chapter 4

Pest Management

In a nutshell...

- Pest management begins with good gardening practices.
- The last defense should be to grab the spray bottle; consider all the options first.
- A pest can be an insect, a disease, a weed, a rabbit…
- Just because you encounter a pest doesn't mean you need to manage it; sometimes you can just let it go.
- It you're going to use any pesticides, you need to know how to use them safely.
- Check the resources at **hort.extension.wisc.edu** for issues not covered in this chapter.

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Introduction

If you look at natural landscapes, you will see that they are self-sustaining, diverse, and constantly in flux. There is a delicate balance between all components of a natural ecosystem. Gardens are artificial ecosystems with a unique mix of herbivores, carnivores, microbes, and fungi, as well as desired—and undesired—plants. When a garden is healthy and imitates a natural ecosystem (e.g., by using the right plant in the right place) it is more likely to handle competition or attack by insects, pathogens, weeds, and some animals.

Learning objectives

1. Become familiar with the concept and components of integrated pest management.
2. Understand various pest management techniques and the place of chemical solutions in the hierarchy of options.
3. Understand the differences and similarities between synthetic and organic products.
4. Be able to read and understand product labels.

Invasive plants and animals are introduced from other parts of the world and grow unchecked in their new ecosystem. They often overpower existing native plants and environments. Dutch elm disease (DED) has nearly wiped out the American elm population; the emerald ash borer (EAB) is an insect pest doing as much damage as DED, but to all ash tree species. Garlic mustard is one of several invasive plants which are outcompeting native flora and significantly altering ecosystems, making it difficult for other plants and animals to thrive.

Our gardens are not often in balance. A well-meaning gardener may purchase a beautiful, healthy plant at a garden center and plop it into the ground without considering what it needs to remain healthy. The plant may or may not receive the appropriate amount of water; the soil pH may or may not prevent the plant's absorption of nutrients; or the shade from nearby trees could keep the plant from receiving the correct amount of light. Any or all of these issues could disable the plant from photosynthesizing enough sugar to grow or defend itself. The plant is now a target for pests and diseases, and may be unsuccessful while competing for resources against surrounding vigorous weeds.

Human-designed gardens are often greatly simplified in the number, arrangement, and complexity of planting versus undisturbed, natural environments. As a result, these simplified systems face a greater risk for pest problems.

It's become common for gardeners to "fix" pest problems by spraying or sprinkling products from stores deigned to "help". Social media offers a constant stream of DIY fixes using kitchen products. These solutions are often band-aids to the problem and do not offer a viable long term answer. Some of these solutions can do more harm than good. To find the best solution, the situation should be systematically analyzed and explored.

This chapter introduces the concept of IPM (integrated pest management) and discusses pest management tactics, including the different types of pesticides, how to read pesticide labels, and how to safely use pesticides.

Diagnosing plant problems requires detective work

- What species of plant is impacted?
- What are the signs?
- What are the symptoms?
- What is the site, or the environment the plant is growing in?
- How does the problem spread across the landscape or within a plant?
- What season did the problem first appear?
- What's the story, or history of the plant, including what's been done to it or what's happened near it over the last several months (or years)?

Gather as much of this information as you can to make a diagnosis.

Integrated pest management

The concept of integrated pest management (IPM) was developed in the agricultural setting as a tool to help farmers make informed decisions on crop health and management. It's a system used by both conventional and organic farmers. Much of IPM can be applied to home gardens. The concept of IPM can also be expanded to manage overall plant health and productivity in a preventative manner, rather than just focusing on pests.

Pest control versus pest management

The traditional strategy for dealing with pest problems is termed **pest control**. Pest control is reactive, so tactics are planned and implemented after problems are found. There is no advance planning to avoid or minimize pest problems. Because many control tactics require some lead time, a reactive approach often leaves pesticides as the only option. This approach is undesirable because of its emphasis and reliance on pesticides.

Pest management is proactive and involves planning strategies before problems occur. It emphasizes tactics that avoid or minimize the risk of pest problems and advocates the tolerance of some damage. Most plants can bear some defoliation or sap removal before it affects overall health, so it is up to the gardener to decide what is intolerable and when it is worthwhile to intervene.

IPM is a thought process that involves observation and decision making, and offers gardeners a simple and organized framework for approaching plant problems. When properly implemented, IPM considers the plant's needs and its environment, the pest's biology, and all options for predicting and monitoring plant health. IPM explores **all** options for pest management, with "what you spray on it" serving as the last resort. It utilizes and incorporates all appropriate pest control methods instead of focusing on a single approach, which can prevent or reduce the severity of pest problems. IPM thought processes can be expanded to manage overall plant health and productivity in a preventive manner.

Definition of IPM

Integrated pest management has long been a buzzword in agricultural production. IPM can mean different things to different people. As a result, definitions are diverse and have ranged from those which advocate mostly organic control to those which focus on chemical control. One common and easily understood definition describes IPM as "a decision-making process that utilizes all available pest management strategies, including cultural, physical, biological, and chemical control to prevent economically damaging pest outbreaks and to reduce risks to human health and the environment."

IPM is fundamentally based in plant ecology and seeks the best tactical combinations to reduce pest populations to a tolerable level. It focuses on management, not control. The word control implies power over something, and to many people, means total eradication. Conversely, management implies a less threatening method of dealing with pests. IPM is proactive and involves strategical planning before problems occur. It emphasizes tactics that avoid or minimize the risk of pest problems and uses pesticides as a last resort.

Three important components of this definition include:

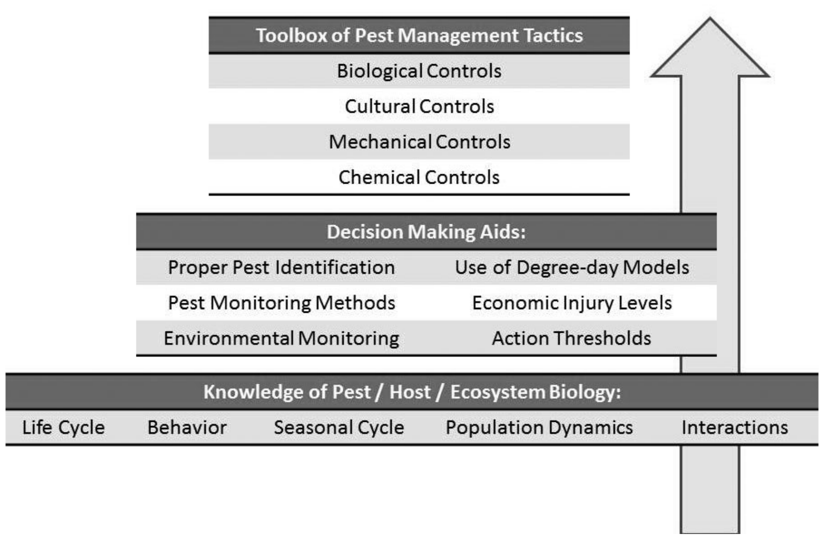
- IPM is a decision-making process.
- IPM utilizes all available pest management tactics.
- IPM can reduce risks to human health and the environment.

The building blocks of IPM form a pyramid (figure 1) that includes:

- At the bottom: A strong foundation of knowledge regarding the pest, the host plant, and the surrounding environment.
- In the middle: Key decision-making aids, including pest identification, monitoring, and action thresholds.
- At the top: Pest management tools and tactics, whether biological, cultural, mechanical, or chemical.

IPM is not the same as organic gardening (see chapter 17, Organic Gardening), although many of the concepts are similar.

FIGURE 1. Building blocks of IPM pyramid



Plant health management

Taking care of your plants will do more to prevent problems than anything you can do later to respond to them. Promoting plant health begins with a thorough understanding of all factors that could negatively impact your plant. Every plant has its own ideal growth conditions and each planting site in your landscape has its own set of environmental conditions. The goal is to match them as closely as possible—also known as "right plant, right place." Providing adequate light, air, water, and nutrients will cultivate a vigorous plant that maintains optimum resistance to adversity. For more details on these practices, see chapter 9, General Gardening Practices.

The base of the IPM pyramid: Knowledge

Effective integrated pest management requires accurate information. The foundation of integrated pest management is knowledge. This is why you are expected to learn about all the topics in this manual, not just the ones you have a personal interest in.

You need to know a lot of things, starting with what's normal for the plant and its environment, as well as the pest, including life cycle, behavior, seasonal cycles, population growth, and interactions with their host and environment. In pest management, not understanding as much as you can about your particular pest situation will make your efforts less effective. Be sure you know what the plant is supposed to look like.

- Don't confuse "golden" or variegated cultivars of a plant for **chlorosis**-related nutrient deficiency.
- Some contorted plants are normal while others may be giving you signs that something is wrong.

Extension fact sheets provide a wealth of information on pests. For example,

- If it's a weed, is it annual, biennial, or perennial? Annuals will come back from seed each year. Biennial and perennial weeds need to be treated differently, because they may have vegetative storage structures that can help them survive weeding or can push through a thick layer of mulch.
- While some insects may produce only a single generation each year, others can produce a whole new generation every 2 to 3 weeks during warm summer weather.
- Some plant diseases may spread through the air, water, or could be harbored in the soil, while some are introduced in your garden through plants.
- Animals can be migratory, territorial, or nocturnal. Breeding seasons and rearing young may also influence their behavior.

Extension fact sheets are structured similar to the IPM pyramid, with overviews of important pest information, decision-making strategies, and pest management options.

Future chapters on insects, diseases, weeds, and wildlife provide more details on each pest type.

In addition to all the information about the pest itself, you need to consider things about the plant, such as its requirements for light, water, and nutrients, as well as its growth habits, life cycle, pollination needs (if any), potential interactions with other plants (such as **allelopathy**—see chapter 1, Botany), and known susceptibility to pests and problems.

The environment in which the plant and pests are found in will also influence the decision-making process. How much light does the location receive? What is the surrounding vegetation or structures? Is it flat, on a hill, or a man-made berm? What is the soil texture and pH? Is this next to a house or the middle of a field? Is the area given supplemental water or fertilization (or none at all)? Sometimes a picture is worth a thousand words and can be very helpful in determining environmental information. See chapter 9, General Garden Practices and chapter 2, Soils for more detail on this.

