Chapter 22

Controlling Pests Safely

Learning Objectives

1. State the importance of using non-chemical methods of controlling pests as a part of an integrated pest management before applying pesticides
2. Explain how natural substances and synthetic chemicals are both pesticides
3. State the types and the functions of pesticides
4. Explain the different pesticide formulations and how they are effectively used
5. Describe how the adjuvants are added to a pesticide formulation to increase its effectiveness or safety
6. Describe how to properly apply pesticides by reading the label and using the proper equipment
Pesticides are one of the many tools in the Master Gardener’s belt for controlling pests. The word “pesticide” can be broken into two parts: “pest” and “cide.” The suffix “-cide” literally means “to kill.” Therefore, the term “pesticide” means “to kill pests.” Generally, pesticides are applied when non-chemical methods fail to provide adequate control or when pest populations begin to cause aesthetic or economic loss. Pesticides are natural or synthetic substances, or mixtures of substances, that are intended to: prevent, destroy, minimize or manage a pest population. The governmental classification of pesticides includes synthetic chemicals used to attract or repel pests and plant growth regulators, defoliants and desiccants.

Currently, natural substances that control pests are not regulated by the EPA and do not have a precautionary warning label. Recently, these pesticides have become popular with gardeners because they are marketed as environmentally safe. However, just because a substance is natural or botanical, it is still a pesticide. Therefore, as a Master Gardener, you should advise its use with caution. Inform clients of the specific guidelines, regulations and even laws regarding pesticides. This will protect you, them and the earth from pesticide misuse.

Using Pesticides
Pesticides should be used to reduce pest population and pest damage to an acceptable level. Pesticides should be used as part of an Integrated Pest Management (IPM) strategy see Chapter 21, IPM. As a Master Gardener, the IPM strategy you advise gardeners to choose will depend on the pest identified and the kind and amount of control needed. To solve pest problems it is necessary to:

- Identify the pest or pests and determine whether control is warranted
- Determine pest control goals(s)
- Know what control tactics are available
- Evaluate the benefits and risks of each tactic or combination of tactics
- Choose a strategy that will be most effective and will cause the least harm to people and the environment
- Use each tactic in the strategy correctly
- Observe local, state and federal regulations that apply to the situation

Pesticide Application and Safe Use
When dealing with pesticides, it is essential to teach gardeners to always follow these guidelines:

- Read the applicable sections of the pesticide labeling before opening a pesticide container or beginning any pesticide handling activity
- When applying pesticides, wear the protective clothing and equipment recommended on the label
- To prevent chemical spillage, check application equipment for leaking hoses or connections and plugged, worn or dripping nozzles before adding pesticide
- Clear all people, pets and livestock from the area before spraying
- To minimize drift, apply pesticides only on days without a breeze. Stop immediately if moderate winds begin while spraying
- Reduce drift by spraying at a low pressure and using a large nozzle opening
- Generally, the safest spray times to reduce drift hazard are early morning or late evening
- Communicate what areas or plants should not be sprayed

Figure 1.
Use a sign to indicate what areas of the landscape or garden should be excluded from pesticide applications.
Applying Pesticides

Spraying
It is important that the sprayed plants be thoroughly covered. To get thorough coverage, plants should be sprayed from two or three directions and from underneath and above. If the label instructions say, “Wet thoroughly or to the drip point,” apply a mist spray until the plant begins to drip. A fine mist spray deposits many fine particles on the foliage, resulting in better coverage and a higher level of control.

Using Pesticides Properly to Prevent Pollution
The proper use of pesticides will reduce the pollution of the environment to a minimum. Pesticides can be carried into the water on soil particles that can erode. Therefore, it is important to take measures to prevent erosion.

Excess spray mixtures of pesticides should not be poured into sewage systems because this can add to stream pollution. Therefore, empty containers should be triple rinsed and then the remaining residue should be mixed into the garden sprayer and applied to plants. The rinsed containers should then be disposed of in a sanitary landfill. In addition, before spraying, wind conditions should be observed. Pesticides should not be sprayed in windy weather because the pesticides may drift.

Tips on Mixing a Garden Spray
1. Read the label carefully
2. Measure the appropriate amount carefully using level teaspoon or tablespoon quantities
3. Mix the pesticide thoroughly in a small volume of water, then bring the liquid up to the desired level
4. Wash all pesticides off the skin immediately

Applying a Garden Spray
1. Adjust the sprayer to deliver a fine mist spray
2. Direct the spray to infested areas of the plant
3. Thoroughly wet plant parts to the point of runoff
4. Apply sprays during periods of favorable weather
   a. 70 to 80 degrees F
   b. Wind less then 5 miles an hour
   c. No rain forecast for 24 hours
5. Repeat application if rainfall exceeds ½ inch within 24 hours of applying
6. Keep the sprayer in good condition
   a. Wash thoroughly after each use
   b. Hang tank upside down with pump assembly removed for complete drying
   c. Do not use the fungicide or insecticide sprayer for spraying weed killers or vice versa
   d. Buy two sprayers and label them
Compatibility

Compatibility occurs when two or more pesticides can be mixed together without reducing their effectiveness or harming the target. For instance, carbaryl (Sevin) is often combined with a miticide, such as Kelthane, in order to kill both insects and mites at one time. Combining multiple, compatible products can lead to synergism. Synergism occurs when the action of two materials, used at the same time and are of the same type, produce a greater effect than the sum of the materials when used alone. For example: Chemical A kills 60 percent, Chemical B kills 20 percent, Chemical A and B together kill 98 percent of the pests. The effects of synergism can be useful because they may increase control of the pest or they may require less chemical to be applied to treat the pest.

Application Rates of Insecticides for Home Gardens

The following rules of thumb for estimating the amount of spray or dust needed to cover the garden are based on linear feet of a row, or the number of square feet.

