For PPE to be protective, it must:

- Shield your head, face, neck, trunk, arms, legs, and feet from exposure while handling pesticides.
- Be durable and resist punctures and tears during normal use.
- Be comfortable enough without restricting your movement so you will wear it.

To protect your skin, your normal work clothing must cover most of your body. Depending on the product's toxicity and use, coveralls, apron, hat, boots, and gloves may also be required. Protective clothing, gloves, and boots must provide a barrier while you are exposed to a pesticide. Labels may require waterproof gloves or boots. Additionally, chemical-resistant gloves, aprons, hats, boots, or suits are required on some labels. EPA defines "**chemical resistant**" as preventing any measurable amount of material from moving through (breaking through) the fabric or material. Things that can affect the extent of breakthrough are contact time, concentration, temperature, and the product itself. When selected correctly, protective clothing reduces the risk of dermal exposure but does not eliminate it.

Your **work clothes** provide a basic barrier to minimize pesticide contact with your skin. Select work clothes made of tightly woven fabrics to reduce pesticide penetration. Make sure they are free of holes and tears. Fasten the shirt collar completely to protect the lower part of your neck. Do not use these work clothes for anything other than handling pesticides. Store and launder fabric work clothing separately from all other clothing after each day's use. See "Maintaining Clothing and Personal Protective Equipment" at the end of this chapter for details on cleaning and disposing of pesticide-soiled work clothes.

Basic work clothes

- **Always wear at least a long-sleeved shirt and long pants.**
- **Make sure work clothes are durable.**
- **Wash work clothes at the end of the day, separate from other clothing.**

Coveralls

Some pesticide labels require **coveralls** (a second layer of clothing) over work clothes. They must be **loose-fitting, one or two-piece garments that cover the entire body except head, hands, and feet**. A coverall can be made of woven (like cotton or twill) or nonwoven fabrics. It must be durable so it does not rip, tear, or puncture easily. It should be either easy to clean and sturdy enough for laundering and repeated use or disposable.

Wearing a disposable coverall reduces decontamination time and lowers the risk of contaminating yourself, your application equipment, and your vehicle. Most importantly, wearing coveralls lessens the chance that you will take pesticides home. Handle disposable coveralls carefully, do not contaminate other people. Very few pesticides require a chemical-resistant coverall. If one is required, work with your PPE supplier to find one that provides the necessary level of protection based on the tasks you perform, the product formulation, and exposure.

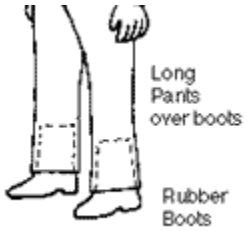
Apron for mixing

Some pesticide labels require you to wear a chemical-resistant apron when mixing or loading a pesticide, or when cleaning application equipment. Select an apron that **covers the front of your body from the middle of the chest to the knees**.

Headgear for Overhead Applications

A pesticide label may require chemical-resistant headgear if an overhead application may result in exposure. The headgear **must protect against sprays so that no liquid breaks through the hat or hood**. You may use either a chemical-resistant hat with a wide brim or a hood. Hoods attached to jackets or spray suits protect your neck and back from pesticide sprays that might otherwise run down your back. Wash headgear at the end of the day. When making overhead applications, **do not use headgear made of absorbent material, such as cotton, leather, or straw**. Cotton ball caps absorb pesticides. Do not wear them if overhead exposure is a concern.

Footwear



Pesticide labels require you to wear **socks and closed-toed shoes**. Some product labels require you to wear chemical resistant footwear. A heavy-duty pair of unlined rubber boots or shoe covers provides protection from pesticides. Wear heavy-duty rubber boots that extend past your ankle and at least halfway up to your knee if you will enter or walk through treated areas before spray has dried. **Put your pant legs outside your boots to prevent pesticides from running down your legs and becoming trapped in your footwear**. Wash the boots inside and out at the end of the day. Leather and canvas absorb pesticides and cannot be decontaminated. Regulations allow you to substitute leather for chemical-resistant boots only when the chemical-resistant footwear required by the pesticide label is not durable enough for use in rough terrain. **Do not use these boots for other purposes.**

Gloves

Pesticide handlers get by far the most exposure from pesticides on their hands and forearms. Research has shown that workers mixing pesticides received 85% of the total exposure on their hands and 13% on their forearms. The same study showed that wearing protective gloves reduced exposure by 99%. Protective gloves are essential to protect your skin. Pesticide labels often require waterproof gloves or one of the following **glove types**: nitrile rubber, butyl rubber, neoprene rubber, barrier laminate, and Viton®.

Each glove type varies significantly in how well it protects from the different solvents in formulated products. **Read each label to determine which glove type is appropriate.** This can vary from product to product, even those with similar active ingredients. The solvent in a formulation determines the type of protective glove to wear. Pesticide labels require either waterproof gloves (for solid or water-based formulations) or chemical resistant gloves for the various solvents (e.g., alcohols, ketones, and petroleum distillates) used in different formulations.

For liquid products that use a solvent other than water, EPA requires the label to specify particular glove materials that provide protection. Read the label carefully to make sure you have the correct protective glove material. Some pesticide labels specify both the glove material and its thickness. As a general rule, the thicker the glove (of the same material under identical conditions), the longer the breakthrough time. A pesticide label's specification of glove type is generally based upon a thickness of 14 mils, except for polyethylene and barrier laminate gloves. Use the 14 mils thickness as a rule of thumb when selecting glove materials that appear on the pesticide label.

Glove durability is another important consideration. Select a glove that is protective, does not tear or puncture easily, and protects you for the duration of the task. Discard them if there is any sign of wear or if they leak. Do not use gloves made of any kind of absorbent material, lining, or flocking, including leather or cloth (exception: cloth gloves are used with fumigants). These types of gloves absorb pesticide and trap it closely against your bare skin, greatly increasing skin absorption.

Choose a glove size that fits you comfortably. Gloves that fit well provide increased dexterity for equipment maintenance or calibration. Gloves that are too tight stretch the material, allowing pesticides to break through. Gloves that are too large can get caught in equipment. Gloves that are too loose may allow pesticides to run down the inside and be directly absorbed by your skin. Select gloves designed to give you extra protection when needed for the job. Use elbow-length gloves when mixing and loading. Wear gloves according to how you are applying the pesticide. Do not use a glove beyond the breakthrough time.

When using reusable gloves, rinse them at each break and wash them thoroughly at the end of the workday. Absorbed pesticides will continue to enter the material if not removed. Make sure your gloves are in top condition. Throw out any gloves showing wear. Check glove integrity before each use. Rinse disposable gloves before discarding them.

Good work practices—gloves

- **Wear waterproof or chemical resistant gloves when applying pesticides. Although pesticide labels do not always specifically require gloves, wearing them reduces your exposure (except when handling fumigants).**
- **Check gloves closely for holes by filling them with clean water and gently squeezing. Discard them if you find any leakage.**
- **Wear gloves whenever you might get pesticides or residue on your hands, such as when cleaning sprayer nozzles or working around contaminated equipment or surfaces.**
- **If pesticide is spilled, splashed, or gets inside your gloves, take them off immediately. Wash your hands and put on a clean pair of gloves.**
- **Replace your gloves immediately if they get cut, torn, or damaged.**
- **If making several applications during the day, change gloves between jobs to avoid contaminating yourself and your vehicle.**

Protect Your Eyes

Eyes readily absorb pesticides. When a label says to wear protective eyewear, you may use goggles; a face shield; safety glasses with shields at the front, brow,

and temple; or a full-face respirator. Use common sense and select eyewear that protects you for the task. Eyewear made of impact-resistant material, such as polycarbonate, can protect you from flying objects, such as granular pesticides. However, safety glasses will not protect your eyes from pesticide splashes.

Products that are corrosive to the eyes (e.g., Danger signal word) require a particular type of eyewear. For example, goggles may be required when your eyes may be exposed to liquids or particulates during a certain application or use. Wear tightly fitting goggles when you are in high-exposure situations, such as an open cab during an air-blast application; applying mists, fogs, or aerosols indoors; or in any other location where you will be enveloped in a spray, mist, or dust. Make sure goggles are splash- and spray-proof and have an air baffle system for airflow and no side vents. If fogging is a problem, use anti-fog lens treatments or purchase low-fog goggles. If your eyewear has a headband that is made of pesticide-absorbent material, change it often or use a rubber strap. If possible, wear the strap under your hat or hood to protect it from becoming contaminated.

Protective eyewear can be worn with a half-face respirator. If you wear eyeglasses, you can buy an eyeglass insert for your full-face respirator that is fitted with your prescription. People who wear contact lenses should consult an eye doctor or their medical professional before using pesticides or wearing respirators.

- **Minimum eyewear is safety glasses with shields at the front, brow, and temple.**
- **If goggles are required, have an eyewash dispenser immediately available.**
- **Consult an eye doctor if you wear contact lenses.**

Protect Your Respiratory System

When you use pesticides, you may be exposed to toxic gases, vapors, particulates (solids or liquids), or all of these. A **respirator** is a safety device that protects you from inhaling contaminated air. The pesticide label states whether you must use a respirator and if so, which type. The respirator type is based on the pesticide formulation, application method, and environment where the application is made.

The National Institute for Occupational Safety and Health (NIOSH) certifies that respirators have been tested according to certain standards. The NIOSH approval of a respirator indicates that it protects the wearer against specified contaminants. All respirator manufacturers issue approval certificates with a chart of all of the components considered part of the approved assembly. Respirator approvals are manufacturer-specific: do not interchange parts, cartridges, or filters between different manufacturers' units. These certificates are typically package inserts with new respirators, cartridges, and filters. Find out if there are federal or state health and safety regulations that stipulate proper respirator selection, care, and use.

There are other respirators on the market that are not NIOSH-approved, such as nuisance dust masks and some surgical masks. **When a respirator is required, wear a NIOSH-approved device that is listed on the pesticide label.**

Types of Respirators

The two classes of respirators most often required for protection from pesticide exposure are **atmosphere-supplying** and **air-purifying respirators**.

Atmosphere-supplying respirators provide clean, breathable air from an uncontaminated source. Examples are airline respirators and self-contained breathing apparatus. In very specific uses, such as releasing phosphide fumigants in enclosed areas, the environment may be immediately dangerous to life and health. In these cases, the only kind of atmosphere-supplying respirators that may be used are either a pressure demand self-contained breathing apparatus (SCBA) with a full face piece or a pressure-demand full face piece air-line respirator with an SCBA escape bottle for emergencies.

Air-purifying respirators (APRs) remove contaminants from the air that you breathe. They do not supply oxygen and should never be used in an environment that has limited oxygen or is immediately dangerous to life or health. Air-purifying respirators may be either powered or non-powered.

- **Powered air-purifying respirators (PAPRs)** use a blower to pass contaminated air through purifying elements. PAPRs are available with a tight-fitting face piece or a loose-fitting hood.
- **Non-powered air-purifying respirators** have tight-fitting face pieces that seal directly to your face. There are single-use particulate filtering face piece respirators and half-masks and full face piece masks with replaceable purifying elements. Gas masks, which use canisters instead of cartridges, are one type of APR.

Purifying Elements for Air-Purifying Respirators

When selected and used appropriately, elements for air-purifying respirators remove specific contaminants from the air passing through them. The pesticide label specifies which type of purifying element is required. Elements that remove particulates (e.g., dusts or sprays) are called filters, while vapor- and gas-removing elements are called either chemical cartridges or chemical canisters.

Particulate Filters

Particulate filters remove dusts, aerosols, or sprays suspended in the air that you breathe. Particulate filters DO NOT remove gases or vapors. The type of filter required on the pesticide label depends on whether the respirator is powered or non-powered.

EPA regulations require that you replace particulate filters according to respirator manufacturer recommendations or pesticide labeling (whichever is more frequent). If there are no other use directions, dispose of particulate filters at the end of eight hours of cumulative use.

Chemical Cartridges or Canisters

Chemical cartridges or canisters use sorbents to remove contaminant specific gases and vapors. They do not remove particles. The most typical chemical cartridge or canister specified by the label for pesticide applications is an organic vapor removing (OV) cartridge or canister.

- **Always use the type of chemical cartridge or canister purifying element required by the pesticide label.**
- **Keep purifying elements sealed until ready to use.**
- **Although it is not a requirement, some respirator manufacturers stamp the expiration date of purifying elements on the outside of the product package. Do not use a purifying element after the expiration date, even if it was never opened.**

The service life of a chemical cartridge or canister depends on the type and concentration of pesticide, the user's breathing rate, and humidity.

Chemical cartridge respirators, when selected appropriately, are essentially 100% efficient until the gas or vapor breaks through. Any taste, smell, or irritation indicates that breakthrough of the pesticide has occurred. **Cartridges should be changed immediately whenever you detect breakthrough in the mask**. Once used, an organic vapor cartridge must be disposed of at the end of the day. The pesticide trapped by the sorbent in the cartridge may desorb very easily overnight. If you were to use the cartridge the next day, you could breathe in the desorbed pesticide vapors. **Always dispose of chemical cartridges at the end of a workday unless the manufacturer directs otherwise.**

Combination Chemical Cartridge and Particulate Filters

The pesticide label may direct you to use both a chemical cartridge or canister and a particulate filter. You have two options:

- A chemical cartridge or canister with a disposable N, R, or P filter using a retaining ring.
- A single combination cartridge or canister.

The combination chemical cartridge or canister for nonpowered air-purifying respirators will include N-, R-, or P-rated filters. The combination chemical cartridges for powered air-purifying respirators will include an HE filter.

Follow the same change-out practices listed individually for particulate filters and chemical cartridges. For example, if you were using a combo chemical cartridge with a P100 filter and detected breakthrough in your mask, you would change out your cartridges immediately even though the filter was still useable.

Identifying the Respirator Type from the Pesticide Label

The respiratory protection required by the pesticide label is product and task-specific. The pesticide label will typically cite respiratory protection required using a NIOSH "TC" (Testing and Certification) designation. The NIOSH designations correspond to the types of respirators that may be specified by the pesticide label and include: TC-84A, TC-21C, TC-23C, TC-14G, TC-13F, and TC-19C.

Use Tight-Fitting Respirators Properly

Before selecting and using any respirator, get a medical evaluation to make sure wearing a respirator does not endanger your health. Next, read and understand the manufacturer's instructions and NIOSH approval certificate that accompany the respirator and its components. For full protection, conduct a fit test before wearing a tight-fitting particulate-filtering face piece, half mask, or full-face mask. When wearing a tight-fitting respirator, nothing must interfere with the seal between the surface of the mask and your face, including beards and stubble.

Fit Tests

Fit testing is a method to select the right size and type of tightfitting respirator for your face. Perform a qualitative or quantitative fit test of a given mask type on a user's face to select the best-fitting respirator. It is important to get a fit test annually and whenever you use a different respirator face piece. Get fit tested again whenever something physically changes that could affect the fit of your respirator (e.g., facial scarring, dental work, cosmetic surgery, or a significant change in body weight). **A respirator cannot protect you from pesticide exposure if it does not fit your face.**

Always consult the pesticide label for the appropriate respirator and purifying elements. If you have any questions about your respirator, consult the manufacturer or use online resources. Be sure to review the manufacturer approved labels for use limitations of the respirator.

Maintaining Clothing And Personal Protective Equipment

At the end of each workday, wash all work clothes and PPE. Some items, such as clothes and coveralls, can be washed using a washer and dryer. Other items, such as gloves, protective suits, goggles, aprons, boots, and eyewear, require hand washing. Wear protective gloves when handling contaminated items. Rinse and discard disposable items. Dispose of any non-reusable or contaminated item carefully to prevent cross-contamination or contamination of others who might handle the discarded item. Dispose of heavily contaminated items as household hazardous waste.

Woven Work Clothes and Coveralls

Launder fabric coveralls and work clothing after each day's use. Some common sense guidelines for cleaning pesticide-soiled clothing include:

1. **Outdoors, shake any dry material from cuffs and pockets and then hang garments out to air.**
2. **Wash work clothes and coveralls worn when handling pesticides separately from other laundry.**
3. **Load only a few items into the washing machine so there is plenty of agitation and water for dilution.**
4. **Use hot water and the highest water level.**
5. **Prerinse items by using the prewash cycle.**
6. **Use heavy-duty liquid detergent.**
7. **Run the washer on the longest wash cycle. Use two entire machine cycles for lightly or moderately contaminated items.**
8. **Properly handle and discard heavily contaminated clothing.**
9. **Line dry laundered items outdoors if possible.**
10. **Run one additional empty cycle without clothing, using detergent and hot water, before using the washer for your household laundry. If using a laundry service, notify them the clothing may be contaminated with pesticides.**

Never wash any garments made of absorbent materials that have been splashed or soaked with undiluted pesticide or large quantities of diluted pesticide. Remember to remove them immediately and dispose of them carefully.