Once you know as much as possible about the pest (and its plant host and environment), you can use that information to make an informed decision on how to deal with it. The central section of our IPM pyramid describes the decision-making tools that form the core of integrated pest management.

The middle tier of the IPM pyramid: Decision-making aids

After you gather as much knowledge about the pest, plant, and location as possible, you must consider each piece of information and make decisions. The middle part of the pyramid helps you assess the situation and will help you determine whether management is necessary.

Proper identification of host and pest

It's critical to properly identify all the players in our pest management structure (it's so important, this falls into both the lower and middle tiers of the pyramid!). Most plants are only affected by a limited number of pests—insects, diseases, weeds, critters, and environmental issues. For example, the emerald ash borer only infests and kills ash trees (*Fraxinus* spp.), and won't infest maples (*Acer* spp.), oaks (*Quercus* spp.) or mountain ash (*Sorbus* spp.)—although each of these species have their own specific problems.

When confronted with an unknown plant, you can turn to a variety of resources for identification. Books and online plant identification keys are available. Having the plant (or a good image of the plant) in hand as well as being familiar with plant anatomy terminology will greatly assist you in the process. Plant identification tools will ask you about a plant's leaf arrangement and complexity, growth habit, flower characteristics, and so on. It's difficult to know every plant you may encounter. Knowing how to describe a plant is valuable when trying to identify the unknown.

Pest identification can run the gamut from the obvious to the elusive. In many cases, you'll need to sleuth for signs and symptoms to determine the cause of the plant's malady. Other cases may be as obvious as tire tracks leading through crushed garden plants. Your county Extension office is available to assist with pest identification. In some cases, especially with many insects and most diseases, you will need to send samples to the diagnostic lab for further confirmation. Future chapters on insects, diseases, weeds, and wildlife will detail the necessary information about each pest type.

Keeping track of the identity of plants in your garden and identifying their potential problems can help make the next step in the decision-making process easier.

Pest monitoring

Keeping track of pest populations is an important component of IPM. Frequently checking plants allows you to detect pest outbreaks when they first occur and to respond before the populations reach high levels. Early intervention is essential for some methods to be effective, especially augmentative biological control of insects and management of many diseases. To be effective, monitor on a regular basis. Taking a few minutes every day to walk through your garden is the best way to stay on top of the situation.

Monitoring techniques

Visual observation is the most common way to detect pests: go out and look at your plants. This is good for spotting exposed-feeding insects, beneficial insects or parasites, plant diseases, weeds, wildlife, environmental disorders (such as frost injury), or nutrient deficiency. In many cases this is the only effective way to determine whether insects or weeds are numerous enough to warrant control. Beneficial insects that could be affecting pest populations may also be observed.

Traps of various kinds can be used to detect or remove specific pests. There are passive traps that insects or other animals stumble into versus active traps that employ:

- **Visual stimuli** (e.g., Apple maggots are attracted to red spheres.)
- **Food smells** (e.g., Snap traps baited with peanut butter are suitable for capturing rodents.)
- **Pheromones** (e.g., Sex attractants are produced by Japanese beetles to find mates.)

General traps, such as yellow sticky traps, monitor for many different insect pests such as leafhoppers, whiteflies, and some root maggot flies. Other traps are very pest-specific, such as pheromone traps available for a number of species of moths. You can find several types of traps for common insect pests online, from mail order garden supply companies, or at your local garden center.

Extraction or knockdown methods, such as flotation to detect chinch bugs in lawns, are used for a few specific insect pests. Other insects can be jarred off plants by lightly tapping on the plant with a stick onto sheets below to be counted.

The type of monitoring methods you choose will depend on the pests to be detected, how much time you have to devote to monitoring, and your tolerance for damage to your plants.

Environmental monitoring
Weather monitoring is also important in predicting pest outbreaks or determining the likelihood of disease. When observing weather as a part of an IPM program, keep in mind that weather conditions as far back as six months or more can have an effect on plants today.

One simple way of keeping track of wet springs, hot and dry summers, or unusually cold and snowy winters is to keep a gardening journal. Recording essential weather data such as maximum and minimum temperature, precipitation, and whether it was sunny, cloudy, or rainy/snowy can go a long way when you're trying to determine the potential cause of a plant problem weeks or even months and years later. See chapter 18, Phenology for more information on this aspect of pest prediction.

Garden journals are a traditional way of documenting what's going on in your garden, allowing you to note when certain plants bloom and when certain pests appear. You can also add comments as to how you responded to the problem and what worked and didn't.

These days, you can place digital images accompanied by descriptive captions on your favorite social media platform. Not only does this document your garden for own use, but it shares the information with your friends and family.

Use of degree-days
Degree days (also known as heat units or thermal units) are a way of incorporating both temperature and time into one measurement to quantify the rate of plant or insect development. Degree day accumulations are not useful alone; you need to know what these numbers mean relative to the life cycles of the specific pests you want to control. Over time, researchers have determined when (in terms of degree days) certain events occur in pest insect life cycles. See chapter 18, Phenology for more detailed information on calculating and using degree days.

Economic injury levels

Would you buy an apple with spots on it? Even though the apple is still perfectly edible, many individuals avoid purchasing fruits and vegetables (or ornamentals, for that matter) with spots, blemishes etc. For commercial growers, that's an important factor to consider when making decisions on pest management strategies—growers lose money when consumers won't buy their imperfect (but still perfectly useful) produce or plants.

Homeowners may have different tolerance to pests (and spots, or other damage) on the plants they grow compared to what they purchase. This would be a big difference between IPM in agriculture versus home gardens.

In IPM, the goal is not to eradicate every pest, but to manage populations and reduce damage to tolerable levels. Any level of pest infestation causes injury (physical harm or destruction), but not all levels of injury cause damage (monetary value lost as a result of injury). Plants often tolerate small injuries with no apparent damage and can sometimes overcompensate by channeling more energy and resources into growth or fruiting. A low level of injury may not cause enough damage to justify the time or expense of pest control operations. Eventually, a pest population could cause enough damage to justify the time and expense of control measures. But how can you tell when damage exceeds this threshold?

The Economic Injury Level (EIL) is "the smallest number of insects (amount of injury) that will cause yield losses equal to the insect management costs." This is based on the value of the plants, the amount of potential pest damage, and the cost of control, and is determined through research for individual pests (usually insects) for specific crops.

Economic Thresholds (ET) have been developed for crops where yield is the primary concern. In ornamental landscapes, aesthetic considerations are often more important. Aesthetic injury levels are subjective, varying with people's attitudes and experiences, so they are harder to quantify. Some damage that looks terrible may only be cosmetic, and pose no real threat to the plant. The plant's location may also influence the degree of damage that it can tolerate. For example, one bite out of a houseplant can ruin its appearance, whereas the same amount of defoliation on a peony bush among other perennials would hardly be noticed. Determining when to initiate control measures is often based on experience rather than scientific study.

Action thresholds

All too often, gardeners find a dead or dying plant in the garden, which is usually too late to revive the plant.

The action threshold is "the pest density at which management action should be taken to prevent an increasing pest population from reaching the economic injury level." Often the time to take action has long passed by the time damage becomes noticeable, so gardeners must be vigilant while monitoring for action thresholds to be useful. Monitoring and prediction models are useful in determining when to initiate pest management.

There are many decision-making aids, and you will not use all of them for every pest. However, they are critical to selecting an appropriate management tactic—the top of the IPM pyramid.

The top of the IPM pyramid: Toolbox of pest management tactics

When pests exceed tolerable limits, you need to act to minimize their impact. There are several approaches to controlling or managing pest populations. These approaches all attempt to limit (or damage) pest numbers rather than eliminating all the insects, pathogens, or weeds. Not all approaches will be effective for all types of pests. An understanding of the pests' biology and life cycle is important in determining which options are most likely to succeed against a given pest, and when to implement the controls. See chapter 5, Entomology, chapter 6, Plant Pathology, chapter 7, Weeds, and chapter 8, Wildlife. IPM helps you to link your knowledge of the pest with the priorities and special needs of your situation to choose the methods of control that are most appropriate.

Whenever possible, use the easiest, least expensive, least disruptive and least toxic tactics first.

Mechanical controls

Mechanical or physical control methods such as barriers, fences, traps, handpicking, and flyswatters either remove pests completely or prevent them from accessing plants.

Physical barriers prevent pests from getting to the plant. These tend to be most useful in the vegetable garden, where aesthetics are less important.

- **Floating row covers**, available at most garden supply stores, are a popular physical barrier. This lightweight polyester fabric allows light and water to penetrate while keeping insects out. Floating row covers are effective at keeping worms out of broccoli or cabbage crops, and flea beetles out of spinach and eggplants. But this will not work if the pests are emerging from the soil under the covers. See chapter 9, General Gardening Practices, for more information on how to use floating row covers.

- **Cardboard or plastic collars** can be placed around individual plants to prevent cutworm damage, and a paper or plastic disc can be laid on the soil surface around the base of cabbage transplants to discourage cabbage maggot flies from laying their eggs on the plants.
- **Fences** can keep out rabbits, deer, and other mammals.
- **Organic or plastic mulch** can be used to suppress weeds and keep soil and soil-borne pathogens from splashing onto the plant. A thick layer of grass clippings or shredded bark will prevent annual weeds from germinating—but perennial weeds such as Canada thistle or quackgrass may grow right through.

Traps can lure some insect pests away from your plants or capture wildlife for removal from the garden. Red sphere apple maggot traps, ant traps, and slug traps are available in garden supply stores. See more about traps in the Monitoring section within this chapter.

Trap plants are sacrificial additions to the garden used to draw pests away from more valued plants. This may include a patch of hostas in the far corner of your property to keep deer away from the more valuable plants near the house. It may also mean using eggplants at the end of your garden to lure white flies away from your other garden plants.

Hand picking is a practical way to control some pests. Squash bugs and tomato hornworms are large enough to be visible on plants, and are usually present in small enough numbers to make this an efficient method of control in small plantings. Large caterpillars on specimen plants in the landscape can also often be effectively eliminated by hand removal. Colorado potato beetle larvae can be removed from small potato patches by hand—though these methods are for the non-squeamish only!

Depending on the plant and the disease, pruning or removing infested leaves is an option for managing some disease problems. Removing the spotted lower leaves on tomatoes can slow the spread of early blight.

