Laws and Regulations for Turf and Ornamentals

Federal Laws and Regulations

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

FIFRA also gives EPA the authority to:

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

Exceptions to FIFRA

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

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

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

Kentucky Laws and Regulations

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

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

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

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

Important Definitions

- **Application** - the spreading of lawn chemicals in liquid or dry form on a lawn.
- **Applicator for hire** - any person who makes an application of lawn chemicals to a lawn for compensation, including applications made by an employee to lawns owned, occupied or managed by his/her employer.
- **Certification** - recognition by the KDA that a person has demonstrated a minimum level of competence by examination and continuing education units and is authorized to use or supervise the use of pesticides in his or her area of certification.
- **Commercial Pesticide Applicator** - any individual employed by an operator to apply pesticides. Applicators must be certified in the appropriate category and must have a valid license issued by the KDA. The annual applicator license expires on December 31, the license fee is $10.
- **Commercial Pesticide Operator** - owns or manages a business that applies pesticides on the lands of another for hire. Operators must be certified in the appropriate category and must have a valid license issued by the KDA. A licensed commercial pesticide operator also must be registered as a pesticide dealer or must be employed by a registered dealer. The annual operator license expires on December 31, the license fee is $25.
- **Customer** - a person who makes a contract, either written or verbal, with an applicator for hire to apply a pesticide to a lawn.
- **Dealer** - stores bulk fertilizer or a restricted use pesticide for redistribution or direct resale, OR is in the business of applying any pesticide to the lands of another.
- **Direct on-the-job supervision** - when a licensed operator or applicator is physically on site and is directly supervising or training an individual to apply a pesticide.
- **Lawn** - a land area covered with turf kept closely mown, except land areas used for agricultural production, commercial production of turf, or land situated within three (3) feet of the foundation of a structure when a pesticide is applied to this area as a preventive or control measure for structural pests.
- **Lawn chemicals** - fertilizers, pesticides, or defoliants applied or intended for application to lawns.
- **License renewal** - There is a 25% fine for license holders who do not file a renewal before March 1. The licensee must take a new certification examination if the license is not renewed before

- **Noncommercial applicator** - an employee of a golf course, municipal corporation, public utility, or other governmental agency certified and licensed to apply pesticides to lands owned, occupied, or managed by his or her employer. The annual non-commercial applicator license expires on December 31, there is no license fee.
- **Pests** - any animals (insects, snails, slugs, rodents, etc.); plant pathogens (nematodes, fungi, viruses, bacteria, or other microorganisms) or plants normally considered to be a pest, or which are declared to be a pest by the KDA.
- **Pesticide** - any substance or mixture of substances intended to:
    - prevent, destroy, control, repel, attract, or mitigate any pest;
    - be used a plant regulator, or a spray adjuvant, after being mixed with an EPA registered product;
    - be used as a plant regulator, defoliant, or desiccant.
- **Restricted Use Pesticide** -any pesticide classified as such by the EPA administrator, or by administrative regulation of the KDA. Only certified applicators can purchase and use them. Generally, the EPA classifies a pesticide as restricted use if:
    - it exceeds one or more human health toxicity criteria,
    - it meets certain criteria for hazards to non-target organisms or ecosystems,
    - the EPA determines that a product (or class of products) may cause unreasonable harm to human health and/or the environment without such restriction.
    - The restricted-use classification designation must appear prominently on the top of the front panel of the pesticide label.
- **Structural pest** - a pest which commonly invades or attacks dwellings or structures.
- **Trainee** - an individual employed by a dealer and working under the direct on-the-job supervision of a licensed operator or applicator.
- **Turf** - the upper layer of soils bound by grass and plant roots into a thick mat.

Important Definitions for Golf Courses (Category 18)

- **Application** - the spreading of plant-regulating materials in liquid or dry form on a golf course.
- **Golf course** - land on which turf and ornamental care, including application of pesticides or fertilizer and storage of pesticides or fertilizer, is done for the purpose of preparing the land for use in the game of golf.
- **Plant-regulating materials** - fertilizers, pesticides, or defoliants applied or intended for application to a golf course.