Nonwoven Clothing

Coveralls may be either a one-day disposable item or a reusable garment. Be sure to check the PPE manufacturer's use limitations and laundering instructions. Replace these garments regularly and at any sign of wear. If any PPE cannot be cleaned properly, dispose of it according to applicable federal, state, and local regulations. Follow manufacturers' instructions, if any, for the service life of reusable nonwoven garments. Pay close attention when reusing these items, and be ready to change them whenever you think that the inside surface may be contaminated. If using disposable garments, render them unusable and discard. If they are heavily contaminated with high-risk pesticides, handle them appropriately and take them to a household hazardous waste facility.

Boots and Gloves

Be sure to clean boots and gloves, even if they are worn only briefly. Before taking your gloves off, wash them thoroughly. Wash both the inside and outside of boots and gloves once removed. Inspect these items and discard if there is any sign of wear or if they leak. Hang or leave to dry. Gloves are not designed to be reused over and over. Replace them often to ensure protection of your hands. Properly cared for, boots should last multiple seasons. Sun will degrade rubber materials quickly, so store gloves and boots out of the sun.

Eyewear and Respirators

Most eyewear, respirator bodies, face pieces, and helmets are designed to be cleaned and reused. These items can last many years if they are good quality and are maintained according to the manufacturer's directions. Respirators require more maintenance than most PPE. When you have finished using your respirator, remove and properly dispose of any expendable components, such as filters, cartridges, or canisters. Wash the face piece according to the respirator manufacturer's directions. Take care to clean under and around gaskets and valves. Allow to air dry. Store cleaned respirators, as well as replacement purifying elements, in a clean, dry

place that is not exposed to sunlight or extreme temperatures. Make sure that the rubber face piece is not distorted when stored so that it maintains its shape. Do not store any protective equipment—including respirators— with or near pesticides or other chemicals.

Summary

Wearing PPE can reduce the potential for dermal, inhalation, ocular, and oral exposure, this lowers the chances of pesticide injury, illness, or poisoning. Check the pesticide label for the minimum PPE required by law. In order to appropriately select and wear PPE, you must understand both its protections and its limitations. Then determine what protective equipment you need for the pesticide task at hand.

Check the "Agricultural Use Requirements" box on the label and the WPS requirements for any other statements about PPE use in farms, forests, nurseries, or greenhouses.

Pesticide Drift

Factors Affecting Pesticide Drift

Drift is the uncontrolled movement of a pesticide away from its target area. They main types are **particle drift** and **vapor drift**.

Drift can

1. damage susceptible off-target sites (plants, animals, etc.)
2. reduce pest control, which wastes pesticide and money, and
3. contaminate the environment: water pollution and illegal pesticide residues.

This can mean lawsuits, administrative action, or criminal fines. Be able to recognize situations that increase potential problems and know how to deal with them.

Particle Drift

Particle drift occurs when spray droplets physically move away from the target site during application.

The main causes of particle drift are:

- **environmental factors**: wind speed above 10 mph, low humidity, or high temperature
- **improper spray practices**
- **equipment problems**.

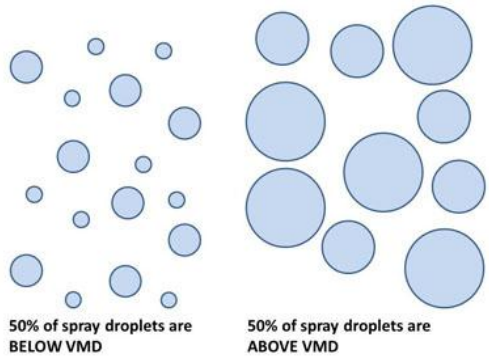
Droplet Size

Droplet size is one of the most important factors that affect particle drift. High sprayer pressure or nozzles that produce fine droplets that cover the target uniformly and completely. However, they can drift long distances.

Spray Pressure

Changes in operating pressure cannot be used safely to make major changes in sprayer output. Doubling the spray pressure (for example, from 20 psi to 40 psi) does not double the flow rate. You must increase the pressure four times (20 psi to 80 psi) to double the flow rate.

Exceeding the recommended pressure range often results in more drift potential. This increase in pressure would produce more fine spray particles, increasing the potential for spray drift.



To obtain a **uniform spray pattern and to minimize drift**, keep the operating pressure within the recommended range for each nozzle tip. To maintain a proper spray pattern, adjust nozzles according to the manufacturer's recommendations on nozzle spacing and spray angle.

Lower pressure and coarse nozzles produce large droplets. The drift potential is lower but coverage is not as good.

Ideal spray droplet size depends upon the type of pesticide being applied. Contact pesticides usually require smaller droplet size to be most effective. Larger droplet size may be more effective for systemic pesticides.

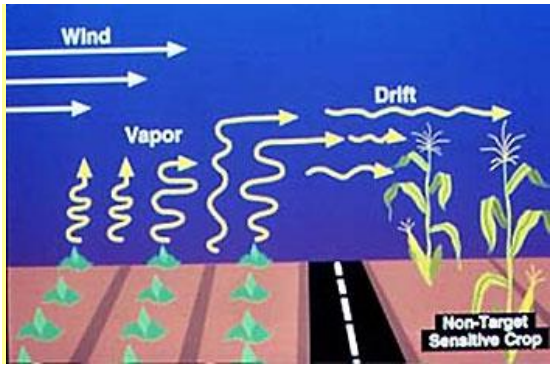
Spray nozzles produce droplets of many sizes. The average droplet size from a specific nozzle is its **volume mean diameter (VMD)**. The unit is a micron (1/25,400 inch). If a nozzle output has a VMD of 300 (droplets of very fine rain) microns, 50% of the spray volume is in droplets that are less than 300 microns and 50% are above 300 microns.

Temperature and humidity affect evaporation of spray droplets. High temperature and low humidity results in faster evaporation, droplets get smaller. The smaller droplets are moved farther by winds.

Vapor Drift

Vapor drift occurs when a pesticide evaporates and moves in the air as a gas. This is most likely to occur when the temperature is above 85° F.

Vapor drift can happen for several days after application. The best way to prevent vapor drift is to read, understand, and follow label directions. Avoid using volatile herbicides near or upwind of sensitive crops.



An example vapor drift warning statement would be:

**Avoid application when temperatures may exceed 85° F
during or 24 hours following the application.**

Preventing Pesticide Drift

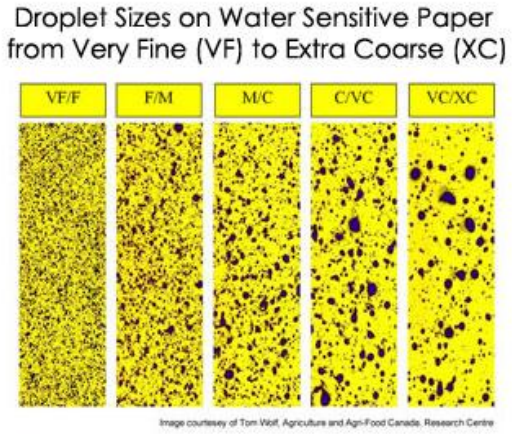
Studies have shown that a sizable percentage of pesticides may never reach the intended target site because of drift. Significant drift can damage or contaminate sensitive crops, poison bees, pose health risks to humans and animals, and/or contaminate nearby soil and water. It is impossible to eliminate drift, but it is possible to reduce it to a tolerable level.

To reduce chances for drift:

- **Spray when the wind speed is between 3 and 10 miles per hour.**
- **Spray downwind from sensitive areas, such as houses, schools, sensitive crops, waterways, or beehives.**
- **Use proper nozzles and pressures.**
- **Use drift control additives (if appropriate).**
- **Lower boom height.**
- **Leave an untreated border or buffer area in the downwind target area.**

Droplet Size

A droplet size classification system describes the droplet sizes produced by a nozzle. This standard system classifies nozzles into eight categories (see table below). You can use them to select a nozzle, orifice size, and operating pressure that produces a label recommended droplet size spectrum. Consult the label for the droplet size specifications that may be in place for a particular application.



Standard Spray Droplet Spectrum Categories		
Droplet Category	**Symbol**	**Color Code**
Extra fine	XF	Purple
Very fine	VF	Red
Fine	F	Orange
Medium	M	Yellow
Coarse	C	Blue
Very coarse	VC	Green
Extra coarse	XC	White
Ultra coarse	UC	Black

Other Factors

Drift Control Additives

Drift control additives are a specific type of chemical adjuvant. They must be mixed and applied according to label directions to be effective. Research has shown that some products intended to reduce drift in fact increase drift potential. Although some of these additives dramatically increase droplet size, they may also reduce coverage and lessen the overall effectiveness of the pesticide. **Thoroughly evaluate drift control additives before using them.**

Wind Speed and Direction

Wind speed and direction are the most important environmental factors influencing spray drift. Labels may indicate maximum and minimum wind speeds for application. **Except in the case of temperature inversions (see below), early morning and evening often are the best times to apply pesticides**. Windy conditions are more likely to occur around midday, when the temperature near the ground increases. This causes hot air to rise quickly and mix rapidly with the cooler air above it, favoring drift.

Best Time to Spray

The **best time to spray** is when spray droplets move slowly upward in the absence of windy or inversion conditions. **Low relative humidity and/or high temperatures also can increase the potential for spray drift.** Under these conditions, water evaporates more rapidly, producing smaller spray droplets that drift more easily. Avoid spraying during these times.

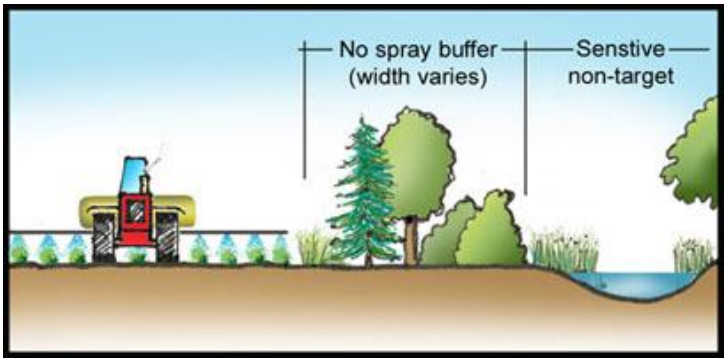
Nozzle Height

Nozzle height above the ground or target affects drift. **The general rule of thumb is 1:1 - the space between nozzles should be the same as the boom height.** Applications that use large droplets released close to the ground often produce little drift. Drift from boom sprayers can be reduced by lowering the boom height. However, lowering the boom can change the coverage pattern significantly.

The higher the boom, the greater the chance for drift.

Pesticide Labels

Pesticide labels may provide more specific instructions to reduce drift. The EPA works with pesticide manufacturers through the registration and registration review programs to provide more detailed information about factors that significantly affect spray drift.



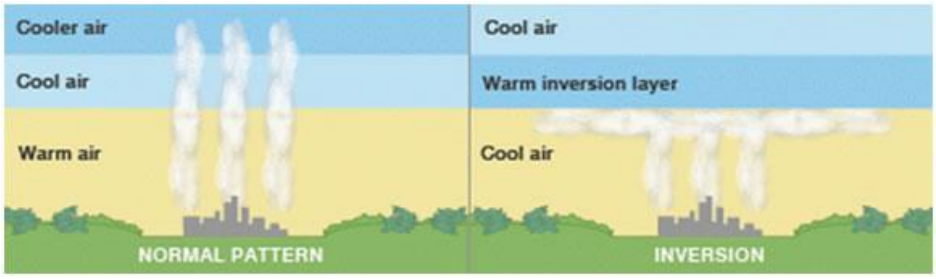
Instructions can include:

- Spray droplet size categories
- Spray release heights
- Minimum and maximum wind speeds
- Buffer zones, if necessary

Wind Speed and Temperature Inversions

Applications made under low-wind conditions can sometimes produce more extensive drift than under high winds. Drift that occurs over long distances (more than a mile) is most often the result of applications made during a **temperature inversion**. This exists when the air at ground level is cooler than the air above it. Under these conditions, the air is considered **stable** because there is little or no vertical air movement.

Almost all air movement during an inversion is sideways. This causes a high concentration of small spray droplets to be suspended in this layer of cool air near the ground. **These droplets can then be carried long distances, especially if wind speeds increase. When the spray droplets settle, they may still be concentrated enough to cause damage or harm.** Inversions may occur at any time of the day and at any height above the ground. However, they **most often develop during the early evening hours** as the ground temperature begins to cool and the warm air has already risen.



Movement of spray droplets or particles during normal and inversion conditions

You can recognize these stable air conditions (inversions) by observing the movement of dust or smoke. If dust or smoke rises little from its source and tends to hang in the air, an inversion may be present or developing. Do not apply pesticides under such conditions.

Whenever possible, choose a pesticide formulated as a low-volatility product. **Do not apply volatile pesticides on hot days. Some products may even volatilize several hours after application so beware if high temperatures are predicted for later in the day.** Many labels advise against applying these products when temperatures are at or above 85°F. Remember to check label precautions for product-specific concerns about vapor drift.

Drift Reduction Technique	Explanation
Follow drift reduction instructions on the product label	**Read the label and reference guide to learn proper nozzle and pressure combinations.**
Select a nozzle to increas droplet size	**Use the largest droplets that provide necessary coverage.**
Look at new technologies	**Air-induction and venturi nozzles may help reduce drift.**
Lower sprayer height if possible	**The higher the nozzle above the target, the greater the potential for drift.**
Use appropriate travel speed	**High travel speeds may result in a bouncing boom.**
Be aware of wind speed and direction and nearby sensitive areas	**More spray volume moves off-target as wind increases or direction changes. Wind currents can drastically affect spray droplet deposition.**

Use buffer zones/no-spray zones near sensitive areas	**Leave a buffer/no-spray zone if sensitive areas are downwind.**
Do not spray during a temperature inversion	**Temperature inversions prevent the dissipation of spray particles.**
Use a drift-control additive when needed	**Drift-control additives increase the average droplet size produced by the nozzles but they do not make up for poor spraying practices.**

Applicator Responsibilities

Applicators are legally responsible for any damages resulting from the off-target movement of pesticides. Assess the vulnerability of neighboring properties and those areas downwind of the application site. Evaluate weather conditions for temperature inversions, wind direction, and wind speed before making the all-important decision about whether to spray. You may have to adjust your application equipment to reduce spray drift. **Consider using low-volatile formulations or adding a drift control agent or thickener to help minimize drift.**

A **good drift management program** includes a combination of all drift reducing techniques available for a particular application. Ensure that:

• Pesticides do not move beyond the target site.

• All people and animals are kept out of the treatment area according to label instructions.

Using approved application techniques and adopting new technologies designed to reduce spray drift can improve the performance of spray mixes, benefit the environment, and be more cost-effective. Any one practice used alone may not sufficiently reduce drift. **Use as many drift-reduction techniques as practical when spraying.**

Some **symptoms of phytotoxicity from herbicide drift**:



- Death of seedlings
- Death of rapidly growing succulent tissues
- Stunting or delayed plant development
- Misshaped or distorted plants, fruits, or leaves
- Dead spots or flecks on leaves
- Dead leaf tips or leaf margins
- Dead areas between the veins of the leaves

Chemical Trespass and Involuntary Exposure

Chemical trespass means that chemicals have moved from the target area onto someone else's property. This creates the potential for involuntary exposure and concern about pesticide residues on a neighboring lawn, garden, or child's or pet's play area. Take steps to avoid drift, such as leaving untreated buffer areas and being aware of wind speed and direction. Take every precaution to avoid drift or accidental overspray.

Pesticide Persistence or Carryover

Pesticides vary greatly in their persistence carryover or persistence in soil. **Carryover can affect rotational crops by causing reduced germination, injury, or illegal residues.**

Carryover injury usually is due to:

1. the pesticide type and rate that was used,
2. sensitivity of the rotational crop, and/or
3. environmental factors that reduce normal pesticide breakdown.