Cultural controls

Cultural controls modify how a plant is grown to reduce or eliminate pests. This includes anything to do with planting and maintenance, such as plant spacing, crop rotation, and timing of planting or harvest to avoid pests. Cultural practices can be grouped into several general categories: avoidance, eradication, and sanitation.

Avoidance

Avoidance uses cultural practice to keep pests away from your plants.

There are several easy ways you can avoid pathogens. Many plant pathogens, particularly viral and bacterial pathogens, are carried on seed. Using clean seed and plants from a reputable source can prevent disease problems (see box on nursery inspectors).

- Buy seed that is certified as disease- or pathogen-free. Certification doesn't guarantee that there are absolutely no pathogens in the seed, but does indicate that the seed has been produced in a way that minimizes the likelihood pathogens are present.
- Planting certified virus-free stock is a good way to avoid virus-related diseases in clonal plants like potatoes or raspberries.
- When buying transplants, make sure that the plants look healthy. In addition to inspecting leaves, stems, and branches, try to get a look at the plants' root systems for root browning, which may be an indication of a root rot or nematode problem. Also inspect plants for insects like aphids and leafhoppers that can transmit viruses and phytoplasma pathogens.

When using mulch, make sure it is free of weed seeds and disease- or insect-infested materials. Purchase mulch from reputable sources. You may need to examine "free" municipal mulch carefully.

> Nursery inspectors at the state and federal level implement programs to screen plant materials at points of entry, in the field, and at garden centers. These inspections minimize the chances of you inadvertently purchasing plants with pesky hitchhikers.

Avoidance techniques can involve avoiding the pests themselves as well as avoiding environmental conditions that favor insect presence or disease development. Don't plant in soil types that encourage pathogens, such as heavy, poorly drained soils that can cause root rot.

Avoid planting during particular times of the season when insects or pathogens are known to be present. For example, prevent **damping off** disease in vegetables by planting later in spring when soils are dryer and warmer. Monitor soil moisture to avoid conditions that favor disease.

- While you can't stop rain from coming, you can control how often and how much you water during dry periods. Provide only enough moisture to prevent your plants from experiencing water stress.
- Be careful not to over-mulch since mulch tends to retain water. A layer more than 3 inches thick is not recommended and can be detrimental.
- High humidity and long periods of leaf wetness favor foliar pathogen infection and reproduction. Modify the environment by orienting your garden rows in a north–south direction, allowing winds to dry the foliage quickly.
- Crowded plants tend to reduce air movement and promote wet leaves. Pruning or increasing plant spacing will increase air movement around landscape or vegetable plants and reduce moisture levels that certain pathogens, such as powdery mildew, require.

Make the area unfavorable for insect pests. Some insects prefer dense cover—keeping an area open will discourage them. Iris borer females prefer to lay eggs on iris plants in weedy patches. Keeping iris beds well-weeded will reduce iris borer infestations.

Minimize the tilling of soil, which can bring weed seeds to the surface and trigger growth. Keep garden areas mowed and avoid piles of garden debris, which might harbor rodents and other problematic garden wildlife.

Crop rotation is a common method of reducing populations of certain insects and microbial soil pathogens. When you plant the same (or closely related) plants in the same location each year, you risk building up soil-borne insects and diseases that can seriously impact the yield of future crops. Planting crops in different locations each year will help to prevent this from occurring. See chapter 14, Vegetables.

Eradication

To eradicate a pest is to eliminate the pest or a key component in the pest's life cycle. In terms of plant pathogens, to effectively eradicate a pest, you need to know its host range and how long it can survive in the absence of a suitable host. For example, plants in the nightshade family (Solanaceae), such as tomatoes and potatoes, are susceptible to early blight, *Alternaria solani*. Early blight remains in the soil on infected seeds or plant debris for up to one year. By rotating plants in the nightshade family throughout the garden on a two-year (or more) cycle, you can reduce the risk to new plants. Planting something the pest can't eat or infect in previously affected places will eventually reduce or eliminate the pest population by removing the food source.

> One early attempt at controlling emerald ash borer was to remove all ash trees (*Fraxinus* spp.) within a several-mile radius of a find. This method of management was eventually abandoned due to the cost and ineffectivness.

Control of **alternate hosts** is another effective method to reduce pathogens. Many disease pathogens require an alternate host for development. Controlling this host can prevent pathogen build up and reduce the waiting period before replanting a desirable ornamental back into a previously problematic spot.

If you have had chronic problems with a particular disease, check to see if there are other hosts of the pathogen nearby. Do not plant any host for the pathogen in the affected area of your garden. Learn about potential weed hosts and keep these under control. For example, cedar-apple rust can be found on the leaves, twigs, and fruits of apples and crabapples and can cause considerable damage. As a part of its life cycle, this disease pathogen also requires juniper (red cedar) plants as an alternate host. If you wish to reduce the likelihood of cedar-apple rust on your apples, remove nearby juniper plants or make sure that you don’t plant apples near juniper plants.

Sanitation

Sanitation is a cultural practice that reduces or eliminates the source of certain pest problems. Keeping your garden, work areas, and tools clean is a fundamental and important means of pathogen and disease control. Many insects and pathogens overwinter on plant debris and quickly move back to the plant host in the spring. A simple fall cleanup will eliminate overwintering sites for these pests.

- Rake up and dispose of infected leaves, which are a major source of spores that cause apple scab or powdery mildew infections. The severity of these and many other foliar plant diseases can be reduced in the following year with a good fall cleanup.
- Don’t compost diseased plant material unless your compost pile reaches the high temperatures necessary to kill disease-causing organisms (which home compost piles generally do not).
- Remove dead plant material in the fall to reduce overwintering sites for some insects. Asparagus beetles overwinter as adults in crop residue or trash, so cleaning up all the old ferns will eliminate many places for the beetles to hide.
- Weedy borders can serve as source of weed seeds, bothersome insects, some diseases, and unwanted animal life.

Diseased plants or plant parts can serve as a source of inoculum, so removing infected plant material can reduce disease. Selective pruning of trees or shrubs can sometimes prevent isolated infections from affecting the entire plant. Some pathogens (in particular *Botrytis*, a common fungal pathogen in ornamentals) have difficulty directly infecting healthy plant tissue but readily infect **senescing** (dying) tissue. Removal of senescing tissue can significantly inhibit development of these diseases.

Clean and disinfect gardening tools when moving from one area to another in your garden to reduce the chance of moving pathogens. This is especially important when you have been working in an area where you have historically had disease problems. Disinfect pruning shears between individual trees or shrubs, or even between cuts on the same tree or shrub. To disinfect tools, use a 10% bleach solution, alcohol (including sprays with alcohol as the major ingredient), or another disinfectant.

Dirty pots and workbenches can serve as reservoirs of plant pathogens as well. Wash bench tops thoroughly, then disinfect them with a 10% bleach solution or another disinfectant. To disinfect clay pots, wash thoroughly then soak for a minimum of 20 minutes in a 10% bleach solution. Be cautious when reusing plastic pots. Some research indicates that certain root rot pathogens can survive in plastic, even after soaking in 10% bleach.

Host plant resistance

This approach uses special cultivars or varieties of plants that are not susceptible to or are tolerant of certain pests. This approach is much more effective for plant diseases than insects for plants in the home garden, so this discussion focuses only on disease resistance.

Many varieties of vegetables and some ornamentals are considered “resistant” to specific diseases. The term is often mistakenly used interchangeably or in conjunction with “immunity” or “tolerance.” If a plant is never affected by a particular disease, then the term “immune” can be used. Resistant varieties can still become diseased, but not as much as nonresistant (or susceptible) varieties. Tolerance describes a plant (usually a food crop) that may become substantially diseased but produces higher yields than a susceptible variety with the same amount of disease.

Keep in mind that some plants that are resistant under certain environmental conditions will not be resistant under other, more extreme environments. Prime examples are powdery mildew-resistant phlox varieties. In a normal year, these varieties exhibit a high level of powdery mildew resistance. During extremely wet years, however, these varieties may not fare much better than susceptible varieties.

You can find lists of resistant plants in many Extension publications and seed catalogs. When disease-resistant varieties are available, choose them carefully. Select varieties that are resistant to the diseases common in your area. Look for disease-resistant plants that have been tested in multiple sites, over several years, and under a variety of weather conditions. Keep in mind that disease resistance is relative and temporary. Varieties that are resistant today may not (and likely will not) be resistant in the future. Pathogens are very adaptable, and resistant varieties tend to select for variants of the pathogen that can overcome resistance.

Biological controls

Biological control is the purposeful manipulation of beneficial organisms (or natural enemies) to manage pest populations. This is a wonderful option for some pests, but is not appropriate for all problems. Biological control utilizes natural enemies—predators, parasitoids, and pathogens—to kill the pests. Predators consume a number of pests throughout their lifetime, and usually feed as both immatures and adults on other insects, arthropods, or both.

Parasitoids—frequently wasps or flies—develop within the pest's body and kill it when the immature's development is complete. The adults are free-living and may require nectar, pollen, or both to reproduce. **Pathogens** are disease-causing organisms (primarily bacteria, fungi, and viruses) that may debilitate or kill the pest, reducing or eliminating reproduction. Pathogens are more commonly used for insect control, but can sometimes be used for controlling plant disease as well. You must be able to tolerate a low level of the pest in order for the beneficial organism to survive. There is often a delay between the initial pest outbreak and when the control agent becomes effective.

Biological control can be implemented in three very different ways:

- **Conservation** encourages the activities of naturally-occurring beneficial organisms by preventing their destruction (e.g., avoiding broad-spectrum pesticide use) or providing additional resources (e.g., providing flowering plants (nectar) for parasitoid wasp adults).
- **Augmentation** is the periodic release of natural enemies to supplement existing agents. Many natural enemies (e.g., lady beetles and green lacewings) can be purchased from commercial suppliers for this use. Microbial insecticides such as Bt are special formulations of insect-infecting pathogens that can be "released" with a sprayer.
- **Importation**, which involves releasing foreign natural enemies against non-native pests, is only conducted by federal or state government agencies. Once established, these natural enemies provide ongoing pest control. One example is the use of leaf-eating "Cella" beetles (*Galerucella* spp.) to control purple loosestrife.