Posting and Notification Requirements

KRS 217b requires that applicator keep records of applications of general and restricted use pesticides. **Keep the records for 3 years.** USDA and/or KDA representatives have legal access to the records.

Recordkeeping, Posting, and Notification Requirements (Category 3)

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

Keep the records for 3 years. USDA and/or KDA representatives have legal access to the records.

The following notification requirements shall be met:

When entering a contract

An applicator for hire shall provide the customer with written information concerning lawn chemicals, application procedures, and other general guidelines about the safe use of lawn chemicals.

At the time of application

An applicator for hire shall provide the following information to the customer, either homeowner or landlord, for each lawn chemical used, and shall record and maintain at the business address the following information relating to the application of each lawn chemical:

- ☑ Brand name or common name of the pesticide applied
- ☑ Pesticide type
- ☑ Fertilize rate and analysis
- ☑ Reason for use
- ☑ Concentration of end use product applied to the lawn, the rate of application, and the total gallons of end use product applied to the lawn.
- ☑ Any special instruction appearing on the label of the lawn chemical product applicable to the customer's use of the lawn following application and any other precautionary or hazard information appearing on the label as applicable to the end use concentration
- ☑ Name and the state applicator license or certificate number of the individual actually making the application
- ☑ Customer name, address, and date of application
- ☑ Total area of lawn treated

Pesticide applications records:

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

Any customer of an applicator for hire, or a neighbor whose residence is adjoining a customer may request prior notification twenty-four (24) to forty-eight (48) hours in advance of an application by contacting the applicator for hire and providing his name, address, and telephone number. In this event, the applicator for hire shall provide notification in writing, in person, or by telephone, of the date and approximate time of application. If an applicator for hire is unable to provide prior notification to a customer or neighbor because of the absence or inaccessibility of the individual, the applicator shall leave a written notice at the residence.

Immediately following application of lawn chemicals

The applicator shall place a lawn marker at a prominent location in the lawn. The lawn marker shall consist of, at a minimum, a four (4) inch by five (5) inch white sign attached to the upper portion of a dowel or other supporting device of not less than twelve (12) inches in length. Lettering on the lawn marker shall be in a contrasting color and shall read on one side "LAWN CARE APPLICATION - PLEASE STAY OFF GRASS UNTIL DRY" in letters easily readable and not less than three-eighths (3/8) inches in height. The lawn marker may also display a symbol depicting the required message and the name, logo, and service mark of the applicator.

The lawn marker shall be removed and discarded by the property owner or resident, or other person authorized by the property owner or resident, the day following application.

For applications to residential properties of three (3) families or less, the applicator shall place one (1) lawn marker per property.

For applications to properties other than residential property of three (3) families or less, the applicator shall place lawn markers at primary points of entry to the property to provide notice that lawn chemicals have been applied to the lawn.

Immediately after Pesticide Applications to Landscape Ornamentals

Immediately following an application of pesticides to ornamentals, place a marker at a prominent location in the ornamentals that reads "PESTICIDES HAVE BEEN APPLIED - PLEASE STAY OUT OF TREATED AREA" in letters easily readable and not less than three-eighths (3/8) inches in height. The marker may also display a symbol depicting the required message and the name, logo, and service mark of the applicator.

Provide prior notification to the customer or adjoining residents in writing, in person, or by telephone if requested, of the date and approximate time of the application. If you are not able to provide prior notification to a customer or adjoining residence due to the absence or inaccessibility of the individual, leave a written notice at the residence.

Notification and Information Requirements for Golf Courses (Category 18)

Immediately following the application of plant-regulating materials on a golf course, the applicator shall place a golf course marker on the number-one (1) and number-ten (10) tees.

The **golf course marker** consists of, at a minimum, a four (4) inch by five (5) inch white sign attached to the upper portion of a dowel or other supporting device of not less than twelve (12) inches in length. Lettering on the golf course marker shall be in a contrasting color and shall read on one side "PLANT-REGULATING MATERIALS HAVE BEEN APPLIED. IF DESIRED, YOU MAY CONTACT THE GOLF COURSE SUPERINTENDENT FOR FURTHER INFORMATION" in letters easily readable and not less than three-eighths (3/8) inches in height. The golf course marker may also display a symbol depicting the required message and the name, logo, and service mark of the applicator. The golf course marker may be removed by the applicator or other personnel authorized by the golf course management the day following application.