- One-half gallon will spray 100 feet of a row and 250 square feet
- Four ounces (1/4 pound) of dust will treat 120 feet of a row or 250 square feet

For row applications, if the rows are:

If rows are:

- 12 inches apart, there are 43,560 feet of row per acre
- 24 inches apart, there are 21,780 feet of row per acre
- 36 inches apart, there are 14,520 feet of row per acre
- 48 inches apart, there are 10,890 feet of row per acre

Example: How much spray should be put on 100 feet of row if the nozzles on the spray boom are 24 inches apart and the recommended application rate is 150 gallons per acre?

Calculation: 150 gallons for 21,780 feet = X gallons on 100 feet

X = (150)(100)/21,780 = 0.688 gallons per nozzle per 100 feet. This is slightly less than 2 ½ quarts

See the appendix for more formulas and conversions useful for calculating pesticide rate applications.

Soil Insects

Many garden insect pests live in the soil during one or more stages of their life cycle. These insects are adapted to feeding in, or on, the planted seeds, roots or lower stems of plants. The length of time the individual insect lives in the soil varies from 2 to 3 weeks for some flies, to three years for some wireworm species.

There may be many newly hatched larvae or partially grown, over-wintered larvae with a ravenous appetite at the time of planting. Plants in an infested soil can be severely damaged, or even killed, overnight following transplanting.

To minimize problems caused by soil insects, the plant bed should be inspected thoroughly as the bed is cultivated and soil insecticides should be applied to prevent insect damage to seeds or seedling plants.

Vaporization

Vaporization is the evaporation of an active ingredient during or after application. High temperatures increase vaporization. Because pesticide vapors can cause injury, it is important to reduce vaporization. This can be done by choosing pesticide formulations that do not evaporate easily and by spraying during the cool part of the day.

Some products, like 2,4-D, are very volatile and can move for miles under favorable conditions. Therefore, advise clients to not apply highly volatile compounds when it is windy or when temperatures following application will exceed 85 degrees F.
Unfortunately, the effects of synergism can be undesirable, causing death or damage to non-target organisms. Therefore, as a Master Gardener, you must always stress caution when mixing chemicals together. A good way to do this is to check the label to see if there are any warnings about incompatibility. Keep in mind that labels may mention non-compatible chemicals, but seldom mention specific compatible chemicals. For instance, most insecticides and fungicides for fruits and vegetables can be mixed; however, specific mixes are not spelled out. This knowledge comes with practice or from contacting the manufacturer of the products directly.

Every pesticide has corresponding material safety data sheets (MSDS) that provide handling and working instructions for pesticide applicators and emergency personnel. MSDS also contain specific information regarding the toxicity, health effects, first aid, safety and protective equipment, storage and disposal, and leak and spill procedures.

Cleaning Equipment
Teach gardeners that all spray equipment should be thoroughly cleaned inside and out with clean water immediately after use. In addition, hoses and nozzles should always be flushed after each use. Rinse water should never be dumped in a place where it will collect or puddle and become a pollutant. If possible, the rinse water should be sprayed over a broad area so the pesticide will be further diluted. Never rinse pesticides down the drain!

<table>
<thead>
<tr>
<th>Location</th>
<th>Phone</th>
</tr>
</thead>
<tbody>
<tr>
<td>Human Pesticide Emergency Poison Control Centers:</td>
<td></td>
</tr>
<tr>
<td>Tennessee Poison Center</td>
<td>1-800-222-1222</td>
</tr>
</tbody>
</table>

| General Questions on Pesticides:              |           |
| EPA National Pesticide Telecommunications Network | 1-800-858-7378 |

| Pesticide Emergency                           |           |
| National Pesticide Safety Team Network - Chemtrec | 1-800-424-9300 |

| Animal Pesticide Emergency                    |           |
| National Animal Pesticide Control Center (possible fee charged) | 1-800-548-2423 |

Storage and Disposal
Teach clients to store all pesticides in their original containers in a locked cabinet. Stored pesticides should be protected from temperature extremes, as some can be damaged upon freezing, while others can be altered by heat. When a container is empty, pesticide labels should be read for instructions on disposal. Most pesticides available for use around homes are packaged in containers that can safely be disposed of in trash cans destined for a sanitary landfill; however, before placing the container in the trash can, it should be rinsed three times, rendered unusable and wrapped in newspaper. Finally advise clients to: never use empty pesticide containers for other uses; never use paper containers; and always keep personal clothing, food, drinks, chewing gum, tobacco products and other belongings away from where pesticides are stored or handled.

Safety Precautions
Pesticides are toxic. If used improperly, they can cause severe illness or even death. The primary hazard - the danger that injury will occur to a person - depends on the toxicity of the active ingredient and the type of exposure to the product. Eating or drinking the product causes many accidental pesticide deaths. Some applicators are injured when they breathe pesticide vapors or get a pesticide on their skin. Repeated exposure to even small amounts of some pesticides can cause sudden severe illness. To lesson the chance gardeners are injured by pesticides, teach them the following protective guidelines and tell them to always check individual labels for any additional precautions.

Personal Protective Equipment (PPE)
When spraying pesticides, long-sleeved shirt, long-legged pants and shoes should always be worn. Generally speaking, this attire will suffice for most pesticides sold for home gardens. However, many professionally-used and all highly toxic chemicals require PPE to be worn during application. Additionally, it is necessary to wear unlined neoprene or rubber gloves, a wide-brimmed plastic hard hat that covers the back of the neck and goggles or a face shield to protect the eyes. Rubber gloves and goggles are particularly important when mixing or pour-
ing pesticides. Highly toxic pesticides may also require neoprene boots, chemical cartridge respirators, face masks, a neoprene suit or even a gas mask. These more toxic chemicals should not be used in a home garden setting.

To be safe, it is imperative to teach gardeners to protect themselves not only during mixing, loading and application of a pesticide, but also during spill cleanup, transport, storage and disposal of pesticide containers that are open or have pesticides on their outer surface. After using any pesticide, hands and arms need to be thoroughly washed with soap and water, or a full shower should be taken and clean clothes put on. Clothing worn while applying pesticides should be laundered separately from other items. Finally, teach gardeners to never eat, drink, smoke or use the restroom while handling pesticides.