Insect biocontrol

Insect biocontrol starts with conserving natural enemies already in the landscape by reducing indiscriminate pesticide use, which tends to kill both "good" and "bad" organisms.

- Lady beetles will often move into unsprayed areas and eat all the aphids on a plant, sometimes almost overnight.
- Later in the season, naturally occurring, insect-attacking fungi often wipe out aphid colonies—if those fungi haven't been killed by chemical fungicide sprays.

Other ways to encourage natural enemies include providing habitat and nectar sources for certain beneficial insects. Insect-attacking wasps need food and shelter, so providing flowers for them to feed or rest on will keep them around your garden longer.

Commercial businesses sell many beneficial organisms that can be used to reduce pests to tolerable levels, including:

- Lady beetles, which are excellent aphid predators, are sold commercially online and through many mail-order businesses. However, since they are sold as adults—which can easily fly away—they may not stay in the area you release them unless they have additional food after the aphids are gone.
- Green lacewings are a great choice for controlling aphids and other small, soft-bodied pests, since the immatures that do most of the feeding do not have wings and cannot leave the area where they're released.
- Numerous species of wasp parasitoids are sold for control of various pests. These are generally host-specific, so you must identify the pest correctly for these to be effective.
- Entomopathogenic **nematodes** are roundworms that infect insects only. They penetrate through the insect skin or natural body openings, release gut bacteria that kills the insect within 2 to 3 days, and complete their development through several stages within the dead insect. Nematodes require moisture to infect their host, so irrigation is needed. They are most effective against pests in soil, where a high moisture level can be easily maintained, as opposed to leaf surfaces which dry out quickly. Many species and strains (but primarily *Steinernema* and *Heterorhabditis*) are commercially available.
- **Bt**, the naturally occurring bacterium *Bacillus thuringiensis*, is the most common microbial insecticide available. Commercial preparations contain a toxin made by the bacterium that acts as a stomach poison. The bacterium is nontoxic to humans, but it can be an allergen or irritant, so it should be applied carefully. The insect pest must eat the toxin for the spray to be effective, so good coverage of the plant is essential. It may take several days for the insects to die, but feeding is suppressed soon after ingestion. Bt is most effective against young larvae, so proper application timing is important to achieving good control. There are several strains available that are effective only against certain types of pests, so select the proper type for your pest. *B.t. kurstaki* and *B.t. aizawai* are active against most caterpillars. *B.t. tenebrionis* is for leaf-feeding beetles, like Colorado potato beetle. *B.t. israelensis* controls mosquito larvae, blackfly larvae, and fungus gnat larvae. As with chemical pesticides, make sure you read the label carefully and follow the instructions.

Disease biocontrol

In plant pathology, biological control is the use of microorganisms or naturally occurring products to suppress or eliminate pathogens that cause disease. Biological pesticides are similar in many ways to chemical pesticides. They are products that are applied to plants in order to control plant diseases, but are biological, rather than chemical, in origin. Most biological pesticides are composed of microorganisms (bacteria or fungi) that either antagonize or compete with pathogens, thus preventing or at least reducing disease. One of the most successful biological protections has been the use of a bacterium (*Agrobacterium radiobacter*) to protect against the crown gall bacterium (*A. tumefaciens*). To control the disease, the roots of a seedling or nursery plant are merely dipped into a suspension of a commercial preparation of *A. radiobacter* prior to planting.

There are a number of commercial products available for biological control of soil-borne pathogens.

Weed biocontrol

Plant feeding organisms are used to reduce populations of unwanted plants. These organisms must be host-specific, otherwise they could destroy desirable plants. Insects and mites are the most common natural enemies used, but fish, snails, ducks, manatees, and parasitic plants have also been used in specific instances. Plant pathogens were once thought not to be host-specific enough, but it turns out in some cases they are, so more of these are being investigated for weed biocontrol.

Typically, governmental agencies or universities—not individual homeowners—implement biocontrol of weeds over a wide area. First, testing is done to make sure that the introduced biocontrol will not harm native plants or animals. One success story in Wisconsin is the introduction of leaf-feeding *Galerucella* beetles to control purple loosestrife infesting wetlands. Started as a research project by the Wisconsin Department of Natural Resources, the Purple Loosestrife Biocontrol Program now encourages citizen cooperation by offering free equipment and starter beetles to all state citizens who wish to use these insects to reduce their local purple loosestrife infestations.

Chemical controls

In an Integrated Pest Management (IPM) system, the last resort for controlling pests should be the use of pesticides. Chemicals are simply one tool in a toolbox available to help us control pests. In a perfect world we would not need such tools, but occasionally we must turn to pesticides as part of a complete management plan. IPM also actively seeks to minimize applications by reducing (only spraying when needed, and not according to a schedule) and replacing (using less toxic alternatives to synthetic pesticides) applications when possible.

Whether trying to control weeds, fungi, bacteria, rats, or bed bugs, there is a pesticide designed or marketed to target that pest. There are a great many pests we try to control, so it is not surprising that there are a great number of chemical pesticides—but not all the products are correct for the job. Examples of common garden pesticides include rose and flower sprays, seed treatments, weed killers, cut-stump treatments, weed-and-feed lawn care products, garden dusts, insecticidal soaps, rodenticides, and wood preservatives such as pressure-treated lumber.

There are also other chemical pesticides found inside your home. Bleach, kitchen and bathroom disinfectants, tub-and-tile cleaners, mothballs, and flea and tick products are all pesticides. These "hidden" pesticides won't be discussed in this chapter, but you should be aware that these products should be handled in the same manner as garden pesticides.

A pesticide is any substance used to directly control pest populations or to prevent or reduce pest damage. Not all pesticides actually kill the target pest; some may only inhibit its growth, repel it, or reduce its capacity to reproduce.

The most important rule to remember is to **always** read and follow all label instructions when using any pesticide.

Pesticide categorization

Chemical pesticides are complicated in their use and in their interactions with pests, humans, animals and the environment. Pesticides and their activity are pigeonholed in many different ways. Many people mistakenly use the words "insecticide" and "pesticide" interchangeably. However, note that the word "pesticide" is a broad term that covers many substances, while insecticides are just one specific type of pesticide that is aimed at one specific type of pest—insects in this case.

The most common way chemical pesticides are categorized is by what they kill:

- **Insecticides** kill insects.
- **Fungicides** protect plants by killing fungi that cause diseases.
- **Bactericides** control bacteria that cause diseases.
- **Nematicides** kill nematodes.
- **Rodenticides** kill rats, mice, ground squirrels, chipmunks, and other rodents.
- **Herbicides** kill, or prevent the growth of, weeds and other vegetation.

There are many chemical pesticides in existence, but not all of them can be used in or around your home or garden. Many pesticides are labeled for other purposes such as agriculture, industrial sites, forestry, etc. **Always read and follow pesticide labels and NEVER use a pesticide that isn't labeled for the site you plan to use it or in any other way not allowed by label directions.** Doing so could harm someone or damage the environment.

Although pesticides are commonly categorized by the pest they control, they are also classified by their chemistry, how they harm the pest, where they are used, and when they are applied. Pesticides as a whole can be grouped by whether they contain carbon or not or by the origin of their active ingredients—pesticides derived from natural sources (made by nature) or synthetic (human-made).

The pesticide you purchase is actually a formulation that contains a number of different materials. Under current law manufacturers are only required to list the active ingredients in a pesticide. The **active ingredient**s are the chemicals that kill, control, or repel pests. All the other ingredients are called "inert ingredients" by federal law. Although they are not required to list what the inert ingredients are—which may include carriers, solvents, surfactants, and other things that improve product performance and usability—these materials potentially can be as toxic as the active ingredients. Some products may also contain contaminants or impurities, which have not been purposefully added but are a function of the production process.

Organic options

The term "organic" is often used in relation with organic farming and production. Organic production can include using pesticides, but is limited to those that are derived from a natural source.

Don't confuse this with the definition of organic chemistry in which "organic" simply means "with carbon." In organic chemistry, any pesticide that contains carbon as part of its chemical composition is referred to as organic, whether or not it is man-made. In this context, most pesticides are organic, whether they are man-made or not, meaning they simply contain carbon.

The term "organic" is often used in reference to pesticides that are naturally derived. The term is associated with a certification process where a producer is required to follow specified guidelines. Many homeowners and gardeners choose to follow the same guidelines. These guidelines state that a producer or person **cannot** use synthetic fertilizers or pesticides. In the production classification, organic producers that use chemical pesticides must use pesticides derived from natural sources to maintain their organic certification. Some organic producers also use inorganic pesticides. See chapter 17, Organic Gardening.

Some people prefer to use only naturally derived pesticides. **Biopesticides** are certain types of pesticides derived from such natural materials as animals, plants, bacteria, and certain minerals. The EPA reported that in 2014 there were more than 430 registered biopesticide active ingredients in 1,320 products.

Botanicals are pesticides derived directly from plants and plant products. Some examples of botanical insecticides are neem oil from the neem tree (*Azadirichata indica*), pyrethrins, an extract from the *Chrysanthemum cinerariaefolium* flower, and rotenone, an extract from *Derris* or *Lonchocarpus* roots.

In some cases, oils can be used to control or repel insects and control weeds. When used as insecticides, oils either interfere with the insect's breathing or cell membrane structure.

Inorganic pesticides are elemental pesticides, comprised of minerals. These include pesticides that use sulfur, coppers, borate, diatomaceous earth, and others. The use of inorganic pesticides is not as common as it once was. One drawback to the use of inorganic pesticides is that they remain in their elemental form. There is no breakdown of the pesticide. Many of the inorganic pesticides used in the past, such as those containing arsenic, were also fairly toxic to humans and animals and are no longer approved for use.

Pesticides that are derived from natural sources all act in different ways on specific pests and have unique risks and toxicities.

Just because a pesticide is derived from a natural source does not necessarily mean it's safer than synthetic pesticides. In fact, plant-derived rotenone is much more toxic to humans than many synthetic chemicals. When choosing any pesticide, consider its toxicity and try to use the least toxic material labeled for that site. For more information, see chapter 17, Organic Gardening.