Any person whose residence directly adjoins a golf course may request prior notification of a plant-regulating material application by contacting the golf course superintendent's office and providing his or her name, address, and telephone number. If requested, the golf course shall provide notification in writing, in person, or by telephone. In the event the golf course cannot provide advance notice, the person shall be contacted at the time of application. It the golf course is unable to provide prior notification or direct notification to a resident because of the absence or unavailability of the resident, the golf course shall leave a written notice at the residence. Material safety data sheets for each plant-regulating material shall be in an area of the superintendent's office where they can be easily read and accessible by patrons of the golf course.

At the time of application of plant-regulating materials to a golf course, an applicator shall record and maintain the following information for each plant-regulating material used:

- ☑ Brand name or common name of the pesticide applied;
- ☑ Pesticide type;
- ☑ Fertilize rate and analysis;
- ☑ Reason for use;
- ☑ Concentration of end use product applied to the golf course, the rate of application, and the total gallons of end use product applied to the golf course.
- ☑ The location of area treated.
- ☑ Any special instruction appearing on the label of the plant-regulating material applicable to the golf course use following application and any other precautionary or hazard information appearing on the label as applicable to the end use concentration.
- ☑ The name and the state applicator license or certification number of the individual actually making the application.

This record shall be maintained in the golf course superintendent's office and shall be readily available to review on request. This record shall be retained for three (3) years and be an inspectable item for the department.

Certification and Licensing

Commercial and non-commercial pesticide applicators must be both certified and licensed. Both are accomplished by passing a written test (minimum score 70%) administered by the KDA.. The test is based on information in this manual.

Evidence of Financial Liability

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

How To Remain Certified

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

Penalties

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

Pests of Ornamentals and Turfgrass

Weeds

Weeds are plants that are growing where they are not wanted. Usually, they cause minimal problems in healthy, vigorously growing turf. However, weeds can out-compete desirable turf due to poor management practices: irrigation, fertilization, mowing, turf diseases, insects, or from heavy use. Weed free turf is not practical in most cases but a balanced management program can keep them to a minimum.

A typical weed has one or more of the following characteristics:

- Produces lots of seed
- Populations establish rapidly
- Seeds can lie dormant for a long time
- Have vegetative reproductive structures
- Adapted for easy spread
- Plant development stages

Plant Development Stages

Most plants undergo four stages of growth and development.

1. **Seedlings** emerge from the soil soon after germination.
2. Leaves, stems, and roots grow rapidly during the **vegetative** stage, water and nutrient demands are relatively high.
3. After a period of vegetative growth, the plant enters the **reproductive** stage where most of the energy production in the plant is devoted to seed formation. Seed production is critical for survival of annual and biennial species.
4. Little or no energy production occurs during **maturity** when seed production is nearly finished. During this stage, the plant typically sheds its seeds and dies.

Plant Life Cycles

Annual plants complete their life cycle in one growing season, often in as little as 45 days. **Biennials** require two seasons. **Perennials** grow for three or more years.

Annuals that grow from **spring to fall** (large crabgrass and goosegrass) are **summer or warm-season annuals**. These are often problems because their life cycle is the same as many crops. Those that grow from **fall to spring** (common chickweed and henbit) are **winter or cool-season annuals**.

Biennial plants complete their life cycles over **two growing seasons**. Most start from seed in the fall or spring and grow through the summer, fall, winter, and following spring. They overwinter as rosettes. In the second summer, biennials flower and die. Examples include wild carrot and musk thistle.

Perennials often are the most difficult weeds to manage. Woody species generally go dormant in the winter and begin growth in spring from aboveground stems. Aboveground parts of herbaceous perennials may die back, but their underground storage organs survive the winter. Many are deep rooted so they continue to grow during summer droughts. Perennials can spread from seed and often from roots, tubers, bulbs, and rhizomes. White clover and yellow nutsedge are examples. Dandelions can be annual or perennial.