Safe Use Precautions

One can prevent harm from pesticides if safety precautions are followed and common sense is used. Minimum safety precautions include:

- Identify the pest to be controlled. Find out which pesticide will control the pest. If there is a choice of several, choose the least toxic product.
- Find out if the host plant and pest are listed on the pesticide label
- Check the safety conditions
- Check the restrictions on use
- Determine the equipment needed to apply the product
- Put on the appropriate protective clothing
- Take the necessary environmental precautions
- Acquire the appropriate protective equipment
- Determine if there are any specific warnings and first aid measures
- Determine what it can be mixed with
- Determine how much to use
- Follow the proper mixing instructions
- Apply exactly as instructed

Symptoms of Pesticide Poisoning

Teach gardeners to be aware of the early symptoms and signs of pesticide poisoning. Unfortunately, all pesticide poisoning symptoms are not the same. Each chemical family, (organophosphates, carbamates, chlorinated hydrocarbons, for example, attacks the human body in a different way. Fumigants and solvents can make a person appear to be drunk. The symptoms: are poor coordination, slurring of words, confusion and sleepiness. Common pesticides, like organophosphates and carbamates, injure the nervous system. These symptoms develop in stages, usually occurring in this order:

- **Mild Poisoning or Early Symptoms of Acute Poisoning:** Fatigue, headache, dizziness, blurred vision, excessive sweating and salivation, nausea, vomiting, stomach cramps or diarrhea.
- **Moderate Poisoning or Early Symptoms of Acute Poisoning:** Unable to walk, weakness, chest discomfort, muscle twitches, constriction of pupil of the eye and earlier symptoms become more severe.
• **Severe or Acute Poisoning:** Unconsciousness, severe constriction of eye pupils, muscle twitches, convulsions, secretions from mouth and nose, breathing difficulty. Illness may occur a few hours after exposure and may lead to death if not treated. If symptoms start more than 12 hours after exposure to a pesticide, the individual probably has some other illness. Always check with your physician to be sure.

### First Aid Procedures

If it is necessary to begin first aid for pesticide exposure, teach gardeners to first read the “Statement of Practical Treatment” on each label. These directions can save lives. Below are guidelines to teach your client if they, or someone they are with, are exposed to a pesticide.

- **If a pesticide gets on the skin,** remove the pesticide as quickly as possible and remove all contaminated clothing. Prompt washing may prevent sickness, even in cases of a large spill.

- **Detergents work better than soap in removing pesticides.** Do not forget to wash hair and fingernails.

- **If a pesticide is inhaled,** get fresh air right away and loosen all tight-fitting clothing. If necessary, artificial respiration should be given immediately and not stopped until the normal breathing resumes or medical help arrives.

- **Take the victim to a physician.**

- **No one should administer anything to a poison victim unless trained in first aid;** otherwise, he or she may compound the injury.

- **In case of poisoning, call a physician,** the nearest Tennessee poison control center, the National Pesticide Safety Team Network or 911 (Table 1).

- **Provide the following information to the poison control center:** name, age and sex of victim; identify yourself and your relationship to the victim; identify the pesticide the victim has been exposed to, the type of exposure—inhaled, dermal exposure or ingested, and if known, how much exposure.

### Pesticides in the Environment

Pesticides become problems when they move off target. This may mean drifting off the target, moving with soil particles by erosion, leaching through the soil, being carried out as residues on crops or livestock, or evaporating and moving with air currents. Fine herbicide mists can drift to nearby crops or landscape plants and kill them or the pollinators and natural enemies of the pest. Accidental spraying of ditches and waterways, by run-off from sprayed fields or by careless container disposal, can decimate aquatic life. Therefore, if more than one pesticide will control a pest, teach gardeners to choose the one that has the least effect on other insects, to avoid excessive use of insecticides that are sprayed and to use pesticides only when pest populations require control. Misapplication of pesticides carries serious consequences.

Gardeners should pay special attention to the protection of insect pollinators, such as honeybees, from insecticide poisoning. When applied to crops frequented by honeybees, insecticides highly toxic to bees have restricted application times. Bees are less active in late evening and early morning, so this is the best time to apply pesticides. Do not apply insecticides when temperatures are unusually low because residues will remain toxic much longer.

### Responding to Pesticide Spills

Should an accidental pesticide spill occur, activated charcoal could be used to reduce the available level of most organic pesticide residues in the soil. Activated charcoal is considered ineffective for inorganic pesticides such as arsenates, sulfur, sodium chloride, lead compounds, borax, etc. and water-soluble organic pesticides such as aminotriazole, MSMA and DSMA. Activated charcoal can be applied as a water slurry. If activated charcoal is not available, kitty litter, soil or sorbent pads may be used to absorb the spill.

### Pesticide Classification

Pesticides are commonly classified several ways, including: target organism, mode of action and application timing, usage or method.
### Table 2. Pesticides Classified by the Target Pest