Home remedies

You may have heard about remedies for pest control that use dishwashing soap, tobacco juice, vinegar, antiseptic mouthwash, or some other household ingredient. Most of these concoctions have not been proven effective and may actually pose more risks to the plant you are treating than a synthetic pesticide.

Synthetic pesticides
Most of the pesticide products you will find in a garden center are synthetic. **Synthetic pesticides** are pure chemicals created from various compounds in a lab. Their toxicity varies considerably and they come in many different formulations. Formulations contain the pure form of the active ingredient and various inert ingredients, including dry or liquid carriers that make it easier to store, mix, and apply.

Minimum risk (25)b exempt pesticides
Minimum risk pesticides are a unique group of pesticides deemed by the EPA to pose a minimum risk to users and the environment. Both their active and inert ingredients must be demonstrably safe for the intended use. To be exempt from registration as a minimum risk pesticide, the pesticide must meet five conditions:

1. The product can only contain ingredients listed as minimum risk by the EPA.
2. The product can only contain the inert ingredients that the EPA has listed as minimum risk.
3. The ingredients must be listed on the label.
4. The label cannot include any false claims.
5. Public health claims are prohibited.

For a list of minimum risk active ingredients, see the EPA web page on minimum risk pesticides.

Some naturally derived pesticides, such as pyrethrum, also have synthetic counterparts—in this case, synthetic pyrethroids. Synthetic pyrethroids act the same way as naturally occurring pyrethrum, but some of the undesirable characteristics of the natural product (primarily degradation by sunlight) have been eliminated.

Insecticides
Not all insecticides are registered for use against all pests. Read the pesticide label to be sure the insecticide is effective against the pest you are trying to control and is registered for use on the specific plant the pest is on or the site you wish to use it. Follow the directions carefully to prevent poisoning yourself or others (including pets).

There are many different kinds of insecticides that control or repel insects in many different ways. Many insecticides affect the function of the insect's nervous system. For example, organophosphates inhibit the enzyme cholinesterase, which interferes with nerve impulses. Pyrethroids and pyrethrins are sodium channel modulators, which also interfere with nerve function. Yet other insecticides affect the development of the insect, ranging from **exoskeleton** development to growth stages.

Several pesticides have recently been implicated in the deterioration of pollinator health. Studies have suggested that certain pesticides may be one component in pollinator decline. The EPA has begun taking steps to protect pollinators. One step is to alert pesticide users of adverse effects on pollinators. Labels of pesticides that have these alerts will have new warnings and use restrictions.

Labels for pesticides that contain neonicotinoids

Products that use the "bee icon" are insecticides whose active ingredients contain one of the neonicotinoids, including:

- acetamiprid
- clothianidin
- dinotefuran
- imidacloprid
- thiacloprid
- thiamethoxam

Many of these are not available for home use and may have label restrictions regarding use timing and notification to bee owners. Other groups of pesticides may be added later.

This bee icon and accompanying advisory statements appear in the "Directions for Use" section of the pesticide label. The icon alerts pesticide applicators that special advisories apply to the product's use in order to protect bees.

Insecticides can be botanical, inorganic, oils, soaps, or synthetic. Table 1 lists some common insecticides. For more information on insects, see chapter 5, Entomology.

Fungicides and bactericides

To properly control diseases, you need to know the disease cycle and host susceptibility to both select the proper pesticide and apply it at the

TABLE 1. Common insecticides for home use

Insecticide	Comments
BOTANICAL INSECTICIDES	
neem	Neem is an extract from the neem tree, *Azadirachta indica*, which disrupts insect growth, development, and feeding. It has low mammalian toxicity, but may be slow acting, taking 7 to 10 days to work.
pyrethrins	Pyrethrins are extracts from *Chrysanthemum cinerariaefolium* flowers. (Pyrethroids are synthetic chemicals that act in a similar manner.) Pyrethrins are non-toxic to most mammals but are poisonous to cats. They are fast acting, but have short persistence. They are often mixed with other substance called synergists that increase their effectiveness, like piperonyl butoxide or n-octyl bicychoheptene dicarboximide (which are not labeled for organic use).
rotenone	Rotenone is an extract from the roots of *Derris* or *Lonchocarpus* and related plants. It's moderately toxic to humans and can be irritating to skin and mucous membranes. It is also very poisonous to fish.
ryania	Ryania is an extract of the roots and stems of *Ryania speciosa* that is moderately toxic to humans.
sabadilla	Sabadilla is an extract from the seeds of *Schoenocaulon officinale*. It has low human toxicity (the dust can irritate nasal tissue) but is toxic to honey bees.
INORGANIC INSECTICIDES	
cryolite	Cryolite contains sodium fluoaluminate, which works as a stomach poison against beetles and caterpillars. It is non-toxic to mammals, birds, and honeybees and most other beneficial insects, but it is slightly toxic to fish.
diatomaceous earth	Diatomaceous earth is the fossil shells of microscopic marine algae called diatoms. When crushed, their very tiny silicon shells are razor sharp and can abrade the insect exoskeleton, causing **desiccation**. This product is most useful in stored grains or against indoor pests; outdoors it must be reapplied after every rain. Even with thorough coverage, pest control is variable. The dust is non-toxic to humans, but it can irritate the lungs.
elemental sulfur	Ground elemental sulfur is used for powdery mildew, spider mite, and thrips control. It is non-toxic to mammals but can irritate skin, eyes, and mucous membranes. Sulfur can also burn plants, especially when temperatures are above 90˚F.
MICROBIAL INSECTICIDES	
Bacillus thuringiensis (Bt) [various strains]	This insecticide is based on a naturally occurring soil bacterium. Strains are available to specifically control caterpillars, beetles, or flies. After application, it must be ingested by insects to be effective. See chapter 17, Organic Gardening.
Spinosad	This insecticide is based on a naturally occurring soil bacterium and has a broader range of activity than Bt. After application, it must be ingested by insects by be effective.
OILS & SOAPS USED AS INSECTICIDES	
dormant oils	Dormant oils are intended to be applied to non-growing plants, primarily trees before bud break. These heavy petroleum distillates can be phytotoxic (cause foliar burning or branch die back) when applied to certain plants or green foliage.
summer oils	Summer oils are more highly refined than dormant oils and can be applied to leaves of many plants without **phytotoxicity**.
insecticidal soap	A soap solution most effective against soft-bodied insects, like aphids. Must be applied directly to insects to kill them and has no residual activity; frequent applications may be required.

right time and in the right way. Some fungicides can be **phytotoxic**, and if used improperly, can lead to plant injury and ineffective management.

Fungi are the most common disease-causing agents in the plant world. Although bacteria can also cause disease in plants, there are a limited number of products designed to control bacterial diseases in plants. Virus and plasmids can also be causal agents, but there are no pesticides available that control viruses or plasmids.

Management of these agents is usually done through quality control, resistance, and controlling the **vectors** that transmit them.

Fungicides control or inhibit fungi in many ways. They interfere with the metabolic process in fungi that ultimately inhibit amino acid production, cell division, synthesis of RNA, membrane formation, and more. However, they are often grouped by how they protect the plant against fungal disease:

- **Protectant fungicides** are applied to the surface of a plant and must coat the entire surface to be effective. Protectant fungicides are not absorbed by the plant, but rather form a chemical barrier between the pathogen and the plant. This group is also said to have preventative activity. Good coverage is critical. These have to be applied repeatedly as the plant grows, as new growth will not otherwise be protected.
- **Systemic fungicides**, or fungicides that have "early-infection activity," are absorbed by the plant and redistributed internally, so application coverage is not as critical as with protectant fungicides. Systemic fungicides tend to remain effective for a longer period than protectant fungicides, because they are less likely to wear or wash off the plant and have less exposure to environmental factors that may lead to degradation. These fungicides are said to have curative activity, but they tend to be most effective 24 to 72 hours after infection occurs.

TABLE 1. Common insecticides for home use, *continued*

Insecticide	Comments
SYNTHETIC INSECTICIDES	
acephate	Acephate is used on woody ornamentals and flowers. It has low mammalian toxicity and comes as an emulsifiable concentrate.
carbaryl	Carbaryl is used against a variety of insect pests. It has low mammalian toxicity, but it is highly toxic to bees and should never be applied to flowering plants. It comes in various concentrations of wettable powders, flowables, dusts, and in baits.
chlorantraniliprole	Considered a "Reduced Risk Pesticide" by the EPA. It is commonly used on turfgrass and ornamentals to control white grubs and caterpillars.
neonicotinoids	Neonicotinoids (including acetamiprid, clothianidin, imidacloprid, dinotefuran and thiamethoxam) are systemic products that come in several formulations. They are commonly applied to the soil to control beetles and white grubs. These products are highly toxic to bees and special care must be taken to minimize risks to pollinators.
phosmet	Phosmet is used on woody ornamentals and fruit. It is moderately toxic to humans and highly toxic to bees. It comes as a wettable powder.
pyrethroids	Pyrethroids—including bifenthrin, cyfluthrin, deltamethrin, esfenvalerate, lamba-cyhalothrin, permethrin, and others—are used on a variety of landscape and indoor pests. Some can be used on some fruits and vegetables. Some can cause spider mite outbreaks, many are temperature-sensitive (they are not effective above 85˚F), and some are toxic to fish.
trichlorfon	Trichlorfon can be used on a variety of insects on turf and some ornamentals. It has low mammalian toxicity and low toxicity to bees. Formulations are granulars and soluable liquid (SL).

- **Anti-sporulant fungicides** inhibit the production of spores. Spores are how fungi spread in the wind or rain. Stopping the production of spores will not stop the progression of disease in that plant, but will inhibit spread and reduce the amount of inoculum.

Fumigants are another type of compound used for control of pathogens, particularly pathogens found in soil. Fumigants are general **biocides** (toxic to all kinds of biological organisms, including pathogens, non-pathogens, insects, weeds, and even desirable plants and animals). Fumigants are not recommended for use in urban settings and the use of fumigants is highly regulated, requiring certified and licensed applicators and recorded management plans.

As with insecticides, there are a variety of fungicides on the market, but very few fungicides and bactericides are available for use at home (see table 2) as they are not appropriate for the home garden.

For information on plant diseases and disorders, see chapter 6, Plant Pathology.