Many weeds produce large quantities of seeds that are easily carried by wind, rain, machinery, animals, and people. Weed seeds can germinate after being dormant for long periods of time. They also can tolerate extremes in weather such as temperature and moisture. **It is best to control weeds before they produce seeds.**

Plant Classification

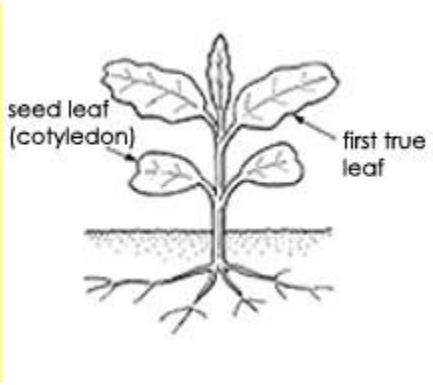
Weeds can be grouped into the following categories:

- grasses
- sedges
- lilies
- broadleaves.

Grasses have only one leaf as they emerge from the soil. Their leaves are two-ranked and typically upright, narrow with parallel veins. Grass stems are round and hollow. The root system of a grass is fibrous with the growing point located at or below the soil surface (surrounded by several layers of leaves). Perennial grasses can produce new shoots from growing points located on rhizomes (belowground) and/or stolons (aboveground).

Sedges resemble grasses but they have triangular stems with three rows (ranks) of leaves. Typically, sedges are listed under the grass section of an herbicide label. They prefer moist, poorly drained soils, but can grow in fertile, well-drained soils. Yellow nutsedge, is a perennial that reproduces by tubers and rhizomes. It is the principle sedge found in Kentucky.

Lilies resemble grasses and sedges but they have long, linear leaves and reproduce from underground bulbs. Two common species found in Kentucky are wild garlic and Star-of-Bethlehem.



Broadleaf seedlings have two leaves (cotyledons) as they emerge from the soil. The leaves are generally broad with net-like veins. Broadleaves typically have a taproot surrounded by a relative coarse root system. Actively growing broadleaf plants have exposed growing points at the end of each stem and in each leaf axil.

Perennial broadleaves may have growing points on roots and stems above and below the surface of the soil.

Summer Annuals

photo: Lynn Sosnoskie, Univ. of Georgia, Bugwood.org

Crabgrass

From seed and roots at lower joints; encouraged by alternating wet, dry soil surface in spring; germination begins mid-April; 3 to 10 finger-like branches at top of stem; thrives in sparse turfgrass stand; low mowing; heavy traffic area; full sun

photo:University of Minnesota

Foxtail

Bright green clumping grass; heavy traffic areas; bushy, cylindrical seed head at top of stem; full sun; low mowing

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photo: Michigan State University

Goosegrass

Germinates May to June; prostrate growth; white center with wagon-wheel appearance; sparse turfgrass stand; low mowing; grows well in compacted soil

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photo: Lynn Sosnoskie, Univ. of Georgia, Bugwood.org

Common knotweed

Germinates in early spring; prostrate growth; alternate, oblong, pointed leaves; heavy traffic; along roads or driveways

Winter Annuals

photo: University of Maryland

Annual bluegrass

Germinates from fall to early spring; light green bunch-type grass with flattened stems; can produce seed heads even with low mowing heights; irrigated turf and moist shade

photo:Michigan State University

Common chickweed

From seed in autumn and creeping stems; pairs of smooth, egg-shaped leaves; small star-shaped white flowers

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photo:Oklahoma State University

Henbit

From seed and roots form lower joints; square stem that branches close to ground; almost circular opposite leaves with rounded teeth or lobes; prefers moist soil in shade

Perennials

photo:Purdue University

Broadleaved Plantain

From seeds and new shoots from taproot; leafless stem; egg-shaped leaves; seeds along half length of seed stalk; thrive in weak, thin turf

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photo:Kansas State University

White clover

From seed and creeping stems; creeping growth; white blossoms; leaves with 3 leaflets; survives close mowing

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photo: Missouri Botanical Garden

Wild garlic

From underground bulbs and aboveground bulblets; round slender leaves are hollow; poorly maintained or thin turf

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photo: Mark Czamota, Univ. of Georgia, Bugwood.org

Yellow nutsedge

From seed, rhizomes, and tubers; fast growing; yellow-green triangular stem; often in wet soil

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photo: msuturfweeds.net

Nimblewill

Warm season perennial, stolons root at nodes producing dense stands. Leaf blades gray-green with loose-spreading growth. Especially common in Kentucky bluegrass. Mowing is not an effective control measure.