<table>
<thead>
<tr>
<th>Term</th>
<th>Substance and Target Pest</th>
</tr>
</thead>
<tbody>
<tr>
<td>Insecticides</td>
<td>Insects</td>
</tr>
<tr>
<td>Miticides</td>
<td>Mites</td>
</tr>
<tr>
<td>Acaricides</td>
<td>Mites, ticks and spiders</td>
</tr>
<tr>
<td>Nematicides</td>
<td>Nematodes</td>
</tr>
<tr>
<td>Fungicides</td>
<td>Fungi</td>
</tr>
<tr>
<td>Bactericides</td>
<td>Bacteria</td>
</tr>
<tr>
<td>Herbicides</td>
<td>Plants (herbicides kill plants, not just weeds)</td>
</tr>
<tr>
<td>Rodenticides</td>
<td>Rodents</td>
</tr>
<tr>
<td>Avicides</td>
<td>Birds</td>
</tr>
<tr>
<td>Piscicides</td>
<td>Fish</td>
</tr>
<tr>
<td>Molluscidic</td>
<td>Mollusks, such as slugs and snails</td>
</tr>
<tr>
<td>Predacides</td>
<td>Pest animals</td>
</tr>
<tr>
<td>Repellents</td>
<td>Chemical that is used to repel pests</td>
</tr>
<tr>
<td>Attractants</td>
<td>Chemical that is used to lure pests</td>
</tr>
<tr>
<td>Plant growth regulators</td>
<td>Chemical used to stop, speed up or otherwise change normal plant processes</td>
</tr>
<tr>
<td>Desiccants and defoliants</td>
<td>Chemical used to remove or kill leaves and stems</td>
</tr>
<tr>
<td>Antitranspirants or antidesiccants</td>
<td>Chemical used to reduce water loss from plants and to protect plants from winter damage, drought, wind burn and transplant shock</td>
</tr>
</tbody>
</table>

### Table 3. Pesticides Classified by Mode of Action

<table>
<thead>
<tr>
<th>Type of Pesticides</th>
<th>How Pesticides Work</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contact poisons</td>
<td>Kills when the pesticide contacts the target organism</td>
</tr>
<tr>
<td>Stomach poisons</td>
<td>Kills when swallowed</td>
</tr>
<tr>
<td>Systemic poisons</td>
<td>Kills by being taken into the blood of treated animals or tissues of treated plants, which are then fed upon by the pest</td>
</tr>
<tr>
<td>Translocated herbicides</td>
<td>Moves from the point of initial application to circulate throughout the plant; the circulation toxin ensures the kill of the entire plant a</td>
</tr>
<tr>
<td>Fumigants</td>
<td>Kills when inhaled or otherwise absorbed by pests</td>
</tr>
<tr>
<td>Selective pesticides</td>
<td>Kills only certain kinds of plants or animals b</td>
</tr>
<tr>
<td>Non-selective pesticides</td>
<td>Kills most plants or animals. Vinegar (which is 5% acetic acid) will burn plant foliage a</td>
</tr>
<tr>
<td>Broad Spectrum</td>
<td>Kills broad range of pests, usually refers to insecticides, fungicides and bactericides</td>
</tr>
<tr>
<td>Disinfectant (Eradicant)</td>
<td>Effective against a pathogen that has already infected the plants</td>
</tr>
<tr>
<td>Germination Inhibitor</td>
<td>Inhibits germination of weed seeds, fungus spores and bacterial spores</td>
</tr>
<tr>
<td>Nerve Poison</td>
<td>Interferes with nervous system function</td>
</tr>
<tr>
<td>Protectants</td>
<td>Protects crop if applied before pathogens infect the plant</td>
</tr>
<tr>
<td>Repellents</td>
<td>Repels pest from crop or interferes with a pest's ability to locate a plant</td>
</tr>
</tbody>
</table>

a Glyphosphate-based herbicides (Round-up®) blocks an enzyme green plants use to make a protein essential for growth. b for example, 2,4 D, which is used for lawn weed control, kills broadleaf plants but does not harm grass.
Target Organism

The target organism method of classifying pesticides simply classifies pesticides by which organisms it targets. See Table 2.

Mode of Action

If a pesticide targets a certain vital function of a specific type(s) of pest, it is classified by mode of action. See Table 3.

Application Timing or Usage

If a pesticide is applied in relation to the life cycle of the pest or plant, it is classified by application timing. See Table 4.

How Pesticides Are Applied

If a pesticide needs to be applied in a specific way, then it is classified according to that specific method. See Table 10-5.

Pesticide Formulations

The formulation describes the physical state of a pesticide and determines how it will be applied. The active ingredient is the chemical that actually kills pests. Added chemicals, those that make the product easy and safe to formulate or apply, are known as inert ingredients. Descriptions of the more common pesticide formulations follow.

<table>
<thead>
<tr>
<th>Table 4. Pesticides Classified by Timing of Application or Use</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pesticide</strong></td>
</tr>
<tr>
<td>-------------------------</td>
</tr>
<tr>
<td>Ovicides</td>
</tr>
<tr>
<td>Larvicide</td>
</tr>
<tr>
<td>Aducticide</td>
</tr>
<tr>
<td>Pre-emergent herbicide</td>
</tr>
<tr>
<td>Pre-plant herbicide</td>
</tr>
<tr>
<td>Post-emergence herbicide</td>
</tr>
<tr>
<td>Seed Treatment</td>
</tr>
<tr>
<td>In-Furrow</td>
</tr>
<tr>
<td>Side-Dress</td>
</tr>
<tr>
<td>Dormant</td>
</tr>
<tr>
<td>Bud-break</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 5. Pesticides Classified by Application</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pesticide</strong></td>
</tr>
<tr>
<td>-------------------------</td>
</tr>
<tr>
<td>Band</td>
</tr>
<tr>
<td>Broadcast</td>
</tr>
<tr>
<td>Crack and crevice</td>
</tr>
<tr>
<td>Directed</td>
</tr>
<tr>
<td>Drench</td>
</tr>
<tr>
<td>Foliar</td>
</tr>
<tr>
<td>In furrow</td>
</tr>
<tr>
<td>Side dress</td>
</tr>
<tr>
<td>Spot treatment</td>
</tr>
</tbody>
</table>
Surfactants

Surfactants are some of the most common types of adjuvants. When added to a pesticide, a surfactant reduces the surface tension between two unlike materials, such as a spray film and a solid surface. For example, by adding a surfactant to a sprayer, oil and water will mix and can be sprayed on plant surfaces.

With increasing emphasis on safe application of pesticides, factors such as droplet size, spray pattern and pesticide drift have increased attention on the surfactant’s ability to give ideal coverage for pesticides. Surfactants include activators; compatibility agents; detergents; dispersants; emulsifiers; foam and drift suppressants; and spreading, sticking and wetting agents. These materials are added to a spray formulation to enhance the effectiveness of the active ingredient. Surfactants are used in a variety of applications, including agriculture, household cleaning products, and industrial applications. They play a crucial role in improving the performance and efficiency of various formulations.