TABLE 2. Common fungicides and bactericides for home use

Fungicides and bactericides	Comments
BIOFUNGICIDES/BACTERICIDES	
Ampelomyces	This biofungicide uses the fungus *Ampelomyces quisqualis* to control another fungus. This fungus is a parasite of several powdery mildew species.
Bacillus	Seed treatment of a bacterium that will colonize developing roots competing against fungal pathogens.
Gliocladium	Used as a drench for the inhibition of seedling and root diseases.
streptomycin (bactericide)	An antibiotic derived from a soil-borne bacteria. Used in the control of fire blight.
SOAPS	
various soaps	Soaps can be effective on powdery mildew.
INORGANIC FUNGICIDES	
copper compounds	Bordeaux mixture often used in grapes to control downy mildews. Used to control cankers, galls, blights, and leaf stops.
lime sulfur	A fungicide that will also control mites for fruits, nuts, ornamentals, and roses. Can be corrosive to flesh—eye protection is required.
OILS USED AS FUNGICIDES	
neem	Oil derived from the neem tree for powdery mildew control.
jojoba	Oil derived from the shrub *Simmondsia chinensis* (jojoba). Used for powdery mildew.
SYNTHETIC FUNGICIDES	
captan	Common general use fungicide available in many formulations. Not to be used in close proximity with oil sprays.
chlorothalonil	Also a common general-use fungicide. Used for mildews, blights, and anthracnose.
mancozeb	Has been formulated as liquid concentrates and granules. It has low mammalian toxicity, but can be toxic to aquatic organisms. Often formulated with zinc.
maneb	Has activity with a wide range of diseases. Often formulated with zinc.
myclobutanil	Found in several products. Used for leaf spots, powdery mildew, and rots. Labeled for several vegetables.
propiconazole	A systemic fungicide for lawns.
thiophanate-methyl	Available in many different products. Labeled for ornamental turf and plants.
triflorine	Used to control leaf spots and powdery mildew on ornamental plants and flowers. Can be found in liquid and granular formulations.

Herbicides

Herbicides are some of the most-used pesticides. They are often mistaken as not being pesticides at all. If you ask homeowners if they use pesticides a few always seem to say, "I don't use pesticides, I just use weed and feed." In reality the "weed" part of "weed and feed" is a pesticide—an herbicide.

As gardeners—whether for a hobby, to produce food, as a side business, or just to make the yard look great—people spend a lot of time and effort on the plants they grow. Herbicides kill plants, the very things they are working to promote. So, care must always be taken to use herbicides in a safe, legal, and planned manner so as not to injure or kill the very plants people are growing.

Like insecticides and fungicides, herbicides are highly variable. If you consider the variability of weeds, it makes sense that there many kinds of herbicides. And some of those herbicides, as with insecticides and fungicides, are not labeled for home garden use.

Herbicides marketed toward homeowners use are usually formulated to make them more convenient and easier to apply than those prepared for agricultural use. Herbicides labeled for agriculture may not be labeled for home use. Be cautious if using products purchased at farm chemical retail stores—these often require more dilution than the homeowner version or need to be applied by licensed operators. In addition, be patient when working with herbicides. You may not see results right away, and additional applications may result in plant damage and run-off pollution.

Apply herbicides evenly. Most herbicide rates are suggested for use on an area basis, so you need to know the approximate area of the beds to be treated. Calculate the rate of application carefully and make sure application equipment is calibrated properly to assure the garden doesn't get too much or too little herbicide. Under-application will result in poor weed control, while over-application may result in damaged plants.

Herbicides are grouped and categorized in many different ways: what they control, how they work, when they are applied, where they are applied, chemistry, and selectivity.

Herbicides can be **selective** or **nonselective**:

- An herbicide is said to be **selective** when it has activity on one group of plants, but little or no activity on others. Selective herbicides should only be used as directed on the pesticide label. For example, a selective herbicide that kills broadleaf weeds in a lawn is likely to injure broadleaf non-target plants if applied in the garden. Often selectivity is based on the desired plant being resistant to the herbicide. Synthetic auxins, such as 2,4-D, control broadleaves but typically have little activity on grasses.
- **Nonselective** herbicides injure any plant tissue they come into contact with. They typically kill or injure plants across groups. Nonselective herbicides are called so because they often kill the desired plants as well.

Herbicides can be grouped based on how they act upon contact:

- **Contact** herbicides cause localized injury on plant tissue only where the herbicide comes in contact with the plant. These herbicides require good coverage to coat the weed to get effective control. Contact herbicides can kill the plant above ground only. They can work well against small annual seedlings.
- **Systemic** herbicides are either taken up by the roots, leaves, or both. These herbicides can move through the plant either moving with the water (root uptake) or phloem (foliar applied). Thorough coverage is not as essential. You need to use systemic herbicides to control perennial weeds because you need to kill the root system. When controlling perennial weeds, optimum timing is often in the fall before leaf loss, when perennials are sending sugars into the underground portions of the plant.

Herbicides can be grouped by the timing of their application:

- **Preemergent** herbicides are applied to the soil before weed seeds germinate. This type of herbicide prevents the germination and growth of seeds and young seedlings and will not affect existing weeds. This means proper application timing is crucial because the herbicide works when seeds take in water. Preemergent herbicides require some water irrigation into the soil. This serves to both incorporate the herbicide into the zone of activity and to provide a substrate for absorption. Dry periods of 7 to 10 days will prevent successful use of preemergent herbicides. Before use, consider soil type, which could affect efficacy. Depending on the soil temperature, soil texture, moisture levels, and type and amount of herbicide applied, preemergent herbicides can last anywhere from a few weeks to a few months in the soil.

- **Postemergent** herbicides (often called foliar-applied) are applied to already established weeds. Postemergent herbicides are either systemic or work on contact.

  Postemergent herbicides can affect both desirable and undesirable plants, so must be applied carefully. These products are most effective when applied at a specific time in a weed's growth cycle, such as when a plant is taking up water from the roots during active foliar growth (systemic), or when storing nutrients in the roots for the dormant season (contact, post flowering).

Knowing whether a weed is an annual, biennial, or perennial will dictate the timing and type of herbicide used. Postemergent herbicides are most effective when applied to green, actively growing plants. Table 3 lists common herbicides for home use.

For more information on weeds, see chapter 7, Weeds.

TABLE 3. Common herbicides for home use

Herbicide	Comments
MINIMUM RISK (25)B	
corn gluten meal	Corn gluten is used as a preemergent herbicide. Some products combine corn gluten with fertilizers in a weed-and-feed combination.
citrus oil, castor oil	These oils can aid in dehydrating weeds by stripping the waxes off the leaf.
sodium chloride (common salt)	Salt has been used as an inorganic pesticide for some time. Most plants are not salt-tolerant; salt should used only in spots where nothing is to be grown.
MISCELLANEOUS	
horticultural vinegar	These herbicides provide **burndown** activity—killing the above-ground shoots but likely leaving the roots alive—of small seedlings. They often contain anywhere between 7 and 30% acetic acid. Some may also contain citric acid. The higher percentage products will have the signal word "danger"—due to its corrosive nature, it will cause irreversible eye damage if eye contact is made. There are presently three horticultural vinegars registered in Wisconsin for organic gardening.
SYNTHETIC HERBICIDES	
2,4-D	2,4-D is a synthetic auxin that has activity on broadleaf plants. The two most common formulations are the ester and amine. Typically the amine formulation is used for home use because it is less volatile than the ester. Many trees and broadleaf plants, for example tomato and grape, can be sensitive to 2,4-D.
dicamba	Dicamba works in a similar way as 2,4-D and is a synthetic auxin. Different formulations have different volatility potentials.
glyphosate	Glyphosate is one of the most ubiquitous herbicides. It is a systemic herbicide with low mammalian toxicity. Glyphosate will injure any green plant that it touches and is often used in the control of deep-rooted perennials. Although glyphosate has no residual activity due to its tendency to bind to the soil particles, it has a half-life of about 47 days.
MCPA	MCPA is often mixed with other herbicides such as 2,4-D and dicamba. Products with MCPA can often have the signal word "danger" due to possible eye injury.
quinclorac	Quinclorac is often in mixes with 2,4-D and dicamba for home use products. It is a synthetic auxin for the control of broadleaf weeds. However, quinclorac has some grass activity. It is often the crabgrass control in the combinations.
triclopyr	Triclopyr is often used for the control of woody shrubs and vines. Often used to control poison ivy.
trifluralin	Trifluralin is a preemergent herbicide that needs some soil incorporation.

Pesticide safety

Pesticides are tools with the potential to cause harm if not used correctly. Part of the risk of using a pesticide is that specific chemical's toxicity.

Pesticide registration

The most prominent pesticide law is the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA). Pesticides and their use are highly regulated. FIFRA gives the Environmental Protection Agency (EPA) the authority to regulate pesticide use in the U.S.

All pesticides must go through the registration process to be used in the U.S. Exceptions to this are the minimum-risk pesticides discussed previously. Registrants must provide data showing efficacy and identifying risks and possible hazards for the uses of each pesticide. The EPA then reviews the data and uses a benefit versus risk analysis to determine if the pesticide should be registered or not, and if so, the level of regulation that must be implemented. The EPA is responsible for all pesticide regulation in the U.S. and is constantly reviewing scientific evidence concerning pesticide use. As new findings identify higher risks, the EPA can alter the use of a pesticide; in some cases, if the risks outweigh the benefits, the EPA will cancel the registration of a pesticide. Some examples of pesticides that have been canceled are DDT, chlordane, and diazinon. It is illegal to use pesticides that have been canceled.

FIFRA sets the federal backbone of pesticide laws in the U.S., but each state can make laws that are more restrictive than federal law. In the state of Wisconsin, the prominent law that deals with pesticide use is Agriculture, Trade and Consumer Protection chapter 29 (ATCP 29). Although these are the two most prominent laws regarding pesticides, there are many other laws and agencies that have rules dealing with the transport and use of pesticides. Some examples of this are the Department of Natural Resources (DNR) and the Department of Transportation (DOT).

Risks, such as toxicity and environmental concerns, have to be identified in the labeling of the pesticide. In essence the EPA regulates the uses of the pesticide by registering the pesticide label.