Preventing Carryover Problems

- **Follow label restrictions for rotational crops.**
- **Use the rate recommended for the soil type. Do not use more than is needed for adequate control.**
- **Apply products accurately. Be sure all nozzles are calibrated and operating properly.**
- **Turn the sprayer off at the end of the field to avoid overlaps at end rows.**

Pesticides in the Environment

Applicators and the public are concerned about how pesticides may harm the environment. At first, hazards to humans were the primary reason the EPA decided to classify a pesticide as a restricted-use product. Now, more pesticide labels list environmental effects (such as contamination of groundwater or toxicity to birds or aquatic organisms) as reasons for restriction. To register new pesticides, EPA requires manufacturers to submit extensive environmental tests. The agency also reviews environmental effects when reevaluating existing pesticide registrations.

Pesticides in the Environment

The **environment** includes everything around us, the natural elements, people, the manufactured parts of our world, and the indoor areas in which we live and work. The environment is air, soil, water, plants, animals, houses, restaurants, office buildings, factories, and all that they contain. Anyone who uses a pesticide must consider how it affects the environment.

Applicators must ask:

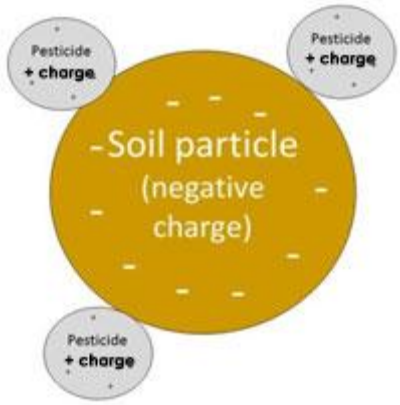
- Where will the pesticide go after it leaves its container or application equipment?
- What effects could it have on those non-target sites it may reach?
- What can I do to minimize harmful effects?

Pesticide Characteristics

You must be aware of certain physical and chemical characteristics of pesticides: solubility, adsorption, persistence, and volatility to know how they move in the environment and interact with it.

Solubility is a measure of the ability of a pesticide to dissolve in a solvent, usually water. Highly soluble pesticides dissolve easily in water. They are more likely to move with surface water in runoff or by leaching down through the soil than less soluble pesticides.

Adsorption measure how well a pesticide sticks to soil particles. It occurs because of the attraction between the chemical and soil particles. Typically, oil-soluble pesticides are more attracted to clay particles and organic matter in soil than water-soluble pesticides. Also, pesticide molecules with a positive (+) charge are tightly adsorbed to negatively (-) charged soil particles. A pesticide that adsorbs to soil particles is less likely to move from the spray site than one that does not adsorb tightly to soil.



Positively charged pesticide particles adsorbed to negatively charged soil particle

Persistence is the ability of a pesticide to remain present and active in its original form for a long time before breaking down. Persistence is described in terms of "half-life": the time needed for 50% of the chemical to break down (degrade). The longer the half-life, the more persistent the pesticide.

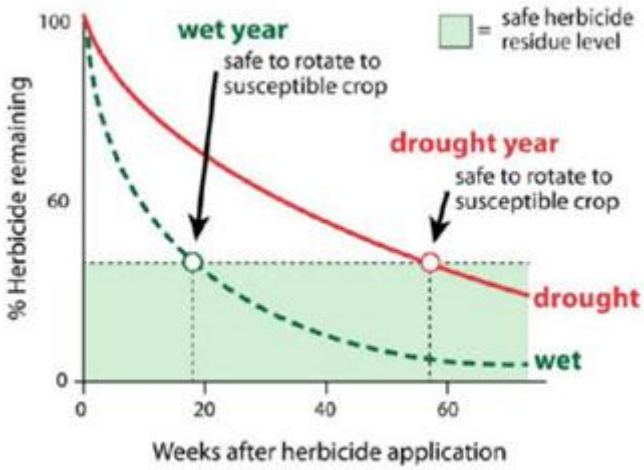


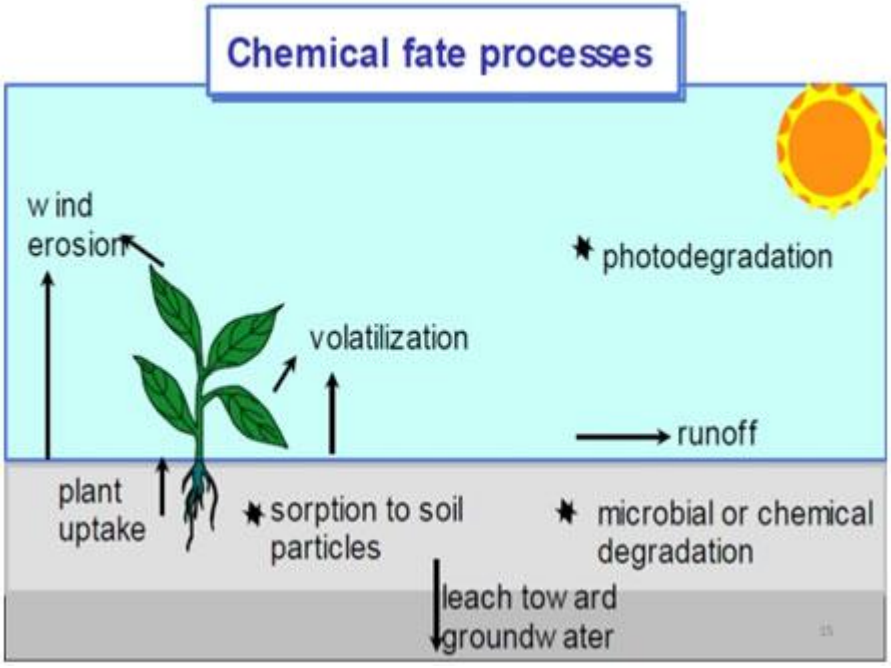
Illustration of effect of soil moisture on herbicide persistence. ***Herbicides can persist much longer in dry soil*** *versus wet soil. (www.striptillfarmer.com)*

Residue is the amount of pesticide that remains in the environment after an application or a spill. A residue is desirable when it provides long-term pest control and reduces the need for repeated applications. However, some persistent pesticides can harm sensitive plants or animals, including humans. Therefore, it is especially important to prevent persistent pesticides from moving offsite through improper handling, application, drift, leaching, or runoff.

Besides being a hazard to persons and non-target animals entering a treated area, the application of persistent pesticides may produce illegal residues on rotational food or feed crops. There are legal limits, called **tolerances**, to protect consumers. **There are limits on the amount of residue that may remain on products sold for food or feed.** Check the label for statements about the persistence of the pesticide and for replanting restrictions. The rate of pesticide breakdown relates to its persistence.

Pesticide Breakdown

Several processes break down pesticide compounds into simpler and often less toxic chemicals. Some pesticides break down very rapidly—in a matter of days or even hours. Others may remain in the environment for a year or more.



Pesticide breakdown processes (slideshare.net)

Pesticides are broken down or degraded by:

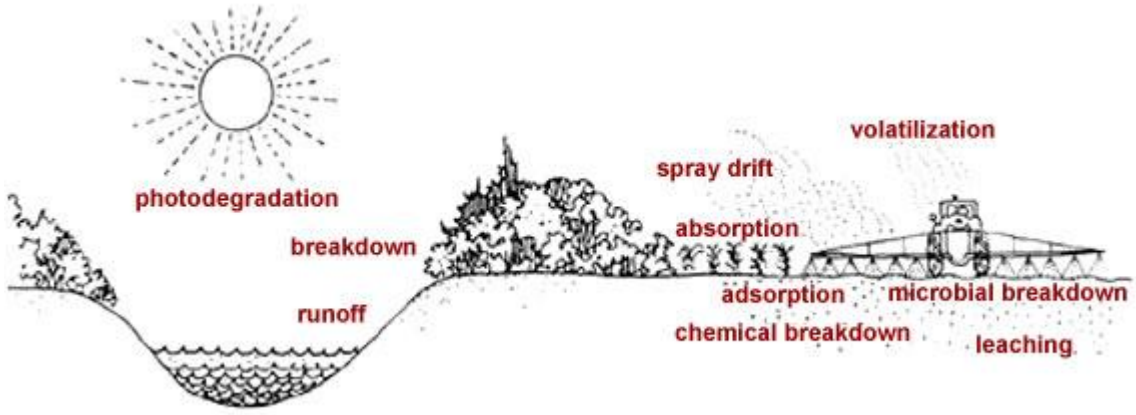
- **Chemical degradation** usually involves a chemical reaction with water; it does not involve living organisms.
- **Microbial action** is the breakdown of chemicals by soil microorganisms, such as fungi or bacteria.
- **Photodegradation** is the breakdown of chemicals in reaction to sunlight.

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

Volatility is the tendency of a pesticide to turn into a gas or vapor. Some are more volatile than others. The chance of volatilization increases as temperatures and wind increase. Also, volatility is more likely under conditions of low relative humidity because evaporation increases in drier conditions.

How Pesticides Move in the Environment

Pesticides may move from the targeted application site in several ways: in air, in water, attached to soil particles, and on or in objects.



Movement in Air

Drift is the movement of a pesticide from the application site by wind or air currents. People who mix, load, and apply pesticides outdoors are usually aware of how easily pesticides may drift offsite. They may travel as spray droplets, vapors, dusts or solid particles, and even on blowing soil particles.

Movement in Water

Most off-site pesticide movement in water is either by **runoff** (surface movement) or by **leaching** (downward movement through the soil).

Runoff and leaching may occur when:

- Too much pesticide is applied or spilled onto a surface.
- Too much rain or irrigation water moves pesticide through the soil offsite or into groundwater.
- Highly water-soluble or persistent pesticides are used.

Runoff water may move pesticides into drainage systems, streams, ponds, or other surface water, where they can travel great distances. Pesticides that leach downward through the soil may reach groundwater. In a greenhouse, pesticides may leach through the soil or other planting medium and contaminate other greenhouse surfaces. Look for special instructions on the label that warn of pesticide hazards caused by the movement of pesticides in water. Sometimes labels require buffers or setbacks from water and wells. *(photo: www.treehugger.com)*

Movement On or In Objects, Plants, or Animals

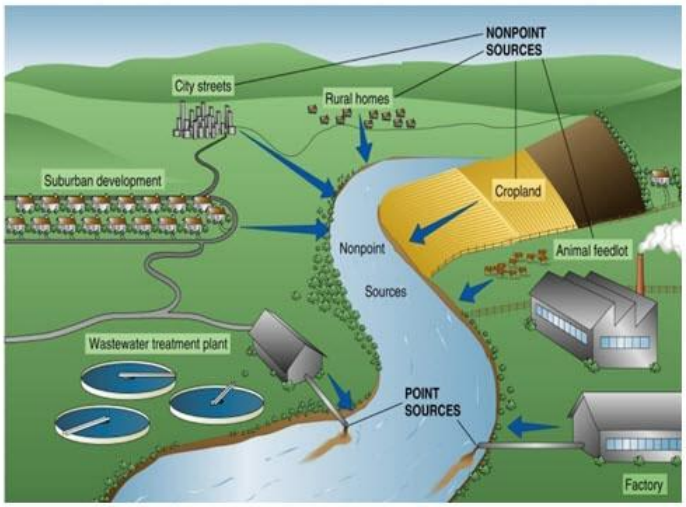
Pesticides also can move from the application site when they are on or in objects or organisms that move offsite. When pesticide handlers bring or wear home contaminated personal protective equipment, work clothing, or other items, pesticide residues may rub off on carpeting, furniture, and laundry items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

Sources of Water Contamination

Surface water or groundwater contamination results from either point-source or nonpoint-source pollution. Nonpoint-source pollution from pesticide applications is usually blamed for pesticide contamination. However, studies show that water contamination may also result from point-source pollution.

Point-source pollution comes from a specific, identifiable location:

- A pesticide spill entering a storm sewer.
- Back-siphoning of pesticides into water supplies.
- Contaminated surface water entering sinkholes.
- Repeated pesticide spills at mixing and loading sites.
- Careless spilling of wash water at equipment cleanup sites.
- Improper handling of spills and leaks at storage sites.
- Improper disposal of containers, rinsate from containers, and excess pesticides.



Potential point source pollution: Do not leave granular herbicides and pesticides where they can enter storm drains.

Nonpoint-source pollution comes from a widespread area. An example is the movement of pesticides into streams or groundwater after broadcast applications to large agricultural fields, rights-of-way, or turf areas.

Pesticide Contamination of Surface Water

Surface water is often a source of drinking water. Therefore, pesticide contamination of surface water (such as ditches, streams, rivers, ponds, and lakes) is a health concern. Pesticides that move in runoff water or with eroded sediment may contaminate plants and animals located downslope and reach sources of surface water.

Factors affecting runoff and erosion rates include slope, vegetative cover, soil characteristics, volume and rate of water moving downslope, temperature, and rainfall amount and intensity. These factors influence how much water runs off and how much moves into the soil (infiltration). In urban areas, runoff may occur on hard surfaces when pesticide granules are left on sidewalks and streets.

Runoff is a potential problem at most application sites. It is critical that runoff does not carry the pesticide into water sources or other vulnerable areas. Generally, runoff risk is greatest when heavy rains immediately follow pesticide applications or when the ground is saturated or frozen. Although surface waters are most likely to be contaminated by runoff, groundwater may also be affected when surface streams connect with shallow groundwater.

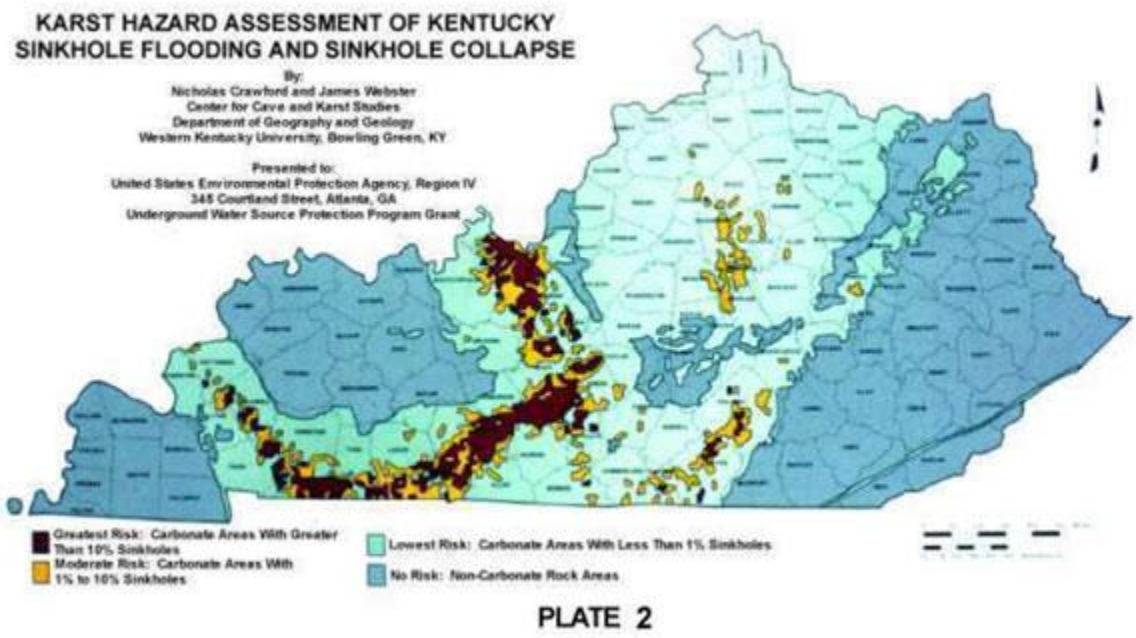
Pesticide Contamination of Groundwater

Nationally, groundwater provides 70% of the water used for public and private water supplies, irrigation, and industry. Like surface water, groundwater must be protected from contamination. **Once groundwater is contaminated, correcting the problem is difficult or even impossible. Groundwater** is found underground in cracks in the bedrock and in the spaces between soil particles, gravel, and rocks. It is the source of water for wells and springs. The layer of soil, sand, gravel, or fractured bedrock in which all available spaces are filled with water is the **saturated zone**. The boundary between the saturated zone and the overlying unsaturated rock and soil is known as the **water table**. The overall geologic formation from which groundwater can be drawn is called an **aquifer**.