Table 6. Common Pesticide Formulations and their Definitions

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Emulsifiable concentrates (EC or E)</td>
<td>In emulsifiable concentrates the active ingredient is mixed with an oil based carrier - often listed as petroleum derivatives - forming an emulsion that is diluted with water for application. These are easy to mix and use and are common in the home garden trade. They can cause phytotoxic damage if applied to sensitive plants. They should be protected from freezing temperatures, which can break down the emulsifier.</td>
</tr>
<tr>
<td>Solutions (S)</td>
<td>Solutions are pre mixed and ready to use. They are often in household pest products.</td>
</tr>
<tr>
<td>Flowables (F or L)</td>
<td>A flowable, or liquid, can be mixed with water to form a suspension in a spray tank.</td>
</tr>
<tr>
<td>Aerosols (A)</td>
<td>Aerosols are very low concentrate solutions, usually applied as a fine spray or mist. They are generally sold in aerosol cans and are usually a very expensive formulation of pesticide.</td>
</tr>
<tr>
<td>Dusts (D)</td>
<td>Dust formulations are made by adding the active ingredients to a fine inert powder or talc. They are generally used dry.</td>
</tr>
<tr>
<td>Granules (G)</td>
<td>Granulars are made by adding the active ingredient to coarse particles (granules) of inert material such as fired clay particles.</td>
</tr>
<tr>
<td>Wettable powders (WP)</td>
<td>Wettable powders combine the active ingredient with a fine powder. They look like dusts, but they are made to mix with water. When mixing a wettable powder, the measured quantity needs to be mixed with a small amount of water to form a slurry. Then the slurry and additional water is added to the spray tank. To maintain suspension, the spray tank must be frequently shaken. Wettable powders are less likely to cause phytotoxicity damage to plants than are emulsifiable concentrates.</td>
</tr>
<tr>
<td>Soluble powders (SP)</td>
<td>Soluble powder formulations are made by combining an active ingredient with a fine powder. Soluble powders dissolve and form true suspensions when mixed with water. Constant agitation is not needed to keep them in suspension.</td>
</tr>
<tr>
<td>Baits (B)</td>
<td>Baits are made by adding the active, ingredient to an edible, or attractive, substance. Baits are often used to control slugs, snails or small ground insects and rodents.</td>
</tr>
<tr>
<td>Adjuvants</td>
<td>An adjuvant is a chemical added to a pesticide formulation to increase its effectiveness or safety. Most pesticide formulations contain at least a small percentage of adjuvants.</td>
</tr>
<tr>
<td>Spreader or film extender (spreader activator)</td>
<td>A spreader increases the area that a given volume of spray will cover and it improves the contact between the pesticide and the plant surface. A spreading agent also builds spray deposits and improves weatherability. Most wettable powder insecticides benefit from the addition of a spreader.</td>
</tr>
<tr>
<td>Sticker or adhesive</td>
<td>A sticker improves the adherence to the plant surface, rather than increasing the initial deposit. Commercial sticking agents are oily in consistency. They increase the amount of suspended solids retained on plant surfaces by coating the particles with a varnish like film. Most fungicides greatly benefit from the use of stickers. Stickers are judged by resistance to wind and water, length of adherence, and mechanical or chemical action.</td>
</tr>
<tr>
<td>Wetting agent</td>
<td>A wetting agent lowers the interfacial tension between a liquid and a solid. Effectiveness is measured by the increase in spread of a liquid over a solid surface and the ability of the spray film to make complete contact with it. When a wetting agent reduces surface tension, spreading naturally occurs.</td>
</tr>
</tbody>
</table>
mix to: help keep the pesticide in suspension, improve cohesiveness and dispersion of the spray, and/or increase the wetting (or coverage) of the leaves, fruits and stems.

Surfactants that act as spreading, sticking and wetting agents are most useful when spraying the hard-to-wet foliage of plants such as azalea, boxwood, camellia, carnation, conifer, euonymus, gardenia, gladiolus, holly, iris, narcissus, peony, rose and yew. This is because whether a spray rolls off or sticks to a plant surface depends on the physical and chemical properties of the spray mixture and the physical properties of the surface itself. If the surface tension of the mixture is high or if the plant surface is waxy, the spray droplets will roll off.

Whenever commercial spreading, sticking and wetting agents are used, it is imperative to mix them strictly according to label directions. For example, adding more surfactant than recommended may cause excessive runoff, resulting in poor spray deposition and reduced pest control. As a general rule, if the spray mix

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<table>
<thead>
<tr>
<th>Advantages and Disadvantages of Dust and Granules for Pesticide Sprays</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Advantage</strong></td>
</tr>
<tr>
<td><strong>Dusts:</strong></td>
</tr>
<tr>
<td>▪ Ready-to-use formulations</td>
</tr>
<tr>
<td>▪ No mixing required</td>
</tr>
<tr>
<td>▪ A duster is less expensive than a sprayer</td>
</tr>
<tr>
<td>▪ Dust formulations are less expensive than spray formulations</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td><strong>Sprays:</strong></td>
</tr>
<tr>
<td>▪ Better coverage of plant surfaces with mist spray</td>
</tr>
<tr>
<td>▪ Adheres to plant surfaces</td>
</tr>
<tr>
<td>▪ Less toxic to bees</td>
</tr>
<tr>
<td>▪ Less problems with drifting</td>
</tr>
</tbody>
</table>
contains one or more pesticides produced or formulated by the same company, use a surfactant sold or recommended by that company. However, keep in mind that surfactants are sold separately from pesticides and are not subject to Environmental Protection Agency (EPA) registration.

If you, or your client is uncertain on whether to add a surfactant or not, check the pesticide label. It should state whether a surfactant is needed, whether it should be added to a spray mix and which brand to use. The label should also indicate restrictions in the selection of compatible surfactants. In many cases, surfactants have been designed specifically for use with fungicides, insecticides or herbicides.