All pesticides are designed/intended to kill a particular pest, but most have a greater spectrum of activity than just the target pest(s). The range of this activity varies considerably. For example, the herbicide glyphosate kills almost any green plant it is sprayed on, while 2,4-D used for lawn weed control only kills broadleaved plants without harming the grass. Many of the older insecticides are very broad-spectrum and kill almost any insect they contact, while newer insecticides have been developed that affect only a few groups of insects. The most selective pesticide should be used whenever possible—**when choosing pesticides, choose the one with the narrowest spectrum as to minimize the likelihood of killing an unintended target**.

Birds, beneficial insects/pollinators, fish, and adjacent plants are some of the organisms that may be indirectly affected by a pesticide application. Drift of herbicides as a fine mist can injure nearby plants. Contamination of waterways through runoff, careless application, or improper container disposal can kill fish and other aquatic life. Many beneficial natural enemies are inadvertently killed by broad-spectrum pesticides, so use them only when absolutely necessary. Flowering plants should not be sprayed with insecticides when bees and other pollinators are present. Humans and pets can also be poisoned if pesticides are used incorrectly.

Pesticide toxicity

The toxicity of each pesticide to mammals is different. Since we can't test for toxicity directly in humans, we use animals to make this determination and assume the toxicity will be similar. The actual toxicity is expressed as the LD_{50} or the dose that is lethal to 50% of a population of test animals (see table 4). LD_{50} values are calculated in milligrams of pesticide per kilogram of body weight. The lower the value, the more toxic the pesticide is because less is required to cause death. This number is a way of comparing the acute toxicity of different materials that act in different ways. Special signal words on the label provide information on the relative acute toxicity of the pesticide. A human would have to ingest as little as a taste to a teaspoonful of a highly toxic material for it to be lethal. Moderately toxic pesticides would require eating a teaspoonful to a tablespoonful. You would have to consume an ounce to more than a pint of low toxicity or relatively non-toxic chemicals to cause death.

Another component of toxicity is the length of time a pesticide persists in the environment. A pesticide with long-term residual activity may be desirable in some cases, although this increases the chance that it will be toxic to an unintended target. It is better in most cases to use pesticides with short residual activity to prevent inadvertent poisoning of other organisms.

The hazard of using a pesticide is based on the pesticide's toxicity and a person's exposure to that pesticide. For example:

Hazard = toxicity x exposure

People do not have much control over the toxicity of a pesticide; toxicity is a characteristic of the chemistry of the pesticide in question. People can have more influence over exposure, which is where personal protective equipment (PPE) comes in. The most common route of exposure is through the skin.

Personal protective equipment

A product label will tell you what to wear—it is a good idea to wear what it says. It is also required if you are going to use the product. Flip-flops and shorts will never be listed as good PPE on any label. PPE includes the clothing you wear to protect yourself from contact with pesticides.

- Unlined, chemical-resistant gloves should be long enough to protect your forearms. Leather or cloth gardening gloves are not chemical-resistant and should not be worn when applying pesticides. Similarly, "surgical" gloves are neither thick enough nor long enough to provide adequate protection. The best option is all-purpose dishwashing gloves.
- Button your sleeves and collars and wear pant legs over boots or shoes to prevent pesticide from getting inside your shoes. Coveralls may be worn over regular clothes for extra protection.
- In addition, some products may specify chemical-resistant boots, safety glasses or goggles, and a wide-brimmed rain hat.

Wearing the proper PPE will eliminate most exposure but cannot eliminate all exposure. If you use pesticides, use them wisely.

Be sure to put on PPE before handling a pesticide—this includes handling the product container. Keep PPE on during the entire mixing, application, and cleanup process.

TABLE 4. Signal word toxicity category

Category	Signal word	Oral LD_{50}	Dermal (skin) LD_{50}
1 = Highly toxic	Danger—Poison (skull and crossbones symbol)	< 50 mg/kg	< 200 mg/kg
II = Moderately toxic	Warning	50-500 mg/kg	200-2,000 mg/kg
III = Slightly toxic	Caution	500-5,000 mg/kg	2,000-20,000 mg/kg
IV = Low toxicity	Caution	> 5,000 mg/kg	> 20,000 mg/kg

Source: EPA *Label Manual Review*; www.epa.gov/oppfead1/labeling/lrm/chap-07.pdf

After making a pesticide application, wash your gloves and boots before removing them. Be sure to also wash your goggles. Check your gloves for holes regularly by filling them with water and squeezing. Do not use gloves that have been used for pesticide application for any other purpose. Store them along with all of your other PPE in a labeled plastic bag

When laundering clothing that has been worn during a pesticide application, launder separate from the family's laundry. Pre-soaking and washing in hot water may be necessary; refer to the pesticide label. Line dry if possible, as sunlight will help break down pesticide residues that remain and this will also prevent these residues from being deposited on the inside of your dryer. If you spilled a pesticide on your PPE, wrap the PPE in newspaper and place in the trash.

If you are contemplating working with or applying pesticides regularly, consider taking Pesticide Applicator Training. While this training is designed primarily for people who want to become professional pesticide applicators, it is also a good option for master gardeners or homeowners. For a nominal fee, the training provides extensive, easy-to-understand information on pesticides and their use.

Contact your county Extension office for more information about where and when classes are offered.

How to read a label

The pesticide label is often the only communication the manufacturer has with the user. Pesticide labels can be complex and are written based on regulations, the product's hazards and risks, how the pesticide behaves in the environment, efficacy, and safety. It is important to read the entire pesticide label every time you purchase and use any pesticide to make sure it contains what you think it does and that you are using, storing, and disposing of the product in the appropriate manner.

The pesticide label is considered a legal agreement between the manufacture and the consumer. The label is the law. If you use EPA-regulated pesticides, even as a homeowner, you are still bound by the law to follow the label—this is not just something for the commercial applicator or farmer. It's important to follow the directions on the pesticide label, or you may face fines for breaking a legal contract.

All pesticide labels contain the same categories of information. They do not, however, all follow the same format. Pesticide labels are often difficult to read—if you are unsure about anything on a pesticide label, ask your county Extension office or contact the product's manufacturer for an explanation.

Other important information about pesticides

Pesticide formulations

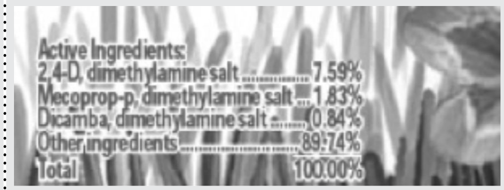
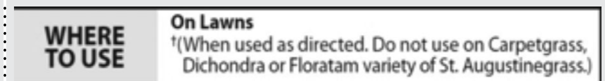
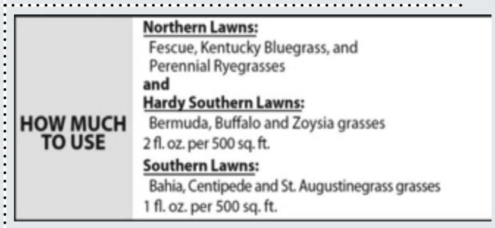
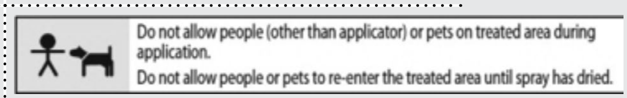
Pesticides can be formulated in many different ways. A pesticide formulation can increase activity, aid in mixing and handling, and may affect toxicity. Pesticides can be formulated as liquids, granules, dusts, oil-based, and many others. In the case of household products, the formulation is often called ready-to-use. This is a premixed and diluted product that is used as is.

In many cases you will be able to purchase the same active ingredient in several different formulations. Be aware of this and understand that you must use only the product labeled for that use.

Pesticide packaging

Pesticides come in a multitude of different packages. Purchase only the amount of material you really need. Buying the large container of concentrate may be more economical than the smaller, ready-to-use product, but can create problems if you end up with excess pesticide to store or dispose. Many pesticides have a limited shelf life, especially when diluted or stored inappropriately. On the other hand, a ready-to-use pump bottle of herbicide is useful for spraying weeds in sidewalk cracks but not a large area of lawn. Most pesticides are packaged in a variety of sizes—garden centers and similar retail outlets generally offer small quantities

The components of a pesticide label

1	Identifying Information	The label must provide the trade name and EPA Registration Number. It must also identify the active ingredients. In this case, this product has 2,4-D at 7.59%; Mecoprop at 1.83%; and Dicamba 0.84%.	
2	All pesticide labels must have signal word	The signal word is a relative indication of acute toxicity. Caution is the lowest, then warning, then danger. You may see danger/poison if the toxicity is high.	
3	The label must identify on what and where the pesticide can be used	The label must identify where it can be used: "on lawns" in this case, but not on carpetgrass, dichondra or Floratam variety of St. Augustinegrass.	
4	The label must identify the kinds of pests it controls	The label must identify which pests the pesticide will kill.	
5	How much of the product to use and how often it can be used	The label must tell you how much and how often you can apply the pesticide. In this case, 2 fl oz per 500 sq ft when weeds are actively growing. In another section it says you can apply this product twice in a year.	
6	Timing of application	In this product's case, the active ingredients at the rates that are used typically do not injure lawns, so they just provide the timing for the weeds.	
7	Safety information	The label will provide information on hazards and what you should do to avoid these hazards, such as what you should wear when you are using the product. In this case, a long-sleeved shirt, long pants, socks, shoes, and rubber gloves.	
8	The length of time you must wait before you can be in the area again and when you can harvest	After you apply the pesticide, there often is an amount of time that you have to keep people and pets away from the site. In this case, until the spray has dried.	

Source: Above examples have been taken from Bayer Advanced Weed Killer for Lawns. EPA Reg. No 72155-4 suitable for home use, while farm supply stores or chemical companies usually offer large quantities more appropriate for agricultural use.

Some products are packaged so they can be applied directly from the container, such as a spray bottle. For all other pesticides, make sure you have the appropriate application equipment. Most pesticides are applied with a sprayer, such as a hose end or compressed air sprayer. Do not use the same equipment for applying herbicides that you use for insecticides or fungicides. It is very difficult to clean the tank well enough to remove all herbicide residue. Plants could be injured or killed from the herbicide residue when a foliar treatment is applied.