Kentucky water statistics

- **Approximately 49 inches of precipitation falls on Kentucky every year. About 40% of this water runs off into streams, 60% evaporates or is transpired by plants.**
- **Kentuckians use more than 4.3 billion gallons of water every day. About 95% of this is from surface water, the rest is from groundwater**
- **More than 1.5 million Kentuckians are served by 185 public water-supply systems that rely on groundwater; 416,000 Kentuckians use water wells or springs**
- **Non-point sources pollute about 3.5 times as many miles of streams as point sources.**
- **Primary nonpoint sources of pollution are: - Mining, 31%- Agriculture, 29% - Land disposal/septic systems, 20% - Urban runoff, 10%**
- **Karst topography refers to areas with sinkholes, springs, caves, and underground streams. Approximately 38% of Kentucky is underlain by limestone exhibiting some karst development, and 25% has well-developed karst features**

Karst is a terrain with distinctive landforms and hydrology created from the dissolution of soluble rocks, principally limestone and dolomite. Karst area (yellow to dark brown on the map below) is characterized by springs, caves, sinkholes, and a unique hydrogeology that results in aquifers that are highly productive but extremely vulnerable to contamination. In the United States, about 40% of the groundwater used for drinking comes from karst aquifers.



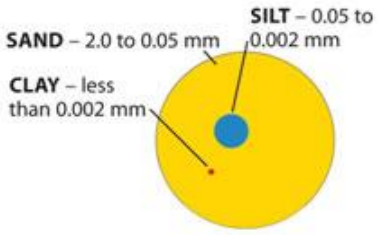
Pesticides can enter groundwater quickly through sinkholes. Follow label directions concerning buffer zones to reduce the chances of contamination.

Some pesticides reach groundwater by moving through the soil in a process called **leaching**. A pesticide that leaches into groundwater must move down through the soil in water and resist binding to soil particles and breaking down into nontoxic compounds. **Pesticides that have high solubility, low adsorption, and/or are persistent are more likely to leach.** They typically have a label statement describing these concerns. A pesticide that adsorbs or binds itself strongly to soil particles will not leach as easily. Besides the characteristics of the pesticide, soil properties and environmental conditions also affect whether and to what extent a pesticide will leach.

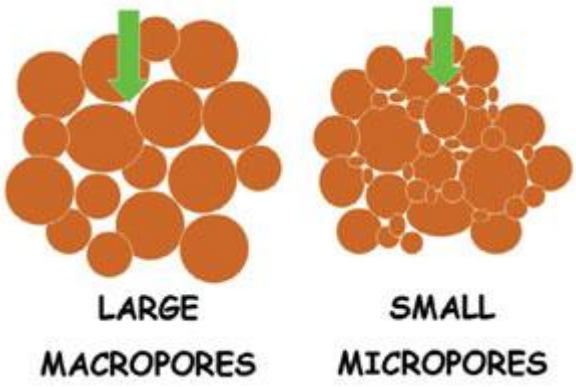
Four soil properties affect a pesticide's potential for leaching:

- texture and structure,
- organic matter,
- depth to groundwater
- geology.

Soil texture is the relative proportions of sand, silt, and clay-sized particles. Percolating water moves faster in sandy soils. Sand also has fewer binding sites available for the adsorption of dissolved chemicals than do clay or silt soils. Though sandy soils are more prone to pesticide movement, leaching may also occur in clay or silt soils. *(Image: soils4teachers.com)*



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



Soil pores (sportsfieldmanagementmagazine.com)

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

Depth to groundwater - **Areas with a shallow water table have a greater chance for groundwater contamination** because less soil is available to act as a filter. There are fewer opportunities for pesticide degradation or adsorption. When using pesticides in areas where the groundwater is close to the surface, choose a product with a low leaching potential. Take extra precautions during mixing, application, and cleanup.

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

Preventing Surface Water and Ground Water Contamination

To help prevent surface water and groundwater contamination, EPA requires all pesticide products labeled for outdoor uses to include the following environmental hazard statement on the label: "***Do not apply directly to water, or to areas where surface water is present, or to intertidal areas below the mean high water mark. Do not contaminate water supplies when cleaning equipment or disposing of equipment wash waters.***"

Pesticides that could contaminate groundwater must bear **groundwater warning statements** on their labels. When such statements appear on product labels, choose pesticides appropriate for use in sandy soils or where extra precautions are needed to reduce the risk of water contamination. You can minimize the risk of point or nonpoint-source contamination by following best management practices (BMPs). BMPs are effective, commonsense procedures that emphasize proper mixing, loading, application, and disposal of pesticides. **Following BMPs reduces the chance that pesticides will harm the environment.**

☑ Use Integrated Pest Management Principles

Apply pesticides only when and where necessary, and only in amounts adequate to control pests. Use nonchemical control methods whenever possible. When using pesticides:

- Determine the type of pest, the density of the pest population, and the proper control method.
- If a pesticide is necessary, choose the least toxic product that will do the job.
- Calibrate pesticide application equipment regularly.
- Use spot treatments or band applications, if possible, to reduce pesticide use.

☑ Identify Vulnerable Areas

The presence of **sandy soil, sinkholes, wells, streams, ponds, and shallow groundwater increases the chance of groundwater contamination**. Never dispose of empty pesticide containers in sinkholes, or dump or rinse sprayers into or near sinkholes. Avoid contaminating drainage ditches and other potential sources of runoff to streams and waterways. Never clean tanks or intentionally discharge water from a tank of any vehicle into a street, along a road, or into a storm drain.

☑ Do Not Mix and Load Near Water

Mix and load as far as possible (at least 50 feet) from wells, lakes, streams, rivers, and storm drains. When possible, do so at the application site. Consider using a sealed permanent or portable mixing and loading pad to prevent seepage into soil.

Photo: duolift.com

☑ Keep Pesticides Away from Wells

Do not store or mix pesticides around wells. Poorly constructed or improperly capped or abandoned wells may allow surface water containing pesticides and other contaminants direct entry into groundwater. Note that wells are sometimes located in or near treated fields and other application sites.

Back-siphoning is the reverse flow of liquids into a fill hose. It sucks tank contents back into the water supply. Back-siphoning starts with a reduction in water pressure and **can draw very large quantities of pesticide directly into the water source**. This happens when the end of the water hose is allowed to extend below the surface of the spray mixture when filling a spray tank.

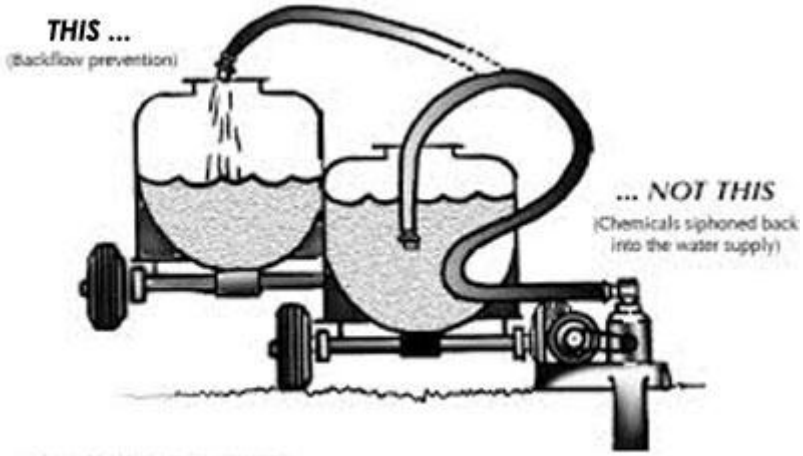


Figure 3: Backflow Prevention
Source: *Protecting Our Groundwater, A Grower's Guide*, USDA Extension Service

The simplest way to prevent backflow is to maintain an air gap between the discharge end of the water supply line and the pesticide solution in the spray tank. An air gap prevents contamination of the hose and keeps pesticides from back-siphoning into the water source if a drop or loss of water pressure occurs. **Keep the air gap at least twice the diameter of the discharge pipe.** Another method to prevent back-siphoning is to use a backflow prevention device or check valve.

☑ Improve Land Use and Application Methods

Terraces and conservation tillage practices can reduce water runoff and soil erosion. Ideally, **growers should leave as much plant residue as possible on the soil surface to lessen erosion.** Where conservation tillage is not possible, decrease runoff potential by incorporating a low concentration of the pesticide into the soil. In ornamental plantings, consider using mulches to reduce water runoff and soil erosion. Grass buffer strips are very effective in reducing pesticide runoff because they trap sediment containing pesticides and slow runoff water. This allows more runoff water to infiltrate the soil. Leaving untreated grass strips next to streams, ponds, and other sensitive areas can trap much of the pesticide running off treated areas.

☑ Time Pesticide Applications According to the Weather Forecast

Pesticides are most susceptible to runoff from heavy rains or irrigation during the first several hours after application. Do not apply to saturated or frozen ground. To avoid over-spraying an area and causing drift, check the pesticide label for application precautions or restrictions during windy conditions. Wind speed, temperature, and humidity all affect the off-target movement of pesticides. *(Photo: indianapublicmedia.com)*

☑ Select Products Wisely

Whenever possible, use pesticides that are less likely to leach. Read labels for such warnings.

☑ Handle Pesticides Safely

Follow these guidelines to prevent surface water or groundwater contamination:

- **Immediately contain and control pesticide spills.**
- **Check application equipment regularly for leaks or damage.**
- **Mix and load pesticides away from water sources.**
- **After the pesticide application is complete, follow label directions for proper equipment cleanup and container disposal.**
- **After applying granular pesticides, sweep or blow any granules from sidewalks, driveways, or patios onto the treatment area.**

Whenever possible, clean sprayers at the application site at a safe distance from wells, ponds, streams, and storm drains. Spray the rinsate on the treated area or on another site listed on the pesticide label, or use in the next tank mix. Be sure not to exceed label rates.

Preventing Harmful Effects on Sensitive Areas and Non-target Organisms

Be aware of sensitive areas, non-target plants and animals (especially endangered species), and damaging effects on habitat. In addition to water sources, sensitive areas include sites where living things could easily be injured by a pesticide.

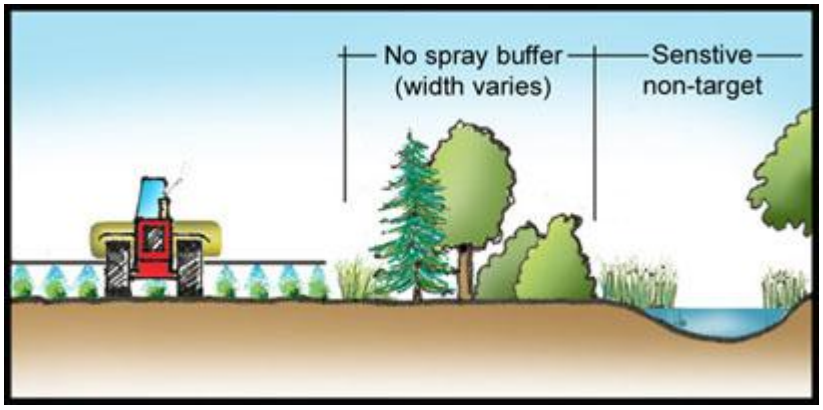
Kentucky bee yard (honeybeesuite.com)

Outdoor sensitive areas include:

- School grounds, playgrounds, and recreational areas.
- Habitats of endangered species.
- Apiaries (honey bee sites), wildlife refuges, and parks.
- Areas where domestic animals and livestock are kept.
- Ornamental plantings, public gardens, and sensitive food or feed crops.
- Indoor areas where ornamental or other sensitive plants are grown or maintained (such as in malls and buildings).

Sometimes pesticides must be deliberately applied to a sensitive area to control a regulated pest (such as mosquito abatement or gypsy moth forest treatments). Only well-trained applicators should perform these applications. At other times, the sensitive area may be part of a larger target site. Whenever possible, take special precautions to avoid treating the sensitive area.

Leaving an untreated buffer zone around a sensitive area is a practical way to avoid contaminating it. In still other instances, the sensitive area may be near a site used for mixing and loading, storage, disposal, or equipment washing. Be very careful to avoid contaminating the sensitive area. Check the label for statements that alert you to special restrictions around sensitive areas. *(Image: nac.unl.edu)*



Pesticide Effects on Non-target Organisms

Pesticides may affect non-target organisms directly, causing **immediate injury**. Or they may produce **long-term consequences** through environmental pollution. Pesticides may build up in the bodies of animals or in the soil. For example, if you use the same mixing and loading site or equipment cleaning site over a long period, pesticides are likely to accumulate in the soil. When this occurs, plants and animals that come into contact with the soil may be harmed.

Non-target Plants

Nearly all pesticides can cause plant injury (**phytotoxicity**) due to chemical exposure, particularly if applied at too high a rate, at the wrong time, or under unfavorable environmental conditions. Phytotoxicity can occur on any part of a plant—roots, stems, leaves, flowers, or fruits.

Growth regulator type injury (ncsupdicblog.blogspot.com) (left) and Glyphosate injury (ncsupdicblog.blogspot.com)(right)

Some symptoms of phytotoxicity:

- Death of seedlings
- Death of rapidly growing succulent tissues
- Stunting or delayed plant development
- Misshaped or distorted plants, fruits, or leaves. Dead spots or flecks on leaves.
- Dead leaf tips or leaf margins.
- Dead areas between the veins of the leaves

Although damage to crops or other nearby plants is primarily caused by drift, it may sometimes be a consequence of surface runoff and root uptake.

Bees and Other Beneficial Insects

Besides making honey and beeswax, bees pollinate many fruit, nut, seed, vegetable, and field crops. You must be aware of bee activity when planning pesticide applications. There has been increasing concern about the decline of bee colonies and the role pesticides may play. Preventing bee loss is the joint responsibility of the applicator, the grower, and the beekeeper.

Honey bees may travel as far as 3 miles from their hive to find blooming flowers. Before applying pesticides labeled as toxic to bees, notify beekeepers in the area so they can protect or move their bee colonies. *(Photo: flicker.com)*

Bees and other insect pollinators may be exposed to pesticides through different routes, including:

1. **Direct contact** during foliar applications.
2. Contact with **residues** on plant surfaces after applications.
3. **Drift** from the application into the hive entrance.
4. **Ingestion of residues** in nectar, pollen, or guttation water (dew) when the pesticide is applied as a seed treatment, soil or tree injection, or foliar application.

Insecticides are generally toxic to bees, but some are more hazardous than others. Herbicides are unlikely to harm bees directly. Fungicides do not appear to affect adult bees but may affect larval development. Tank mixing insecticides and fungicides may create a mixture that is more toxic to bees than either product used alone.

Minimize bee kills from insecticide poisoning by following a few basic principles:

- **Pay careful attention to pesticide labels. For each application site, look for the bee hazard icon in the "Directions for Use" section for specific use restrictions and instructions to protect bees and other pollinators.**
- **Do not apply insecticides to crops in bloom.**
- **Apply insecticides in the evening or at night when bees are not foraging. (Early morning application may protect honey bees, but wild bees forage at or before dawn.)**
- **Do not apply insecticides when weeds or other plants around the treatment site are in bloom.**
- **Do not allow the pesticide to drift onto attractive habitat, natural areas, or beehives.**
- **Choose the least hazardous insecticide, formulation, and application method.**

Pollinator protective warning label (goodnewsnetwork.com)

Pesticides can harm other beneficial insects in addition to bees. These beneficials may be valuable allies in keeping pest populations below damaging levels. **A pesticide application often harms the beneficial insect population as much or more than the target pest. So do not spray when beneficial insects are in the target area unless it is unavoidable. Alternatively, choose a product that does not harm beneficials.**

Fish, Wildlife, and Livestock

Pesticides can harm all kinds of animals. **Most injuries occur from the direct effects of acute poisoning.** Fish kills often result from water pollution by a pesticide. Insecticides are the most likely cause, especially when small ponds or streams are under conditions of low water flow or volume.

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

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

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

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

Protecting Endangered Species

Certain plants and animals have been identified as endangered or threatened species. Be very careful not to harm these populations. Because all living things are part of a complex, delicately balanced network, removing a single species may set off a chain reaction that affects many other species. The full significance of extinction is not always readily apparent, and the long-term effects are often difficult to predict.