The Importance of Using Correct Terminology

Gardeners often attempt to compare a spray with a dust. However, dusts are a type of formulation and sprays are a means of applying several different formulations, such as wettable powders, soluble powders or emulsifiable concentrates. Confusing these terms can make for unnecessarily difficult conversations and could lead to misapplying the product. Applying an EC powder, which should be mixed with water, as a dust could be very costly and ineffective as a pest control. Therefore, when talking to clients, remember to always emphasize correct terminology and explain how each formulation is used.

The Pesticide Label

Any information printed about a synthetic pesticide product is called "labeling." Labeling includes: the product label, brochures and flyers from the company or its agent. The product label is what is printed on, or attached to, a container of pesticide and it tells how to correctly use the product and what special safety measures need to be taken. All products must bear the statement “Keep Out of Reach of Children.” In some pesticide literature, the term LD50 is used to give an indication of toxicity. LD50 is the dosage necessary to kill 50 percent of a test population of animals—usually mice or rabbits. LD50 values are presented in milligrams of material per kilogram of body weight. Thus, a low LD50 value indicates a more toxic pesticide—it takes less of the product to kill 50 percent of the test population. For example, an LD50 of 5 is more toxic than an LD50 of 20 because only 5 milligrams per kilogram of body weight is necessary to kill 50 percent of the test population. Specific parts of the label and the definitions can be found in Table 10-7.

- **Restricted-use pesticides**: Pesticides in which the efficacy data indicates it may have adverse effects on people and/or the environment. The label states “restricted-use pesticides for retail sale to and application only by certified applicators, or person(s) under their direct supervision.” A license from the Tennessee Department of Agriculture (TDA) is required by law for purchase and use of restricted-use pesticides. For more information on becoming a certified applicator, contact your local county Extension office, UT Extension Pesticide Coordinator’s office or TDA.
Statement of practical treatment: The pesticide label lists emergency first aid measures that should be taken if an applicator accidentally swallows, inhales or exposes the product to the skin. The label will also state the types of exposure requiring medical attention.

Directions for use: Directions for use indicate the following:

- Pests the product will control
- Crops, animals or other items that can be treated with the product
- Directions for applying the product
- The rate at which to apply the product
- Where and when the product should be applied
- Re-entry statement

Table 7. Terms Found on the Pesticide Label and their Definitions

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brand name or trade name</td>
<td>Identifies the product. The brand name shows up on the front panel of the label</td>
</tr>
<tr>
<td>Type of formulation</td>
<td>States how the pesticide is formulated. The same pesticide may be available in more than one formulation</td>
</tr>
<tr>
<td>Use classification</td>
<td>Pesticides are classified for general use or restricted use</td>
</tr>
<tr>
<td>Ingredient statement</td>
<td>Lists the names and amounts of the active and inert ingredients in the product</td>
</tr>
<tr>
<td>Common name and chemical name</td>
<td>Pesticides have complex chemical names derived from their chemical composition. Some also have a shorter name, or common name, to make them easier to identify. A pesticide may be sold under several brand names, but will only have one chemical name.</td>
</tr>
<tr>
<td>Net contents</td>
<td>Refers to how much product is in the container. It is expressed in units of measure</td>
</tr>
<tr>
<td>Name and address of manufacturer</td>
<td>The law requires the maker or distributor of a product to print the name and address of the company on the label</td>
</tr>
<tr>
<td>Registration number</td>
<td>Shows that the product has been approved by the EPA for the uses listed on the label. Every pesticide label must have one</td>
</tr>
<tr>
<td>Establishment number</td>
<td>Tells which factory made the chemical</td>
</tr>
<tr>
<td>Precautionary statements</td>
<td>A section with a title similar to, &quot;Hazards to Humans and Domestic Animals.&quot; States how the product may be poisonous to people and animals. It also describes special steps necessary to avoid poisoning and types of protective equipment needed for application. If the product is highly toxic, this section will inform physicians of the proper treatment for poisoning</td>
</tr>
<tr>
<td>Uses of the pesticide</td>
<td>Lists the legal uses and areas for which the pesticide is registered.</td>
</tr>
<tr>
<td>Environmental hazards</td>
<td>Tells how to avoid environmental damage. For example: &quot;Do not contaminate water when cleaning equipment or when disposing of wastes&quot;</td>
</tr>
<tr>
<td>Physical and chemical hazards</td>
<td>Lists specific fire, explosion or chemical hazards that the product may have</td>
</tr>
<tr>
<td>Signal words and symbols</td>
<td>Tells how toxic the chemical is.</td>
</tr>
</tbody>
</table>
- **Application-to-harvest periods:** When applied to food crops, there may be a period of time that must pass from the time of application to the time it is safe to pick and use the crop. This time period is known as the application-to-harvest period and is expressed as “days to harvest,” this is the time required for the pesticide residue to drop to safe levels.

- **Misuse statement:** This section informs the reader that it is a violation of federal law to use a product in a manner inconsistent with its labeling.

- **Storage and disposal directions:** Every pesticide should be correctly stored and disposed. Information on the proper storage and disposal of the pesticide will be found in this section of the label.

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**Application Equipment**

As a Master Gardener, you need to stress to gardeners that it is never safe, or desirable, to use the same sprayer for weed and insect control. This is because no matter how well a tank is rinsed after use of a pesticide, there is always some residue left in the tank, gaskets and/or hoses. Therefore, it is best to maintain two, clearly labeled, sprayers: one for herbicides and another for insecticides and fungicides.

Pesticide application equipment is available in all shapes, sizes, types and prices. As a Master Gardener it is important to teach gardeners to select durable equipment that is designed to do the job they need it to do, is convenient to fill, and is easy to operate and clean.