In order to avoid any promotion of a brand name product, it is recommended to reference only the active ingredients in any pesticide. For example, refer to glyphosate-containing products rather than RoundUp;® Synthetic pyrethroids instead of Bayer.™ This also reinforces the habit of reading the labels as sometimes the same brand with similar packaging can have different active ingredients, and thus may have different instructions for use.

Storage conditions

Always store pesticides in their original, labeled container. Putting pesticides in old soda bottles or food jars is a leading cause of accidental poisoning. To help prevent degradation, mark containers with the date of purchase and use older products first. Store pesticides in a cool, dry, dark place protected from temperature extremes. Keep them separate from food, seeds, and protective clothing. This will prevent accidental contamination of these items.

Keep all pesticides out of the reach of children and pets—at least five feet from the ground and preferably in a locked cabinet or room. Even if you don't have children, friends and relatives may bring their children to your home.

Mixing and applying pesticides

Using pesticides involves the handling of a potentially hazardous product and therefore certain precautions must be followed. Read the entire label before mixing any pesticide product. The label will tell you what equipment you will need, whether conditions are right for application, and what precautions to take when handling the pesticide.

Mixing and loading can be the most hazardous time when using pesticides. Collect all of the necessary equipment for mixing, application, and cleanup following the application. Always measure the pesticide accurately. Designate a separate set of measuring spoons or cups solely for the purpose of pesticide mixing and label them clearly. Mix pesticides in a well-ventilated area away from a well or surface water.

Only mix pesticides if the weather conditions are suitable for spraying—this includes winds less than 5 miles per hour and no rain expected for the period of time specified on the product label. Don't smoke, drink, or eat while mixing or applying pesticides. This may seem obvious, but when wearing the necessary protective clothing on an 80˚F day you may be inclined to take a break in the middle of applying a pesticide to drink some water.

Don't mix one pesticide with another or with a liquid fertilizer unless the combination is listed on the product's label. When filling your sprayer with water, make sure to use an anti-backflow device, or an air-gap, between the hose and faucet to protect your water supply from accidental pesticide contamination. If you spill a pesticide while mixing, stop what you're doing immediately and right the container. Do not hose down the area until you have contained the spill. Contain the spill with an absorbent material such as kitty litter or sand. Put all of the contaminated material into a double plastic bag and discard in the trash. If the spill occurred on a hard surface, such as a driveway, scrub the surface with soapy water and rinse. For specific information, consult the label.

Before you make a pesticide application, you must prepare the area to be treated. Remove all food, toys, and pet dishes from the area. Keep adults, children, and pets away during treatment and for any time period afterwards that is specified on the product label. In most cases, children and pets may reenter a treated area after the pesticide has dried, but the label will specify the exact time period. If you are treating an area outdoors near the house, close nearby windows to prevent the pesticide from entering the house.

Calibrate your equipment with water (do not use a pesticide to calibrate) and make sure it's working properly and doesn't leak. Follow the manufacturer's instructions on calibration or consult Extension publications that include calibration techniques. **Never open a sprayer when its contents are under pressure; the materials may spray onto you.** The owner's manual will tell you how to relieve the pressure before opening the container.

Check the weather before making outdoor applications.

- Don't spray if the wind is blowing hard enough to keep leaves in constant motion. Many of the spray droplets coming from your sprayer are too small to see. Even if you were to stand in the way of these fine droplets, you may not realize the spray is landing on your body. The finer the droplets and the stronger the wind, the more likely drift will occur.
- Don't spray if rain is expected within the time period specified on the label.
- Avoid applying pesticides when the air temperature exceeds 80˚F as some plants can be damaged by pesticides that volatilize in hot conditions.

Spraying in the early morning or evening when the wind is calm is the best time to make pesticide applications without causing damage to other plants or pollinating insects.

Do not apply insecticides to flowering plants if bees or other pollinators are present or are likely to visit the blooms within a few hours of application.

When applying pesticides to your lawn or garden, post the area with signs saying "Pesticide Application—Keep Off" to alert others to stay out of treated areas. Leave the signs up as long as the reentry period demands. Homeowners are not required to post their applications when using pesticides sold for homeowner use, but it's a neighborly thing to do. Signs can be obtained at large garden centers where pesticides are sold.

After application, clean your equipment thoroughly. Fill the sprayer part way with water, shake, and spray the rinse water onto a safe area (see the label instructions for details). If you applied a granular weed-and-feed product, make sure you wash off the spreader before storing it. Once your equipment is cleaned and the pesticide concentrate safely stored, remove your personal protective equipment and wash thoroughly with soap and water separately from household laundry.

Disposal

Each type of pesticide has its own set of disposal options. **Never pour unwanted or leftover pesticide on the ground, in the storm sewer, or down the drain**. If you have an unwanted pesticide in its original container the best option for disposal is to give it to someone who can use the product. If this isn't an option, take it to your local clean sweep site or permanent local household hazardous waste facility. Your county Extension office or local recycling and solid waste department can tell you when and where the clean sweep site is located. If you purchased a pesticide and realized that it isn't the product you need, you may return the unopened container, along with the receipt, to the retailer.

Occasionally, you might mix too much pesticide in a sprayer to use. If possible, apply this excess to another site listed on the label, or give the sprayer and the labeled container to a neighbor for their use.

When you've emptied a pesticide container, rinse the container three times by filling it with water to about 20% of its capacity, shaking it, and then pouring the rinse water into the sprayer. Wrap the triple-rinsed container in newspaper and place it in your trash. Do not reuse, recycle, bury, or burn empty pesticide containers. Cut the bottoms off of bags of weed and feed and shake the bags over the fertilizer spreader to remove any excess granules that may be trapped in the folds of the bag.

If you spill a pesticide concentrate on your clothing, dispose of the clothing by wrapping it in newspaper and placing it in the trash. You cannot fully clean clothing that has been drenched with pesticide concentrate.

Rodent baits, no-pest strips, treated seed, and other pesticide-impregnated products should also be wrapped in newspaper and placed in the trash.

Conclusion

Knowledge is a critical component of integrated pest management (IPM). Having the know-how to keep plants healthy in the first place will do a lot to stave off pest problems. When pests do occur, knowing about the pest's life cycle and biology can allow you to make the most appropriate choices for management tactics.

Pesticides are tools, with the potential to harm you, surrounding people and animals, and the environment. You can reduce the risks by using them properly and according to the label instructions. The decision to use pesticides is legally yours, but be sensitive to the fact that others may not share your comfort with the use of this tool. Communicate with the people around you to ensure that others and animals do not chance upon your application unawares.

Most pests can be controlled without a spray bottle, but if a chemical control is necessary, choose the product that will most effectively get the job done in a manner that has the least impact on your garden and the environment.

Resources

Wisconsin Horticulture publications are available at hort.extension.wisc.edu.

FAQs

Is there one thing I can use that will take care of all my pest problems?
Since all pest problems are different there isn't one broad solution. Use Integrated Pest Management techniques to garden in a way that can reduce disease, increase beneficial insects, and eliminate weed pressure.

If it's organic, it must be safe, right?
Not all organic pesticides are safe. Read the label of all pesticides to better understand the risks with using them.

How can you have a spray if it's organic?
Organic just means it comes from natural sources. There are many organic pesticides that can be used by organic growers, and these come as sprays, powders and liquids just like synthetic pesticides.

I used twice as much spray and now the plant doesn't look very good…
Always follow the label instructions. Pesticides are specially formulated to work at the concentrations listed on the bottle. Using more than stated can injure (or kill) plants and create pesticide resistance in the pest populations you're trying to control.

IPM, practice exam questions

(Answers below)

1. **The first step in an IPM plan is:**
   a. Spray the pest with the appropriate chemical
   b. Determine at which action threshold to take action
   c. Monitor the environment
   d. Obtain knowledge of the pest, host and ecosystem
2. **Which of the following is an acceptable solution for managing cosmetic damage on a plant?**
   a. Spray the pest with the appropriate chemical
   b. Tolerate the damage
   c. Dig out and dispose of the plant
   d. All of the above
3. **Applying the bacterium called "Milky Spore" to your lawn to control grubs would be an example of:**
   a. Biological control
   b. Cultural control
   c. Mechanical control
   d. All of the above
4. **Avoiding overhead irrigation to reduce the formation of leaf blight on your tomatoes would be an example of:**
   a. Biological control
   b. Cultural control
   c. Mechanical control
   d. Chemical control
5. **Spraying unwanted grass with high concentrate vinegar (labeled for garden use) would be an example of:**
   a. Biological control
   b. Cultural control
   c. Mechanical control
   d. Chemical control
6. **Applying straw mulch in the garden has many useful purposes (many related to IPM), such as:**
   a. Smothering weed seeds
   b. Conserving soil moisture
   c. Contributing to soil organic matter
   d. All of the above
7. **An example of mechanical control in an IPM plan is:**
   a. Hoeing and hand pulling the weeds
   b. Vacuuming bugs off your plants
   c. Pruning diseased infest branches from the shrub
   d. All of the above
8. **An example to conserve beneficial insects in the garden would be:**
   a. Mowing the lawn at 3" height
   b. Watering plants at night
   c. Using only narrow-spectrum (selective) insecticides
   d. Purchase and release beneficial insects from the store
9. **When opting for chemical control a gardener should:**
   a. Choose only botanical products
   b. Read and follow the product label
   c. Use broad-spectrum (nonselective) products
   d. Double the application to double the efficacy
10. **Which of the following is a pesticide?**
    a. Pyrethrin
    b. Trifluralin
    c. Copper
    d. All of the above
11. **A chemical product labeled WARNING would be:**
    a. Highly toxic
    b. Moderately toxic
    c. Slightly toxic
    d. Non toxic
12. **Which of the following would not be considered adequate PPE when handling and mixing chemicals?**
    a. Long-sleeved shirt
    b. Chemical-resistant footwear plus socks
    c. Cotton gloves and flip-flop sandals
    d. Waterproof gloves

Answer key

1. (d) 2. Depending on the situation any may be appropriate, so any answer is correct 3. (a) 4. (b) 5. (d) 6. (d) 7. (d) if you are physically removing the pest, its mechanical. 8. (c) A way to preserve beneficial insects is to not accidentally kill them. 9. (b) 10. (d) If you're using a product to kill something, it's a pesticide. 11. (b) 12. (c) .