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

Each state is responsible for implementing the federal **Endangered Species Protection Program** in cooperation with EPA to protect endangered and threatened species from the harmful effects of pesticides. Under this program, pesticide products that might harm an endangered species carry a label statement instructing applicators to consult a county bulletin to determine if they must take any special precautionary measures when using the product. EPA develops these bulletins, which identify precautionary measures required in each county where one or more pesticides could affect an endangered or threatened species. **Precautionary measures may include buffer strips, reduced application rates, and timing restrictions. Or an applicator might be prohibited from using the pesticide within the identified habitat altogether.** Check with your state, tribe, or territory department of agriculture; local Extension Service; or the EPA website to find out the status of available county bulletins.

Summary

An important part of using pesticides legally and responsibly is considering where the pesticide may end up once it leaves the container and whether it might harm or damage non-target sites, plants, or animals. By applying pesticides at the right time, in the right place, and with the proper application technique, you can greatly reduce—or even prevent—drift, runoff, and leaching.

Pesticides that enter groundwater and surface water are hazardous to aquatic organisms, plants, and wildlife. Therefore, you should implement best management practices to prevent runoff and leaching of pesticides. Sensitive areas include places such as schools, playgrounds, endangered species' habitats, and ornamental plantings. Non-target organisms include plants, bees and other beneficial insects, fish, wildlife, and livestock.

Because of the greater risk of injury to people, plants, and animals, you must know when and how to properly apply pesticides in or near such areas. Always check the label for statements on endangered and threatened species. You may need to consult a county bulletin that details the procedures for protecting them. **It is your responsibility not only to follow label directions but also to use the best management practices that present the least risk to the environment while achieving effective pest control.**

Transporting and Storing Pesticides Safely

Transporting Pesticides

Every pesticide applicator should understand the hazards of transporting pesticides and the procedures for minimizing those risks.

Pesticides are moved by manufacturers to distributors, from retailers to end users, and from storage sites to job sites. Transportation-related accidents can happen at any point along the way. The first line of defense is recognizing how to prevent these transportation mishaps. When accidents occur, the timing of your response could determine the size of the spill.

The Transportation Vehicle

Transport vehicles **should be in good mechanical condition.** Make sure brakes, tires, and steering work properly. Repair all fluid leaks before putting a truck on the road or leaving the job site. Regularly inspect application equipment to be transported and used. Inspect hoses under pressure for wear and cracks and hose clamps for rust. Always carry supplies and replacement parts to make emergency repairs if a leak should develop while going to and from the job site.

Never carry liquid pesticides in the passenger area because spilled chemicals may cause harmful fumes that can be inhaled. A pesticide spilled in the cab is difficult to remove and may lead to long-term inhalation exposure.

Keep pesticide containers in the original shipping box. Depending on the material, many of these boxes meet the U.S. Department of Transportation (DOT) packaging standards to give added protection to the contents. Try to carry a minimum amount of pesticide products on a vehicle at any one time.

Secure and protect pesticide containers against punctures and impacts from items packed closely together. Enclosed cargo boxes provide extra security from curious children, thieves, or vandals. Never stack pesticide containers higher than the sides of the vehicle. Make sure flatbed trucks have tie-down rings or racks to simplify the job of securing the load.

The Vehicle Operator

The driver or owner of the company is accountable for injuries to people and any pesticide release into the environment. The vehicle operator (driver) is the first person who can contain a spill and prevent it from spreading. By the time first responders arrive on the scene, the spill may already be contained. Therefore, it is important that the driver know basic emergency response procedures to contain the spill, company guidelines, and who will notify local, state, and federal authorities. A later chapter, Emergency or Incident Response, explains in detail how to respond to a fire, spill, or leak involving pesticides.

Some drivers transporting pesticides regulated as hazardous materials will be required to follow DOT regulations regarding commercial driver licenses, placarding, shipping papers, and annual inspections.

Other Safety Precautions

Always carry product labels and Safety Data Sheets (SDSs) when transporting pesticides on highways. The SDS contains critical information for the driver and emergency responders after a pesticide spill. It lists steps to safely deal with the spill, including the personal protective equipment (PPE) to use, whether the spill carries an inhalation or explosion risk, decontamination procedures, and emergency telephone numbers. Have the labels and SDSs well organized and alphabetically arranged by product name to allow quick access in the event of a spill.

Always carry a spill kit with the items you will need to handle a spill during transport. (The contents of a spill kit are discussed later.) Inspect containers to ensure they have legible and attached labels, tight closures, and pesticide-free outside surfaces. Secure application equipment (such as hand sprayers, backpack sprayers, and spreaders) during transport.

Protect pesticides from extreme temperature and moisture during transit. Depending on the pesticide, either extremely low or extremely high temperatures can alter the stability of certain pesticide formulations.

Vehicle Placards

DOT requires diamond-shaped signs called placards to be placed on vehicles that transport certain types and quantities of hazardous materials. Most distributors will give you any required placards to place on your transportation vehicle. Placards provide emergency responders with the information necessary to quickly assess an accident situation.

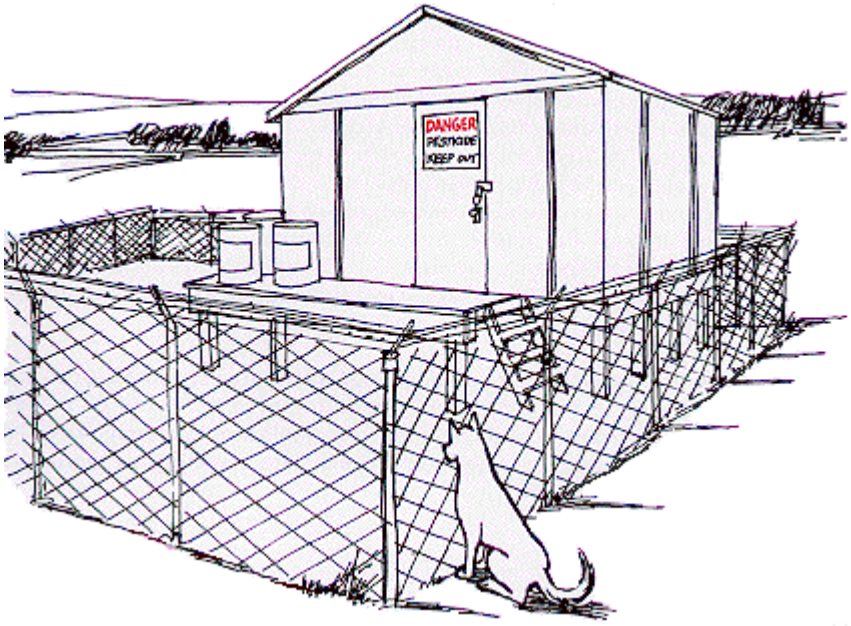
If you ship or transport materials in quantities that require placards, you must develop and implement a transportation security plan.

Vehicles must be placarded when transporting pesticides:

- Bearing a DOT poison label.
- In containers larger than 119 gallons.
- In quantities greater than 1,000 pounds.

The security plan must include measures to prevent unauthorized access, a security check of employees who pick up and transport placarded hazardous materials, and the intended route of travel. For further details on the transportation security plan, contact the Hazardous Materials Information Center.

Storage of Pesticides in Buildings



Although existing buildings are often used for pesticide storage, it is **best to have a separate storage facility for pesticides, fertilizers and other similar products.** Storing pesticides separately gives emergency response crews more options in dealing with fires and spills. Keeping equipment, employees, and records away from pesticides is always recommended where possible.

A well-designed pesticide storage site:

- **Limits access.**
- **Permits better inventory control.**
- **Protects people from exposure.**
- **Reduces the chance of environmental contamination.**
- **Prevents damage to pesticides from temperature extremes and excess moisture.**
- **Safeguards pesticides from theft, vandalism, and unauthorized use.**
- **Allows fire departments to know the location of products.**

Secure the Site

Whether the designated storage area is a cabinet, an entire room, or a separate building, keep it locked when not in use. Post warning signs on doors and windows to alert others that pesticides are stored inside.

Prevent Water Damage

Pesticide storage facilities should not be located in a flood zone. **Carefully consider soil and land surface characteristics when selecting a storage site to prevent contamination of surface water or groundwater**. Do not locate the storage facility near a stream likely to flood or where runoff water flows toward the facility. If flooding is likely, consider building dikes around the storage facility. Work with local zoning and building code professionals to determine how best to protect the environment if high water were to enter the storage facility.

Consider storing pesticides on a raised pallet or on shelves to prevent high water from damaging pesticide containers or flowing water from moving them offsite. Water or excess moisture may damage pesticide containers and their contents and cause:

- Metal containers to rust.
- Paper and cardboard containers to split or crumble.
- Pesticide labeling to peel, smear, or otherwise become unreadable.
- Dry pesticides to clump, degrade, or dissolve.
- Slow-release products to release their ingredients.

Control the Temperature

Choose a well-ventilated room where temperatures are controlled. Exhaust fans directed to the outside of the building reduce the buildup of noxious vapors from many of the solvents used in pesticide formulations. Ventilating the pesticide storage room into an adjoining room does little to solve the problem. Pesticide labeling often gives temperature limits for storing a product.

Consider installing an exhaust fan on a timer to automatically turn on at a certain temperature. If the exhaust fan is not on a timer, turn on the fan switch before entering the storage room. Wait a few minutes to allow vapors to clear.

Provide Adequate Lighting

Be sure the pesticide storage facility is well-lighted. Pesticide handlers entering the building must be able to read the product labels and determine whether containers are leaking.

Use Nonporous Materials

Use cement or other impervious materials for flooring to retain the spilled material on the surface. Such surfaces are easy to clean and decontaminate in the event of a release. A floor that slopes into a sump helps collect and contain the spill. Consider using shelving and pallets made of nonabsorbent materials, such as plastic or metal, for the same reasons as impervious floors.

Maintain the Storage Site

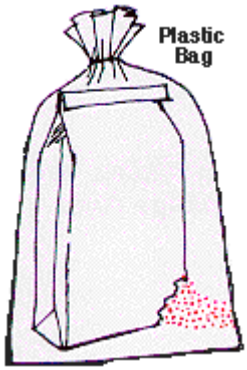
Store only pesticide containers, pesticide equipment, and a spill cleanup kit at the storage site. Keep food, drink, tobacco, feed, medication, medical or veterinary supplies, seed (treated and untreated), clothing, and PPE (other than that necessary for emergency response) out of the storage location.

Keep Labels Legible

Store pesticide containers with the labels in plain sight. Costly errors may result if the wrong pesticide is chosen. **Be sure labels are always legible.** If the label is destroyed or damaged, immediately mark the container with some basic labeling information, such as the trade name, the EPA registration number, signal word, and use classification. Go online to find a product replacement label or get a new label from the manufacturer.

Store Pesticide Containers Safely

Store pesticides in their original containers or, if allowed by state law, in a properly labeled service container. Never use any other container to store a product. Besides being illegal, serious injury may result when using food containers, such as milk jugs or soft drink bottles. Children will associate the shape, size, and color of the container with its usual contents. Never use a pesticide product from an unmarked or unlabeled container unless you are certain what it is. Guessing wrong can cause serious damage at the application site.



Keep pesticide containers securely closed when not in use. Dry pesticide formulations can clump together under high humidity. Consider placing partially used bags of wettable and soluble powders, dry flowables, dusts, and granules in a plastic trash bag or tub with a cover to reduce clumping.

Place drums and bags on plastic pallets. Store other pesticides on metal shelving, placing the heaviest containers on lower shelves. Do not allow containers to extend beyond the edge of the shelving—they could be knocked off or torn open.

Place bulk and minibulk tanks on a reinforced concrete pad. **Diking around bulk tanks keeps leaking pesticides inside a contained area**. Make the area inside a dike large enough to contain the volume of liquid in the tank plus at least an additional 10%. Keep valves and pumps as well as transfer hoses within the diked area when not in use. Contact your state pesticide regulatory agency for guidance on what constitutes bulk pesticides and to learn specific rules for building containment structures.

Look for Damage

Regularly inspect pesticide containers to detect problems early. **If you find a damaged container, put on appropriate PPE and place it into a larger container, such as a 5-gallon bucket. Clean up spilled pesticide and place any contaminated materials in the bucket.** If possible, use the pesticide immediately on a site and at a rate allowed by the label or dispose of it according to label directions.

Use the Oldest Product First

Keep an inventory of all pesticides in storage, marking each container or box with the year it was purchased. In this way, you can use the oldest product first. Remember to use it as it was meant to be used: a replacement product may have different label directions and uses. If you have questions about the shelf life of a product, contact the dealer or manufacturer. Avoid storing large quantities of pesticides for long periods. Buy only as much as you need for the season.

Follow these safety tips for best results:

- **Have duplicate copies of pesticide labels and SDSs available in case of an emergency.**
- **Wear appropriate protective clothing when handling pesticide containers.**
- **Label items such as measuring utensils and protective equipment to prevent their use for other purposes.**
- **Have absorbent materials readily available to soak up leaks. Keep a shovel, broom, and heavy-duty plastic bags on hand to remove the contaminated absorbent material.**
- **Check the SDS for materials that will deactivate a contaminated surface. When in doubt, contact the pesticide manufacturer for a recommendation.**
- **Have readily accessible clean water for decontamination, an eyewash station, personal protective equipment, a fire extinguisher rated for chemical fires, first aid equipment, and emergency telephone numbers.**
- **Additionally, keep plenty of soap, water, and paper towels available near the storage facility.**

Isolate Unwanted or Waste Products

Do not accumulate outdated or unwanted pesticide products. Not only will you lose money by not using the product but you may have to pay a disposal service. If you use the product up according to the label, you will avoid both problems.

If the EPA cancels a product registration, it usually either allows the continued use of the product until it has cleared the distribution chain or issues a federal notice prohibiting use after a specific date. If you keep such products after that date, you may have to dispose of them as hazardous waste. Be sure to follow label directions for disposal of any excess or leftover product.

If you are holding pesticides or emptied pesticide containers for disposal or recycling, keep them in a special section of the storage area. The Kentucky Department of Agriculture has a pesticide disposal programs that collects unwanted pesticides from growers and applicators free or at reduced cost.

Pesticide Security

Minimizing risks for the safety of employees, customers, and communities should always be a top priority when it comes to storing pesticides. Every pesticide storage facility should examine its security efforts and plan for worst-case scenarios. Routinely review your security measures to determine whether all risks have been accounted for in the plan. **Without effective security procedures, you may be**

vulnerable to both internal (employee theft) and external (terrorism, theft, and vandalism) threats. This puts both employees and the community at risk.

Benefits of Security Efforts

By developing a strong and workable security plan, managers, employees, and emergency responders can reduce the likelihood of theft or other mishaps. In addition, effective security avoids costly losses. An incident of any magnitude can seriously disrupt operations and result in lawsuits, costly remediation actions, employee fear and uncertainty, and damage to the company's reputation.

A well-planned security program can:

- Safeguard employees and the community.
- Maintain the integrity of operations.
- Reduce insurance costs.
- Prevent theft.
- Reduce vandalism and sabotage.
- Protect confidential business information.
- Improve relationships with local authorities and community leaders

Risk Assessment

The first step in developing a security program is to conduct a **risk assessment**.

Make a list of assets that need protecting, possible threats, and steps that can be taken to protect them. Any place that stores or transports pesticides shares similar assets, which are broadly defined as people, information, and property.

"**People**" includes employees, visitors, customers, contractors, and neighbors.

"**Information**" includes business, proprietary, and employee material deemed confidential.

"**Property**" may include:

- Pesticide storage facilities.
- Vehicles.
- Application equipment.
- Bulk storage tanks.
- Mixing and loading sites.
- All utilities, such as telephone, water, gas, and electric.

Employee Training and Security Awareness

Train employees to be vigilant in detecting security threats. Employees are familiar with what occurs in and around a pesticide storage facility or at the job site. They can provide an early warning when something seems out of place or someone is acting suspiciously. At a minimum, instruct all employees on pesticide inventory control, security of storage facilities and application equipment, and emergency preparedness and response.

Pesticide Security Checklist

 ***Secure buildings, manufacturing facilities, storage areas, and surrounding property***— Prevent the unauthorized entry of persons into pesticide storage areas. Elements of an effective security plan may range from log sheets, identification badges, fencing, lighting, and locks to detection systems, cameras, and trained guards.