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**Table 8. Chemical Toxicity Labeling**

<table>
<thead>
<tr>
<th>Signal Words</th>
<th>Toxicity</th>
<th>LD50</th>
<th>Approximate human lethal dosage</th>
<th>Symbol</th>
</tr>
</thead>
<tbody>
<tr>
<td>Danger Poison</td>
<td>Highly Toxic</td>
<td>0-50 mg/kg</td>
<td>A taste to a teaspoon</td>
<td><img src="image1" alt="Skull and Crossbones" /></td>
</tr>
<tr>
<td>Warning</td>
<td>Moderately Toxic</td>
<td>50-500 mg/kg</td>
<td>A teaspoon to a tablespoon</td>
<td><img src="image2" alt="Skull and Crossbones" /></td>
</tr>
<tr>
<td>Caution</td>
<td>Low toxicity/relatively non-toxic</td>
<td>500-5000 mg/kg</td>
<td>An ounce to more than a pint</td>
<td><img src="image3" alt="Exclamation Mark" /></td>
</tr>
<tr>
<td>Keep out of Reach</td>
<td>Relatively non-toxic</td>
<td>5000+ mg/kg</td>
<td>More then a pint</td>
<td><img src="image4" alt="Child and Parent" /></td>
</tr>
</tbody>
</table>
Non-Powered or Hand-Operated Equipment
Non-powered or hand-operated liquid spray equipment is used for applying pesticides to small areas, specific targets or specific locations that are difficult to reach with larger equipment. Most are lightweight and carried by the individual. Most are not equipped with agitators.

Aerosol Cans
Pressure spray applicators and aerosol foggers are examples of aerosol cans. Pesticides packaged this way are commonly used around the home and are popular because of their convenience. Larger volume aerosol cans are used by pest control operators for structural and greenhouse applications. The aerosol cans can be carried on the applicator’s waist belt and connected to a hose and spray wand that enables the operator to inject liquids into cracks and crevices. This method of application offers convenience and portability to professional applicators and eliminates the need for chemical mixing.

Proportioner or Hose-End Sprayer
These inexpensive, small sprayers are designed for attachment to a garden hose. A small amount of pesticide is mixed with water, usually no more than a pint, and placed in the receptacle attached to the hose. A tube connects this concentrate to the opening of the hose. When the water is turned on, the suction created by water passing over the top of the tube pulls the pesticide concentrate up and into the stream of hose water.

Problems with proportioners result from poor spray distribution, clogged nozzles and inaccurate metering out of the concentrate into the stream of hose water. Additionally, proportioners put out an excessively high volume of spray for most needs, causing excessive use of pesticide.

Many gardeners use proportioners because of the low cost. However, as a Master Gardener, you need to point out that although proportioners are low in cost, the price is quickly negated by the cost of excessive pesticides use. Also, inform your client’s that if a hose-end proportioners is used, it needs to be equipped with an anti-siphon device to prevent back siphoning of toxic chemicals into the water system.

Trombone Sprayer
The trombone sprayer is a medium-sized, hand-held piece of equipment. When using a trombone sprayer, a spray mixture, in the correct dilution, is prepared in a container such as a bucket. The intake tube of the sprayer is then inserted into the bucket and pump pressure is created by operating the sprayer in a trombone-like motion. The pesticide is pulled up the hose and out the end of the sprayer. A uniform concentration of the spray is maintained because the pesticide is mixed with a known quantity of water. If gardeners have to spray many trees and shrubs, direct them to a trombone sprayer. Although they require some effort to use, they are easy to wash and keep clean.
Compressed Air Sprayer (Knapsack or Tank Sprayer)

In a compressed air sprayer, spray is mixed in a small tank, generally 1 to 5 gallons, and the tank is carried over the shoulder. A hand-operated pump supplies pressure during application. A uniform concentration of spray can be maintained since the pesticide is mixed with a known quantity of water. The applicator has excellent control over coverage, making it a good choice for treating dwarf fruit trees, vegetables, and ornamentals. However, spray from a compressed air sprayer will not reach into tall trees. As water weighs approximately 8.33 pounds per gallon, small tanks are easier to use than large tanks.

Small Power Sprayers

These sprayers have the advantage of being motor driven so the operator does not have to stop to pump up the tank. They are also lightweight and provide uniform pressure. However, they are generally too expensive for home garden use.

Hand Duster

A duster may consist of a squeeze tube or shaker, a plunger that slides through a tube, or a fan powered by a hand crank. Uniform coverage of foliage is difficult to achieve with many dusters. Dusts are more subject to drift than liquid formulations due to their lightweight and poor sticking qualities.

Wick Applicators

Wick or wiper applicators, also called rope wick applicators, are used exclusively for the application of contact or systemic herbicides. They can be used in areas where weeds are taller than the crop plant. Wick applicators reduce problems of drift and waste of herbicides.

Calibrating Sprayers and Spray Patterns

Calibration is the adjustment of equipment to apply the desired rate of pesticide. Application equipment should be calibrated frequently to ensure that each pesticide is being applied at the rate directed on the product’s label. Too much pesticide is dangerous; too little will not do an adequate job in controlling the targeted pest. Only by calibrating correctly can you safely ensure the best results with the product.

The best spray pattern to use to cover an area of ground is one that will give uniform coverage with little spray overlap. If the herbicide has been mixed correctly and the sprayer is properly calibrated, a continuous, uninterrupted flow of chemical will be sufficient for effective pest control. Make sure gardeners know that once the herbicide is being applied, they should not slow down or stop at each weed.

Additionally, the spray pattern should be directed so that no one will walk in the pesticide during the application and it should form an arc of no more than 3 to 4 feet on either
side of the operator. If good spray coverage is questionable, as with a hose-end sprayer, tell gardeners to cut the application rate in half and make two applications. The first application should be in made in an east-west pattern. The second application should be made in a north-south pattern.