 ***Secure pesticide application equipment and vehicles***—Keep unauthorized people away from equipment used for storing, mixing, loading, transferring, transporting, and applying pesticides. Secure and disable equipment in the field to prevent misuse. For example, do not leave keys in the ignition, and lock doors and cabinets. Reclaim keys from employees when they terminate employment.

 ***Protect confidential information***— As safety and security systems become more reliant on computers and other technology, it is important to secure them from hackers and intruders. Such efforts include contingency planning for power disruptions, adherence to password and backup procedures, and other measures to ensure that only authorized personnel have access.

 ***Develop procedures and policies that support security needs***— Recommended practices include effective hiring and labor policies, inventory management, and planning for emergencies. Hiring and labor policies should include employee training, background checks, and workplace violence prevention. Inventory management is necessary to keep track of pesticides stored at the facility. Planning for emergency response is critical. It helps to ensure that managers and employees know how to respond in the unlikely event of pesticide release, bomb threat, or terrorist activity.

 ***Coordinate with authorities in a timely manner***—If you believe a security breach or suspicious activity has occurred, contact local authorities immediately. In addition to alerting the police department, call the local emergency planning commission, fire departments, and other emergency response agencies. The Federal Bureau of Investigation (FBI) cautions that any suspicious activity related to the use, training, or acquisition of pesticides should immediately be reported to management and local authorities.

Steps to Prevent Security Problems

- **Adopt security measures to deter tampering with chemicals, equipment, or the facility itself.**
- **Include local authorities (e.g., police and firefighters) in developing the security plan.**
- **Keep an accurate inventory of all chemicals.**
- **Keep chemical storage areas locked when not in use.**
- **Update your emergency response plan and practice the procedures.**
- **Post telephone numbers of law enforcement and emergency response agencies in a prominent location.**
- **Be cautious of unknown persons who want to pay cash for large quantities of pesticides.**
- **Ask employees to report any unusual incidents or requests.**
- **Restrict access of nonemployees to your pesticide storage facilities.**

Summary

It is essential to establish safety and security practices for moving pesticides on the highways and at storage and job sites. Because spills and accidents are more likely to occur while transporting or applying pesticides, drivers, and pesticide applicators must be trained to respond quickly to a spill.

Pesticide labels and SDSs for the pesticide carried in the vehicle can provide important information in the event of a spill.

Attention to pesticide site security and managing pesticides should be a top priority. Develop security and emergency management plans for every pesticide-handling and storage facility to safeguard employees and the community. Design security plans to reduce the risk of theft, vandalism, and deliberate misuse of pesticides by those wanting to harm others. Train employees in security and emergency response procedures, and to coordinate their efforts with local police, emergency response personnel, and the FBI.

Dealing With Pesticide Emergencies and Spills

Pesticide accidents and emergencies are rare but they do occur. Some can be catastrophic. Pesticide spills or burning storage facilities can contaminate water, soil, and air and endanger the health of the applicator and emergency responders. They also may lead to financial loss due to cleanup, liability claims, and fines assessed by government agencies. Do all that you can to **prevent accidents** and **be prepared** in case of an emergency.

Developing Your Response Plan

A carefully thought-out response plan can help to prevent an emergency from becoming a catastrophe. It also helps to protect employees and communities, to minimize environmental damage, and may reduce liability if an accident happens. Emergencies can take many forms: tornado or high winds, flood, fire, or a highway accident. How you and emergency personnel respond determines whether the problem is handled quickly and safely.

Develop Your Plan:

☑ **Designate an emergency coordinator** to make important decisions during an emergency, including coordinating with local first responders, such as fire, police, and paramedics. This person will make the necessary calls and fill out reports to government agencies.

☑ **Post a list of names and phone numbers in the office, shop, and truck** of response agencies that may require notification.

☑ Prepare a/an:

- **Form or an outline of critical information to give to emergency personnel.** Keep it with the calling list. Be sure to include: the name of the person reporting the incident; the precise location of the incident; and a general description of what happened.
- The **exact name, quantity, and classification of pesticides involved; the extent of injuries (if any) and whether pesticides have entered surface water.**
- **Facility map** that shows a layout of all chemical storage buildings and bulk storage tanks; access roads; main shutoffs for electricity, water, and gas; perimeter fencing or gates; fuel storage tanks; the location of fire alarms, fire extinguishers and other firefighting equipment, and protective clothing; and drainage ditches, wells, and surface flow of water.
- **Area map** that shows your facility in relation to the surrounding area. Provide emergency response agencies with an updated copy of the facility map and area map whenever changes are made.

☑ Keep an **inventory of chemicals stored at the facility**. Let your emergency response plan show peak seasonal storage of pesticides, fertilizers, and fuel. Store copies of pesticide labels and Safety Data Sheets (SDSs) away from the storage area.

☑ **Maintain the emergency equipment and supplies** needed to respond to fires and spills.

☑ **Train all employees how to execute the response plan** each year.

Determine Actions to Take in a Crisis

The backbone of any emergency response plan is a description of the sequence of actions to take in a crisis. **Prepare step-by-step procedures on how to respond to various emergencies**: fires, spills, storms, and transportation accidents, etc. Specify in writing every activity from sounding the alarm to interacting with local emergency response agencies. Once internal emergency procedures have been established, ask your local response agencies if they have anything to add to your plan. Offer them a copy of your plan for their files.

Fires & Pesticides

Pesticide products vary significantly in their flammability. However, any pesticide product involved in a fire is dangerous to responders working at the scene because of smoke and fumes. Even after the fire has been put out, pesticide residue in the debris, soil, and runoff may be dangerous.

Precautions to Reduce Fire Hazards

Chapter 7 discussed where to locate a pesticide storage facility and proper design and components of a secure facility.

Follow these guidelines to help you prepare for—and respond to—a fire in the storage area:

- Store combustible pesticides away from heating sources.
- Install a fire-detection system.
- Train employees to use a fire extinguisher. Prompt action is essential when a fire occurs. Coordinate all details on managing a fire with local emergency response officials.

Take the following actions:

- **Make sure employees evacuating the premises go to a designated rendezvous point to be counted.**
- **Notify the fire department.**
- **Provide emergency response teams with SDSs, labels, the emergency plan, and a site map.**
- **Follow the instructions given by the onsite incident commander.**
- **Establish a security perimeter to discourage onlookers.**
- **Contain contaminated runoff water and leaking pesticide onsite by building berms.**
- **Consult with emergency responders to decide whether to allow the fire to burn out.**
- **Call your insurance agent.**
- **Make all regulatory phone calls required by state and federal agencies.**

Pesticide Spills

A **spill** is an accidental release of any amount of pesticide, small or large. Spills on public highways, such as when a tank on a truck overturns, usually have major consequences. Failure to respond quickly and appropriately to such mishaps could seriously endanger public health and environmental quality.

In the event of any pesticide spill, remember the three C's: **CONTROL the spill, CONTAIN it, and CLEAN it up**.

Control the Spill

Plug a puncture to stop the spill

Act immediately to control the spilled product. **Always put on the appropriate personal protective equipment (PPE) before responding to a spill.** Place small, leaking containers into larger ones. If a larger container (such as a drum) is leaking, try to plug the leak. Then, transfer the contents to another container. Turn off the pump to stop leaks from pressurized systems (such as sprayers). **Never leave the site unattended.**

Contain the Spill

Protect drains and waterways

Do all you can to keep the spill from spreading or getting worse. Prevent the material from entering surface water. Using a shovel, you can quickly berm off an area to keep the spilled pesticide out of drains and waterways. A spill that is contained on the surface is much easier to clean than one that has entered a body of water.

If the spilled pesticide does contaminate a stream, pond, or other waterway, immediately contact the state regulatory agencies responsible for streams and fisheries and for pesticides. **Do not delay notifying the authorities.** They need time to alert downstream users who draw surface water for drinking, prevent accidental poisoning of livestock, evacuate people using the water for recreational purposes (such as swimming and fishing), and avoid contamination of irrigated crops. Call the manufacturer's emergency number on the SDS to find out what steps you or the emergency response coordinator should take to lessen the dangers of water contamination.

Call 911 to report the spill and be ready to respond to the authorities arriving at the scene. Be sure to have the product label and SDS available for emergency responders. After the spill has been contained, follow your emergency plan. In some cases, the applicator will call the emergency responder, who will then call the proper authorities.

Clean up the Spill

Clean up the spill

The last step is to clean up the spilled product**. Sweep up any absorbent materials and other contaminated items and place them in a drum.** If the spill occurred on concrete or asphalt, you will have to neutralize the surface. Follow the instructions on the SDS or contact the manufacturer, whose number is listed on the data sheet.

The state regulatory agency will tell you what to do when the spill occurs on soil. The only effective way to decontaminate soil saturated with a pesticide is to remove the top 2 to 3 inches and replace it with fresh topsoil.

Areas contaminated by application errors or minor spills can sometimes be cleaned by immediately applying activated charcoal to the contaminated surface. The charcoal can adsorb or tie up enough chemical to avoid significant plant injury and long-term contamination. However, applying activated charcoal to areas where large spills have occurred will do little to reduce soil contamination and subsequent plant damage.

Clean the Equipment and Vehicles

Clean any equipment and vehicles that were contaminated either as a result of the original accident or during the clean-up procedure. Before you begin, however, **be sure you are properly clothed and protected** to avoid contact with the chemical. Use ordinary household bleach in water (approximately 30 percent bleach) or an alkaline detergent (dishwasher soap) solution to clean your equipment. **Do not mix bleach and alkaline detergent together as this is a hazardous combination.**

Keep records of your activities and conversations with regulatory authorities, emergency responders, news media, and the public when dealing with a pesticide spill. Photographs help document any related damage as well as steps you have taken to clean up the spilled product.

Prevent Spills

A key to reducing the likelihood of any spill is to **properly maintain your application equipment and transport vehicles.** Leaks and drips from cracked hoses or loose hose clamps clearly indicate problems. Defensive driving techniques and refraining from cellphone use while driving are two important habits that can prevent vehicle accidents that might result in a spill.

Spill Cleanup Kit

Keep a spill cleanup kit in each pesticide transport vehicle and at the site where pesticides are mixed, loaded, and stored. Store your spill kit items in a plastic container and keep them clean and in working order.

Include the following items in a **spill response kit:**

- **Telephone numbers for emergency assistance.**
- **PPE designed for use with pesticides.**
- **Absorbent materials, such as spill pillows, absorbent clay, and cat litter.**
- **A shovel, broom, and dustpan.**
- **Heavy-duty detergent.**

Summary

Prepare for a pesticide emergency. Make sure the plan includes designating an emergency response coordinator, maintaining a list of emergency response agencies, preparing a map of the facility, and keeping a product inventory. **Be sure all employees at the facility are familiar with the emergency response plan and know what to do in a crisis.** Take precautions to reduce the chance of pesticide fires. The best way to manage pesticide spills is to prevent them from happening. It is your responsibility as a pesticide applicator to do everything possible to avoid spills and adhere to a few basic guidelines when handling spills and leaks. Accidents happen. Be prepared so that they will not become catastrophes.

Planning A Pesticide Application

Selecting the Pesticide

When choosing the right pesticide for your particular situation, it is critical to determine whether the pesticide can be used safely under the application conditions. You also need to determine how much product is required for the area you are treating. Before purchasing or applying the pesticide, read the label to determine:

- Safety measures to follow.
- Where you can legally use it (i.e., target sites).
- When to apply it (considering factors such as the life cycle of the pest, weather conditions, pre-harvest and/or grazing interval, and the rotational or replanting interval).
- How to apply it (e.g., selecting and setting up equipment; following label directions).
- If there are any special use restrictions (e.g., restricted entry intervals or prohibitions against certain types of application methods or equipment).
- Whether there are other restrictions (e.g., environmental conditions, setbacks or buffers, and drift warnings).

Reviewing the Pesticide Label

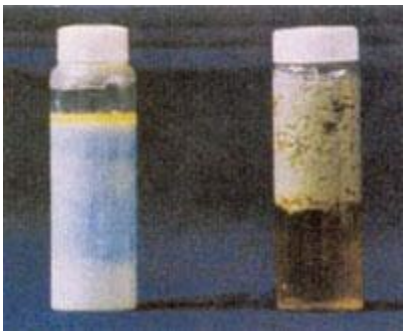
Review the label carefully and to apply the pesticide as directed. The "**Directions for Use**" section lists the various crops, animals, or sites on which you may legally use the pesticide. It also lists the target pests, application rates, spray quality (droplet size) specifications, and general application methods.Also check for instructions on sprayer cleanout, proper storage and disposal of empty containers.

Determining Pesticide Compatibility

Tank mixing two or more pesticides can save time and labor. However, it can reduce the effectiveness of one or more of the products. Determine the compatibility of your products before mixing them.

Pesticides are **compatible** when they can be mixed and applied without reducing the effectiveness or changing the physical and chemical properties of the mixture. Problems develop when two or more incompatible products are mixed together.

Physical Incompatibility



Physical incompatibility is the failure of pesticide products to stay uniformly mixed in the spray tank. It may result in the formation of a putty or paste, a separation into layers, or a mixture that looks like cottage cheese (precipitates). The mixture may clog screens and nozzles and will not control target pests.

Physical incompatibility may be caused by:

- Improper mixing procedures.
- Inadequate agitation.
- Lack of stable emulsifiers in some emulsifiable concentrates.
- Mixing with liquid fertilizers.
- Mixing pesticides with hard water (a pH greater than 7).

Chemical Incompatibility

Chemical incompatibility occurs when mixing certain pesticides in the spray tank alters the activity of one or more of them. In other words, a chemical reaction takes place and produces new substances. Clues indicating chemical incompatibility may include heat, a color change, the formation of a gas or a precipitate, the appearance of surface scum or foam, or the formation of gel or "sludge." The resulting mixture is different from the products applied separately.

There are two types of chemical incompatibility. **Antagonism** occurs when the pest control activity of at least one of the components in a tank mix is reduced when two or more products are mixed.

Synergism occurs when the activity of two or more products applied together is greater than if each pesticide were applied separately. The increased effectiveness may damage desirable plants. Some product labels list pesticides (and other chemicals) known to be compatible with that formulation. Many have very helpful tank-mixing instructions. If you cannot find information about tank mixing on one or more products you wish to combine, do a "jar test" with a small amount of the mixture before you mix a large quantity.

Remember, **it is illegal to mix pesticides with other products (e.g., other pesticides, adjuvants, or carriers) when such mixtures are expressly prohibited on the label**. Also, if a tank mix contains a pesticide that has a higher toxicity level (e.g., DANGER) than the other pesticides (e.g., WARNING or CAUTION), treat the entire mixture according to the more restrictive signal word (e.g., as a DANGER pesticide). You must use the required safety equipment and follow all other label requirements found on the label with the greatest restrictions.

Conducting a Compatibility Test

To conduct a jar (compatibility) test, use a small glass or plastic container. Mix proportionate amounts of all the carrier and products you intend to combine in the spray tank. Start by filling the jar one-fifth to one-half full with the carrier (water or liquid fertilizer). Then add proportionate amounts of each product, one at a time, in the order suggested under "Making Tank Mixes".

Shake the jar thoroughly after each product is added. Allow the mixture to stand for 10 to 15 minutes. If flakes, sludge, gel, precipitates, or other solids form; the products separate into layers; or heat is given off, the products cannot be safely tank mixed. Adding compatibility agents may improve the mixing of the ingredients.

Certain kits can help you test for compatibility. There are also online sources as well as smartphone apps to help you determine the proper mixing order for various tank mix components.

Making Tank Mixes

Follow correct mixing procedures to minimize compatibility problems with tank mixes. Add and thoroughly mix the products, one at a time, beginning with those that are hardest to mix. To ensure thorough mixing of dry formulations before adding them to the mixture, make a pre-slurry—mix the products with a little water to form a paste before adding them to the tank mix. **To be certain you have a uniform spray mixture at all times, keep the mixture agitated during the entire application until the tank is empty.**

Tank Mixing Order

1. **Fill tank one-fifth to one-half full with carrier (e.g., water or liquid fertilizer). Start agitation.**
2. **Add compatibility agent (if needed).**
3. **Add suspension products: first, dry formulations—wettable powders (WP), dry flowables (DF), water-dispersible granules (WDG) (as a preslurry, if necessary), then liquids—flowables (F), liquids (L), microencapsulated (ME).**
4. **Add solution products—solutions (S), soluble powders (SP).**
5. **Add surfactants or other adjuvants (if needed).**
6. **Last, add emulsion products—emulsifiable concentrates (EC).**

Follow Safe Mixing and Loading Practices

People who mix and load concentrated pesticides have an especially high risk of accidental exposure and poisoning. Observe the following precautions to reduce the risks involved with this part of the job.

Locate the pesticide mixing and loading area in a **well-ventilated (if indoors), well-lighted place away from people, animals, food, and other items that might be contaminated.**

Protect water sources by ensuring that no tank mixture can back-siphon into a water source. **Leave a distinct air gap when filling a tank using a water pipe or hose.** Place the pipe or hose end well above the surface of the pesticide mixture between the two. If water is pumped directly from the source into a mix tank, use a check valve, anti-siphoning device, or backflow preventer to prevent back-siphoning if the pump fails. The backflow preventer has a mechanism that automatically closes if a drop or loss of water pressure occurs. Check valves are crucial for chemigation and similar systems where pesticides are injected into irrigation water.

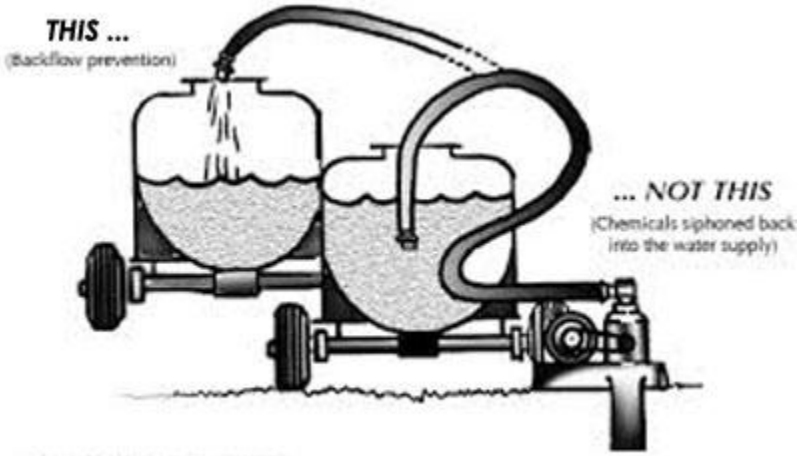


Figure 3: Backflow Prevention
Source: *Protecting Our Groundwater, A Grower's Guide*, USDA Extension Service

Mix pesticides in areas where any spills, leaks, and overflows cannot flow toward a drain or into water sources. If using a permanent mixing and loading site, use a containment pad (see Chapter 11, Pesticide Application Procedures). **When possible, mix and load the pesticides at the application site.** Be careful not to use the same site repeatedly, and do not contaminate any water sources.

Use Personal Protective Equipment

Be sure to wear appropriate personal protective equipment (PPE) when handling pesticide containers, even before opening them. Pesticide handlers must wear all of the PPE that the pesticide labeling requires. This may include:

• **Body protection**—Wear a bib-top apron made of butyl, nitrile, or foil-laminate material in case you get splashed while mixing and loading or come in direct contact with contaminated equipment. The style that includes built-in gloves and sleeves is especially protective.

• **Face protection**—Wear a face shield to keep splashes and dusts off your face, nose, and mouth while pouring liquid pesticides or adding dry pesticides to a liquid.

• **Respiratory protection**—Wear the appropriate respirator when handling pesticides. Choose one with the National Institute for Occupational Safety and Health (NIOSH) code given on the pesticide product label.

• **Eye protection**—Wear shielded safety glasses, goggles, or a face shield to protect your eyes.

Open Containers Carefully

Do not tear open paper or cardboard containers. Use a sharp knife or scissors. This reduces the danger of spilling and makes bags easier to close after use. Clean the knife or scissors afterward, and do not use them for other purposes. To prevent spills, close containers after each use even if you plan to mix more of the same pesticide.

Measure Accurately

Liquids and some granular pesticides are measured by volume; dusts, powders, and most dry formulations are measured by weight. Pesticide labels use the English system of measurement (i.e., fluid ounces, pints, quarts, and gallons for liquids; pounds and ounces for dry materials). Use an assortment of glass or plastic measuring utensils, from 1 cup to 1 gallon, to accurately measure liquids. Some pesticides react with metal—especially aluminum and iron—so **avoid using metal measuring utensils.**Wear proper PPE when mixing and loading.

Use an accurate scale and a set of measuring cups and spoons to measure and weigh dry pesticides. **Mark each pesticide measuring item clearly to avoid using it for other purposes.** To prevent accidental poisonings, paint handles with brightly colored waterproof paint or attach waterproof warning labels. After each use, clean and wash utensils before storing them to prevent contaminating future mixtures. **When you are not using them, keep all measuring and weighing equipment and utensils locked in the pesticide storage area.**

Transfer Pesticides Carefully

After measuring or weighing the correct amount of pesticide, carefully add it to the partially filled spray tank. **When pouring, keep the container and pesticide below face level. If there is a breeze outdoors or strong air current indoors, stand so the pesticide cannot blow back on you.** Rinse the measuring container thoroughly and pour the rinsate into the spray tank. Use caution while rinsing to prevent splashing. Never leave the spray tank unattended while it is being filled. When transferring wettable powders, dusts, or other dry formulations, avoid spillage and inhalation of dusts.

Keep container and pesticide below face level when pouring.

Cleaning and Disposing of Pesticide Containers

Follow the container-handling instructions on the pesticide label. The instructions will tell you how to clean and dispose of an empty container. Not all containers must be triple-rinsed or pressure-rinsed. **If rinsing is required, follow the directions on the label and rinse immediately after emptying the container.** Otherwise, residues may become difficult to remove if allowed to dry. If possible, add the rinsate to the next application.

Do not leave pesticide containers unattended at a mixing, loading, or application site—return them to a secured storage area until they can be recycled or disposed of properly. Clearly mark and safely store them. Follow the label directions on what to do with an empty container. If a pesticide label says it is a "refillable" container, it will have instructions to return the container to the pesticide dealer or manufacturer for refilling. Never tamper with a container designed to be returned and refilled. If it is a "nonrefillable" container, the label will tell you whether you can recycle, recondition, or dispose of the container and the manner of disposal.

Never reuse pesticide containers. Contact the Kentucky Department of Agriculture (http://www.kyagr.com/consumer/pest-and-recycling.html) to locate the nearest pesticide container collection point.

Container Rinsing Procedures

Follow rinsing instructions on the product label.

For small containers 5 gallons or less, triple rinse as follows: Empty the remaining contents into application equipment or a mix tank (drain for 10 seconds after the flow begins to drip). Fill the container one quarter full with water and recap. Shake for 10 seconds. Pour rinsate into application equipment or a mix tank or store rinsate for later use or disposal. Drain for 10 seconds after the flow begins to drip. Repeat this procedure two more times.

For containers too large to shake (i.e., with capacities more than 5 gallons or 50 pounds), triple rinse as follows: Empty the remaining contents into application equipment or a mix tank. Fill the container one-quarter full with water. Replace and tighten closures. Tip container on its side and roll it back and forth, making at least one complete revolution, for 30 seconds. Stand the container on its end and tip it back and forth several times. Turn the container over onto its other end and tip it back and forth several times. Empty the rinsate into application equipment or a mix tank or store rinsate for later use or disposal. Repeat this procedure two more times.

For bags or liners: Completely empty bag or liner by shaking and tapping sides and bottom to loosen clinging particles. Empty residue into application equipment or a mix tank or store for later use or disposal.

To pressure rinse containers: Empty the remaining contents into application equipment or a mix tank (drain for 10 seconds after the flow begins to drip). Hold container upside down over application equipment or a mix tank or collect rinsate for later use or disposal. Insert pressure-rinsing nozzle in the side of the container and rinse at about 40 pounds per square inch for at least 30 seconds. Drain for 10 seconds after the flow begins to drip.

Applying Pesticides Correctly

Applicators have many important responsibilities when applying pesticides: protecting themselves, others, and the environment and applying it correctly. This means using proper PPE and following correct application procedures.

Personal Protective Equipment

By law, applicators must wear the PPE and other clothing the pesticide labeling requires. Consider using additional protection for some types of pesticide application tasks.

Hand-Carried and Backpack Applications

Exposure is quite likely when applying pesticides using hand-held equipment or dust shakers. Dripping or partially clogged nozzles, leaky hoses, and loose equipment connections are other potential sources of exposure. Many applications performed on foot cause the applicator to walk into the path of the pesticide being applied. **Whenever possible, apply pesticides so you are backing out of the treated area.** If you must walk into the path of the pesticide, consider wearing shin-high or knee-high rubber boots (or other protective footwear) with spray-resistant or waterproof pants. **Wear appropriate protective clothing and equipment** when entering treated areas to fix clogged nozzles or other malfunctioning equipment parts.

High-Exposure Applications

Certain types of pesticide applications are especially risky because they may expose the applicator to large amounts of pesticide. These include:

- Mist blower or air-blast sprayers.
- Aerosol and fog generators.
- High-pressure sprayers and power dusters.
- Equipment that directs applications overhead, such as to tree canopies or roof eaves.

Pesticide exposure is likely whenever you are working in these situations. **For high-exposure applications, use appropriate gloves, protective coveralls with a hood, footwear with sealed cuffs, and a full-face respirator or half-face respirator with sealed goggles.**

Pesticides are sometimes applied **in enclosed spaces**, such as warehouses, factories, restaurants, and homes; railcars; ship and truck cargo areas; silos, elevators, and other grain storage areas; and greenhouses. This increases the risk of inhalation and dermal exposure. **Wear an approved respirator and additional protective clothing**, even if you would not need them for the same application outdoors.

Application Procedures

To ensure that pesticides are being applied properly, follow these basic procedures:

☑ Before applying a pesticide, **clear all people and pets from the area. Remove toys and pet dishes from the application area and cover garden furniture, swimming pools, and birdbaths.** Check the pesticide label to find out when it is safe to return to the application area. If the label does not include specific restricted-entry statements, keep people and non-target animals out of the treated area until the spray has dried or the dust has settled.

Be aware of wind speed, direction, and nearby sensitive areas.

☑ **Ensure that the pesticide is reaching the target surface or area.** Be sure to remove pesticide granules from sidewalks and other non-target areas.

☑ **Apply the pesticide evenly and in the correct amount.** Do not allow liquid pesticides to form puddles or dry pesticides to pile up in the application area. Be especially careful in places where you turn or pause your equipment. You may have to shut off your equipment in these areas.

☑ **Ensure that the pesticide maintains a uniform mix or appearance during the application.** Several pesticide formulations mixed with liquid require agitation to remain in suspension. Granules and dusts should appear dry and not form clumps on the target site.

☑ **Check hoses, valves, nozzles, hoppers, and other equipment parts often** during the application.

☑ **Turn spray equipment off when you pause for any reason.** Maintain agitation if the spray mix is a suspension of particles (such as wettable powders, flowables, or dry flowable formulations). Whenever you stop an application, depressurize spray tanks. Turn off the main pressure valve on the tank and release the pressure remaining at the nozzles.

☑ **Check the label for any post-application requirements**, such as soil incorporation.

Professionalism

As a certified pesticide applicator, you do important work and provide valuable services. These services include:

- Producing a safe and plentiful food and fiber supply.
- Protecting public health from vector-borne diseases.
- Creating value for property owners through their landscapes and structures.

- Protecting land and water ecosystems from invasive species.
- Enhancing the public's quality of life through parks and other recreation venues.
- Creating safe roadways and other rights-of-way.

What you do and how well you handle yourself while on the job will leave an impression on others. These expectations of conduct and your actions in specific situations create your professional image, best summed up as "professionalism".

What Is Professionalism?

Merriam-Webster defines professionalism as "the skill, good judgment, and polite behavior that is expected from a person who is trained to do a job well." The heart of professionalism for a pesticide applicator is exercising good judgment when there are no clear-cut right or wrong options. Professionalism includes fair treatment of customers, respect for others, and being an asset to your community.

While regulatory compliance is necessary, you as an applicator or a supervisor will need the expertise and good judgment to make decisions on issues affecting security, safety, health, or the environment not addressed by regulations or the pesticide label.

You should:

- Study this manual to help you gain the basic knowledge needed to educate your customers and others who are concerned about pesticides.
- Educate others about the work you do.
- Know how to minimize risks to yourself, coworkers, the public, and the environment.
- Learn how to communicate the benefits and risks of pesticide use with your customers, coworkers, and the public. The impression you make on others depends on your ability to answer questions from customers, neighbors, and others about the work you do.

Demonstrate Professional Ethical Standards

A professional **demonstrates ethical behavior in all aspects of his or her work**. This means not taking shortcuts that may harm your customers, the public, or the environment. Offer honest and knowledgeable advice, keeping in mind the best interests of others.

Integrated pest management is also part of your professional training because it helps you make sound pest management decisions, apply pesticides only when needed, and protect sensitive sites from harm.

Communicate with Customers, Neighbors, and the Public

Being a professional involves knowing the correct terminology when discussing your work and communicating with others. **When speaking with the public, it is better to use simple, direct language than to use technical jargon.** Be proactive and reach out to neighbors, customers, and others who may have concerns about a nearby sensitive site where you are applying pesticides. Inform others that you are a professionally certified and trained pesticide applicator. Explain what that means because many people will not know. Be familiar with your company or organization policy for talking to customers, neighbors, or the media.

Keep accurate records of all your pesticide applications. Good records provide the facts of what you did and demonstrate your care in the work you do. If there is a complaint or legal action following an application, having good records may be your most valuable defense. Having no or insufficient records makes you vulnerable to baseless accusations and additional scrutiny.

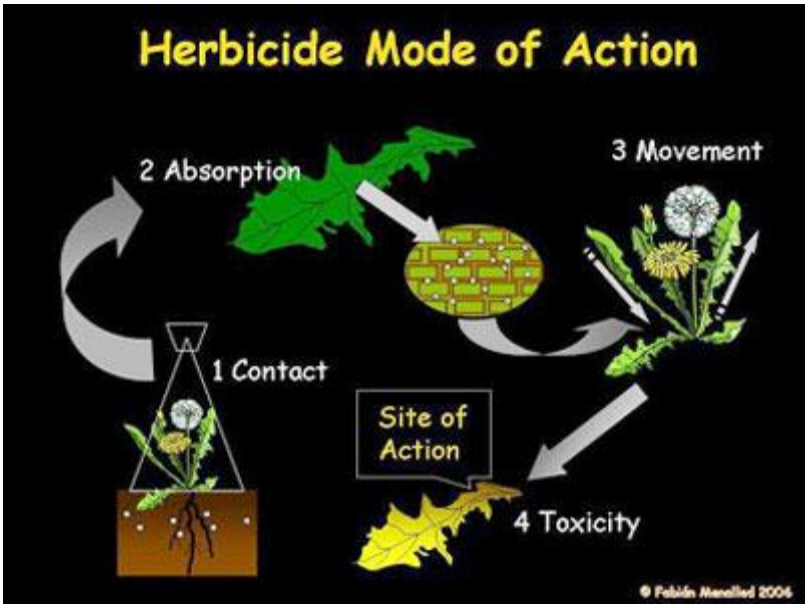
Being an effective pesticide applicator is more than just the skills and knowledge needed to conduct an application. It also requires **good judgment, polite behavior, and a professional demeanor**.

How Pesticides Work

Mode of action describes where and how a particular pesticide acts to affect or kill the target pest. Pesticides with the same mode of action typically produce similar effects or symptoms.

Herbicides

Some weed problems are best controlled with herbicides. This is accomplished through one or a combination of processes: damaging leaf cells and causing them to dry up, altering the uptake of nutrients, interfering with growth and development, or interfering with photosynthesis.



(Image: www.old.wssa.net)

To be effective, herbicides must:

1. adequately contact plants,
2. be absorbed into the plants,
3. be delivered to the site of action in the plant without being deactivated, and
4. accumulate at toxic levels at the site of action.