**Home Garden Vs. Commercial Pesticides**

Some pesticides are packaged specifically for home garden use. These products are available in small quantities such as pints, quarts, ounces or pounds. The label rate is given in spoonfuls per gallon or in pounds per 1,000 square feet. Because of the small label size, home garden products may not list all of the plants or pests for which the product may be registered. For example, one manufacturer sells Diazinon 25 percent EC as Fruit and Vegetable Insect Control and Diazinon Insect Spray. Both are basically the same product, but plants and pests listed on the labels greatly differ. This situation causes some confusion in pesticide application and stimulates the purchase of excessive amounts of pesticides. Therefore, before making a purchase, teach gardeners to check the active ingredients of the products and determine if, in effect, the same items are being purchased.

Products packaged for the commercial grower may appear to be less expensive, but homeowners should not be tempted to use them. They are generally more concentrated than those for home use and may require special protective clothing and equipment for application. Additionally, commercial products are usually packaged in larger containers than the homeowner could expect to use or safely store.

**Pesticides and the Law**

Laws governing the registration and use of pesticides are changing rapidly. It is imperative that you address current Environmental Protection Agency (EPA) and Tennessee Department of Agriculture (TDA) regulations before spraying. Under the amended Federal Insecticide, Fungicide and Rodenticide Act of 1972—the initial federal pesticide regulation act— it is illegal to use a pesticide on a plant unless that plant is listed on the label and the given rate of application on the label is not exceeded. Fines and other penalties change and vary according to the violation. Under federal law, the homeowner is liable for misuse of pesticides on their property.

Pesticides are divided into two groups: general-use and restricted-use. General-use pesticides are primarily for homeowner use.

**Calibrating Equipment**

There are many ways to calibrate equipment. The preferred methods differ according to the kind of equipment used. Therefore, direct clients to consult the directions on the specific equipment being used for the proper calibration method. Below is a general method of sprayer calibration.

1. Fill the sprayer with water and fully pressurize. Determine delivery time by spraying water into a pint jar. Mark how much water is delivered into the jar in 30 seconds.
2. Measure and determine the square footage of the area to be treated. Multiply length by width to determine the area of a rectangle, or base times height divided by 2 to determine the area of a triangle.
3. Spray an area with water while walking at a normal speed for 30 seconds. Measure the area sprayed. This tells how much area can be sprayed in 30 seconds and the amount that is applied over that area (see item 1). For example, say that 30 seconds of spraying delivers 8 fluid ounces and covers 100 square feet. The total area to be covered is 1,000 square feet; therefore, treatment of 1,000 square feet will require 80 fluid ounces of diluted material (8 fluid ounces X 1,000 square feet/100 square feet). If the pesticide label calls for 3 tablespoons of pesticide for 1,000 square feet, then 3 tablespoons of pesticide must be mixed with 80 ounces of water to achieve proper spray coverage. Many commercial-type chemicals are given in pounds to the acre or quarts to 100 gallons of water. To convert rates to equivalents used by a homeowner, consult the pesticide conversion chart at the end of this chapter.

**Spraying Upright Plants**

When the mixture on the label is in teaspoons or tablespoons per gallon and the plants are upright—such as shade trees, fruit trees, shrubs and vegetables—spray the leaves until the pesticide solution drips from the leaves. Also, always spray the underside of leaves for thorough coverage.
Restricted-use pesticides are for farmers and commercial applicators. One must be certified to buy a restricted-use pesticide and certified to use one or, if not certified, work directly under the supervision of a certified applicator. TDA (phone 615/837-5148) is the regulatory agency for certifying pesticide applicators. The University of Tennessee, Extension Service trains private and commercial applicators. Private applicators (farmers, greenhouse and nursery operators) are trained at the local Extension office; Commercial applicators are trained by the UT Extension Pesticide Coordinator located in the Department of Entomology and Plant Pathology. For more information on certification training call 865/974-7138. The Pesticide Safety Education, PSEP, hotline is 865/974-0875.

Summary

Pesticides are generally applied when non-chemical methods fail to provide adequate control or when pest populations begin to cause aesthetic or economic loss. They come in a variety of formulations and can be made from natural or synthetic substances. Whenever pesticides are used, they need to be treated with great caution. This is because if used inappropriately, pesticides can cause severe damage to people as well as to the environment.

Terms To Know

Acaricides
Adjuvant
Aerosols
Antitranspirants or antidesiccants
Attractants
Avicides
Bactericides
Baits
Broadcast
Compressed air sprayer (Knapsack or Tank Sprayer)
Contact poisons
Desiccants and defoliants
Directed
Drench
Dusts
Emulsifiable concentrates
Granules
Hand Duster
Herbicides
In-furrow
Insecticides
Flowables
Foliar
Formulation
Fungicides
MSDS
Miticides
Molluscsicides
Natural/Organic Pesticides
Nematicides
Non-selective pesticides
Personal protective equipment (PPE)
Pesticides
Phytotoxic
Pre-emergence
Post-emergence
Plant growth regulators
Predacides
Proportioners
Repellents
Rodenticides
Selective pesticides
Sidedress
Soluble powders (SP)
Solutions (S)
Spot treatment
Spreader or film extender (spreader-activator)
Sticker (adhesive)
Stomach poisons
Suppression
Surfactant
Synergism
Systemic poisons
Threshold levels
Translocated herbicides
Trombone sprayer
Vaporization
Wettable powders (WP)
Wetting agent
Wick Applicators
Test Your Knowledge

1. When should one consider using a pesticide rather than non-chemical means of controlling pests?

2. Briefly describe the three main goals of controlling a pest.

3. What is the main difference between selective and non-selective pesticides?

4. What is a pesticide formulation and what are the main ingredients in it?

5. Briefly describe symptoms of and first aid for pesticide poisoning.

Resources

University of Tennessee Insect and Disease Control Manual, The Red Book, PB 1690
UT Extension
Available at local Extension offices
Certification and Training of Pesticide Applicators
epa.gov/oppfed1/safety/applicators/applicators.htm
The University of Tennessee Entomology and Plant Pathology Department
eppserver.ag.utk.edu
MSDS Search
msds.com