Herbicide Selectivity

Selectivity refers to whether a herbicide impacts the target plant. A selective herbicide controls or suppresses certain plant species without seriously affecting the growth of plant species. It may be due to plant age and stage of growth, plant morphology, absorption, translocation, deactivation, or environmental conditions. Selective herbicides are used to kill weeds without harming nearby desirable plants.

For example, 2,4-D may be used for selective control of many broadleaf weeds without significant injury to desirable grasses. However, **desirable plants growing under environmental stress may be injured by herbicides that normally do not harm them.**

Plant age and stage of growth

Young, rapidly growing plants are more susceptible to herbicides than are larger, more mature plants. In general, plants in the vegetative and early bud stages are very susceptible to translocated herbicides.

Plant morphology

Plant structure or shape affects herbicide performance. For example, growing points that are covered or those below the soil surface are protected from contact herbicide sprays. Similarly, herbicide spray droplets tend to bounce off or run off narrow, upright leaves as opposed to broad, flat leaves. A thick, waxy cuticle and/or leaf hairs may slow **absorption** or movement of a herbicide into the leaf. Typically, the leaf cuticle becomes thicker with age.

Other factors

In systemic herbicides, differences in **translocation** between the weed and desirable plant may give selectivity.

Deactivation or metabolism - some plants can stop the activity of the herbicide so the plant is tolerant to a particular product.

Nonselective herbicides, such as glyphosate and diquat, control plants regardless of species if applied at an adequate rate. These herbicides are commonly used where plant growth is not wanted, such as fencerows, irrigation and drainage ditch banks, and greenhouse floors and benches.

Application Timing

Herbicides can be grouped when they are applied relative to crop or weed growth stage and/or weed seed germination. They are generally either soil active or foliar active.

Soil-applied herbicides generally affect seed emergence or seedling growth.

Foliar-applied herbicides control weeds through contact with leaves and stems after the plants have emerged from the soil.

Although the majority of herbicides may be classified into one category, a few are considered soil active and foliar active herbicides.

Pre-plant herbicides are applied before seeding. Some must be incorporated into the soil to be effective; these are referred to as **pre-plant incorporated (PPI)** herbicides. Pre-plant herbicides are applied from a few days to several months before crop planting, depending on their soil persistence.

A **pre-emergence herbicide** is applied before weed germination to form a barrier at or just below the soil surface. Most pre-emergence herbicides prevent cell division during weed seed germination as the emerging seedling comes into contact with the herbicide. Some products do not move within the plant so injury symptoms appear only at the site of uptake.

Post-emergence herbicides are applied directly to emerged weeds. This group of herbicides provides little, if any, soil residual control of weeds. They either kill plants on contact or move to a site of action.

Foliar-applied herbicides are effective generally against young weed seedlings. A spray can be applied broadcast over the crop and weeds, used as a basal spray if there is limited crop selectivity, or applied under shields if there is no crop selectivity. Foliar sprays also are used to control emerged weeds present at planting in conservation-tillage systems. They are called "**burndown herbicides**".

Foliar-applied herbicides are referred to as **contact herbicides** when only the treated part of the plant is affected. Thorough spray coverage is required for them to be effective. **Systemic or translocated**

herbicides enter the plant and move to the site of action. They are particularly effective against perennial weeds because the chemical reaches the root system. However, control may take up to 3 weeks or longer.

Herbicide Persistence

After application, herbicides are broken down at different rates by factors such as microorganisms, sunlight, or moisture.

Persistent herbicides, also called residual herbicides, are stable chemicals. They do not change for a long time after application. Persistent herbicides give long-term weed control without repeated applications. However, if sensitive plants are seeded too soon after an application, herbicide carryover may injure them. Check the Rotational Crop Restrictions section of the label for waiting periods to minimize potential problems.

For example:

ROTATIONAL CROPS*
Treated areas may be replanted with any crop specified on an imidacloprid label, or any crop for which a tolerance exists for the active ingredient, as soon as practical following the last application. For crops not listed on an imidacloprid label, or for crops for which no tolerances for the active ingredient have been established, a 12-month plant-back interval must be observed.

IMMEDIATE PLANT-BACK: All crops on this label plus the following crops not on this label: barley, canola, corn (field, pop & sweet), rapeseed, sorghum, and wheat.
30-DAY PLANT-BACK: Cereals (including buckwheat, millet, oats, rice, rye, and triticale), safflower
12-MONTH PLANT-BACK: All Other Crops

***Cover crops for soil building or erosion control may be planted any time, but do not graze or harvest for food or feed.**

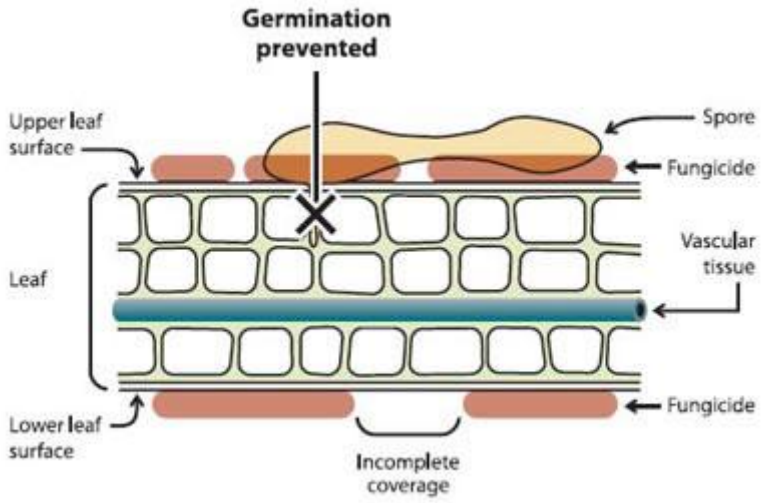
Fungicides

Depending on the target pest, **pesticides used to control plant disease agents are classified as fungicides, bactericides, or nematicides**. Fungicide use appears to be the fastest growing segment of crop protection in the US. When used properly, these chemicals can be important pest management tools. However, they are not a substitute for good crop management practices. Pesticides are the last line of defense for controlling crop diseases.

Classification

Fungicides control diseases caused by fungi. They may be applied to seeds, soil, or foliage. These pesticides may be classified in several ways.

Protectant fungicides are **applied before an infection period begins to protect leaves, fruit, etc. from becoming infected**. They will be effective only on the plant tissue present when the pesticide is applied. Protectant fungicides can stop both spore germination and host penetration but have little or no effect once the fungus has entered or colonized host plant tissue.



Mode of action of protectant fungicide (www.agr.gc.ca)

Protectants must be applied before or during an infection period. Persistent fungicides may protect plants for a relatively long time. Non-persistent fungicides control the pathogen on contact or for a short time so they have to be applied more frequently. The product label tells how long to wait between treatments. The interval varies with the persistence of the pesticide; environmental conditions (humidity, temperature, or rainfall) may make more frequent applications necessary.

Curative or eradicant fungicides have the ability to **inhibit or stop the development of infections that have already started**. With some fungicides, this includes a degree of anti-sporulant activity that helps to slow disease development by limiting the reproductive potential of the fungus. This post-infection activity makes fungicide effective if the disease is established at a low level. It is very important to remember that the curative activity may be limited.

Uni-site fungicides target a specific function of fungal development so they are **very prone to resistance development**. Just one mutation on the target site or any other means of avoiding or countering the effect of the fungicide, can lead to a significant loss of efficacy of the fungicide. Biosynthesis of compounds essential to the development of the fungus, respiration and cellular division are the most common targets of unisite fungicides.

Multi-site fungicides act on several functions of fungal development. They are **less prone to resistance development** because mutations in the fungus must occur at all target sites for resistance to develop.

Broad-spectrum - active against many fungal pathogens.

Narrow-spectrum - effective against only a few types of fungi. The label lists specific diseases controlled by a product.

Systemics - move from the application site to plant parts where disease is occurring. Movement is usually upward toward plant tops and leaf tips.

Locally systemic pesticides enter the plant where they land and move only a short distance. They may act as both a protectant and an eradicant.

Bactericides kill bacteria. These protectants cannot eradicate existing infections so they must be applied before infection occurs.

Nematicides are used to **control diseases caused by nematodes**. They are usually toxic to warm-blooded animals and should only be used with extreme caution. Nematicides may or may not be fumigants.

Factors That Affect Fungicide Performance

1. **Timing** is the most important part of fungicide application. Diseases can develop and spread quickly. Most fungicides cannot cure a disease infection, they can only protect against it. **If an application misses the window, control is lost**.
2. **Water volume** is the **most important application parameter for fungicide application**. In years of study, increasing water volume had a greater effect on fungicide performance than changes in droplet size or spray pressure. More water is needed for fungicides than herbicides because of the greater amount of plant material present. Getting coverage on leaf areas deeper into the canopy requires more water. Although finer sprays can also help with coverage, this practice is riskier due to drift potential and higher evaporation rates.

3. **Double nozzles**, especially the asymmetric types, are becoming more popular for fungicide applications. They have proven **effective for diseases where an exposed vertical part of the plant canopy is the primary spray target**. Double nozzles are also useful for keeping spray droplets from getting too coarse.
4. **Travel speed** is important. Canopy penetration sometimes improves with slower travel speeds; this can be used to advantage by eliminating the need for a special fungicide nozzle.

Insecticides

Insecticides are chemicals used to kill insects and some other arthropods (mites, ticks, spiders, etc.) or to prevent them from causing damage. They are classified based on their structure and mode of action. **Acaricides** are pesticides that are targeted to control mites; they may have little or no activity against insects.

Many insecticides **act at specific sites in the insect's nervous system**. These usually provide very quick knockdown of insects that may ultimately die from dehydration or starvation. The insecticides usually are sprayed on infested plants or surface on which they rest. Depending on the pest, the insecticide may kill by

direct contact with the spray droplets, ingestion of treated foliage, or prolonged contact with the residue on a treated surface.

Some Types of Insecticides

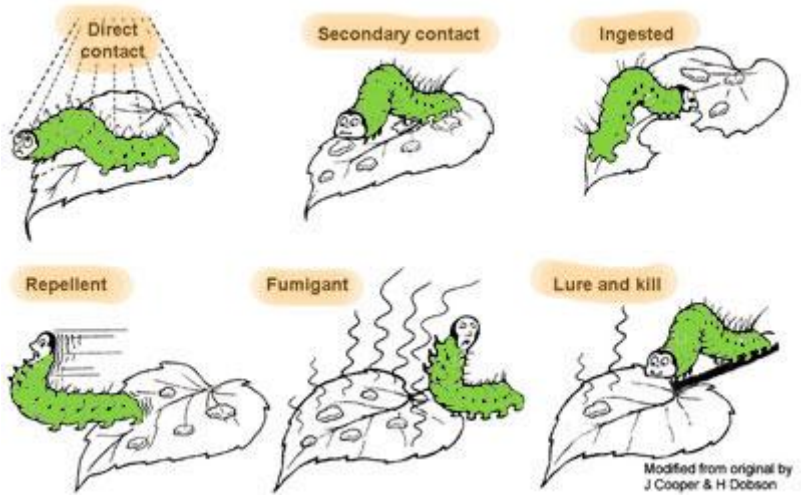
Cholinesterase inhibitors interfere with nerve impulse transmission at the synapse gap. Organophosphate (malathion, diazinon, acephate) and carbamate (carbaryl) insecticides belong to this group. They can be used as contact or residual insecticides. Once widely used for insect control, these insecticides have largely been replaced with other groups.

Bacterial toxins are produced by certain soil microorganisms. Examples include *Bacillus thuringiensis* (Bts) and spinosyns. **Bt toxins disrupt the digestive tract of caterpillars** so they are specific insecticides that must be eaten.

Botanical insecticides are **defensive chemicals extracted from plants** and used for pest control. Pyrethrins are extracted from the flowers of certain Chrysanthemum species. Pyrethroid insecticides are synthetic chemicals based on the molecular structure of the natural insecticide. Nicotine found in some solanaceous plants is the basis for neonictinoid family or insecticides. Both groups work on the nervous system. Azadirachtin is a chemical from the neem tree that has insect and disease control activity.

Insect growth regulators (IGRs) are chemicals based on hormones that regulate arthropod development. They **disrupt metamorphosis** so they are active against immature stages but not adults.

How Insecticides Enter the Target



Ways insecticides can enter pests (www.dropdata.org)

1. **Direct contact** - the target insects are hit directly with spray droplets.
2. **Secondary or indirect contact** by crawling over or resting on treated surfaces. The insecticide is **absorbed through thin portions of the exoskeleton**. These are especially effective against soft-bodied insects such as aphids, some caterpillars, thrips, etc. They are less effective against insects with thick or hard exoskeletons or hard wing covers (beetles), or hairy caterpillars. Insecticides on treated surfaces may enter insects through thin portions of the exoskeleton, especially the flexible areas of the feet.
3. **Ingestion** of spray residues of contact insecticides on plants by pests with chewing mouthparts (beetles, caterpillars) or of systemic insecticides in sap by aphids, leafhoppers, plant bugs, etc.
4. **Repellents** prevent insects from staying on or eating treated surfaces. Chemicals called **anti-feedants** stop insects from eating treated tissue.
5. **Fumigants** are pesticides that become gases when released into the air or soil. Fumigants can be used to control nematodes and pathogens in the soil or insects in wood or stored products.
6. **Pheromones**, chemicals used by insects for communication, can be used in insect control. For example, some female insects release sex pheromones to attract males for mating. Synthetic sex pheromones of some species can be released from dispensers in sufficient amounts to confuse males so they cannot locate females.

Broad spectrum insecticides kill a variety of arthropods, including beneficial and harmful species.

Narrow spectrum or selective products work on a limited, often related group of species. For example, "Bt" insecticides must be eaten in order to kill caterpillars. They are specific stomach poisons.

Factors That Affect Insecticide Performance

Successful control of an insect pest requires proper application, including coverage and timing of the treatment. Some products are effective against specific pests, such as caterpillars. Higher labeled rates are required for specific pests (such as fall armyworms) or pests that are in the later stages of their development (small grasshopper nymphs *vs* the larger adults).

Other Pesticides

Molluscicides are pesticides that are toxic to slugs and snails. They must be eaten so they are formulated as baits that may require specialized application equipment. The two common active ingredients in slug baits are metaldehyde and iron phosphate. **Metaldehyde** prevents slugs from producing the mucus that they need to move and feed. However,**metaldehyde can poison and even kill dogs and other mammals** that might feed on it. **Iron phosphate** is a stomach poison that damages their digestive tissue. Snails may stop feeding on plants after consuming this pesticide but can take up to 7 days to die. Iron phosphate may be more effective than metaldehyde during periods of high humidity or if there are rainy conditions.

Rodenticides, pesticides used to kill rats and mice, are available in three main forms: **poison baits, tracking powders, and fumigants.**

Poison baits are rodenticides that are formulated as food-based toxicants containing seeds or grain to attract the rodents. Many baits are **anticoagulants** that kill by interfering with normal clotting of the rodent's blood. This causes the rodent to die from internal bleeding. The newer anticoagulants are normally lethal to rodents after a single feeding. However, the rodent usually lives for 3 to 5 days before it dies. The older anticoagulants required several feedings and two or more weeks for death to occur.

There are some **non-anticoagulant rodenticide baits**. Most of them kill rodents after a single feeding. Some kill rodents in 2-3 days by causing paralysis. One causes an excess of calcium in the blood which leads to heart failure in 3-4 days. Zinc phosphide kills rodents in 1-24 hours by forming phosphine gas in the circulatory system.

Commercial baits, in pelleted or meal form, are available in sealed plastic, cellophane or paper packets (known as "place" packs), as loose bait, or molded into paraffin (wax) blocks. The wax block formulation is very useful for both outdoor and indoor baiting locations because it resists dampness and moisture.

Regardless of which bait formulation is used, **be sure to place baits in areas that are inaccessible to children, pets, and wildlife** or in tamper-resistant bait stations. Dogs, in particular, will seek out and find baits placed in areas that are accessible. **Other than when placing baits directly into a rodent burrow, it makes good sense to confine baits in an enclosed bait box.**

Bait boxes help to

- reduce accidental contact with people and non-target animals
- keep bait fresh by protecting it from dirt, moisture, and dust
- provide a protected and attractive place for rodents to feed, and
- allow label, company contact number, and other pertinent information to be provided at the baiting site.

Avicides are available to control nuisance birds in some situations. They must be applied according to label instructions to prevent harming non-target species.