Perennial or Annual

Common dandelion

From seeds and root shoots; stems contain a milky juice and arise from a long, thick, fleshy taproot

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photo: Rob Routledge, Sault College, Bugwood.org

Wild violet

From seed and underground root; heart-shaped leaves; often grow in shade

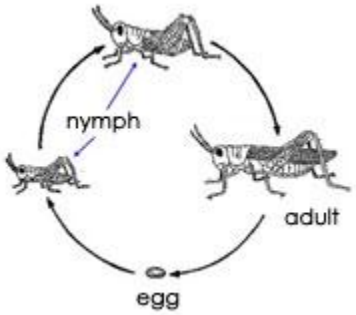
Pests of Ornamentals and Turfgrass

Insects and Other Arthropods

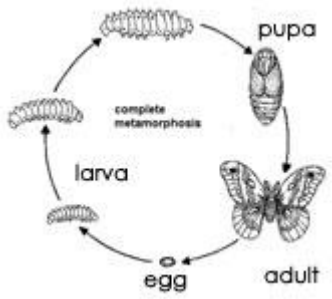
Insects, spiders, scorpions, millipedes, centipedes, ticks, and mites are arthropods. They have hard external skeletons and segmented legs and bodies. Most insects have 3 main body regions and 3 pairs of legs; they are the only arthropods that can fly.

Insect Life Cycles and Growth

Insects go through a series of changes during their development from egg to adult in a process called **metamorphosis**. When the insect hatches from an egg, it is either a **nymph** (gradual metamorphosis) or a **larva** (complete metamorphosis). The immature stage must shed its external skeleton, a process called **molting**, in order to grow.



Grasshoppers undergo **gradual metamorphosis**, passing through three stages of development: egg, nymph, and adult. Nymphs resemble adults. They eat the same food and live in the same environment. The change in form from nymph to adult is gradual. Only the adult state has wings. Other examples are aphids, stink bugs, and leafhoppers.



Insects with **complete metamorphosis** include butterflies and moths, beetles, flies, bees, and ants. There are **four stages in complete metamorphosis – egg, larva, pupa, and adult**. The larvae, are specialized for feeding and look very different from the adult. They have general names such as caterpillar, maggot, white grub, or wireworm. **Larvae usually live in very different situations and often feed on different foods than adults.**

A variety of insects and mites can attack plants but most are not pests. Some are beneficial, providing natural control or pollination services. Others are scavengers on dead or dying plants so they recycle nutrients. **Just because an insect is around damage does not mean it was the cause.**

Mouthparts and Feeding - Ways Insects Can Damage Plants

Pest insects may be divided into major groups according to how they feed:

1. piercing-sucking
2. chewing
3. rasping plant tissue

Sap feeders with piercing-sucking mouthparts can cause wilting, leaf curl, or stunted foliage. Chemicals injected by some species of leafhoppers can cause leaf burn. Stink bug feeding can cause distorted leaves or fruit. Several aphid and leafhopper species can carry virus diseases.

Rasping tiny thrips tear plant cells and feed on sap. These tiny insects may leave feeding scars or distorted leaves; some can carry plant disease.

Chewers include caterpillars and beetles. They feed on foliage. The amount of feeding a plant can tolerate without significant impact on growth or yield varies with a plant's age, growth stage, or stress (drought, etc.).

Arthropod Pests of Trees and Shrubs

Sap Feeders (Piercing-Sucking)

Pests with sucking mouthparts cause similar types of damage. Using their mouthparts, the pests pierce or rasp tissue so they can suck plant juices. **Damaged foliage is usually mottled, but other symptoms may be wilting, scorched leaf tips, or puckering and curling.** When sooty mold occurs on plants, it is almost always associated with "honeydew" that is excreted by certain kinds of sucking insects.

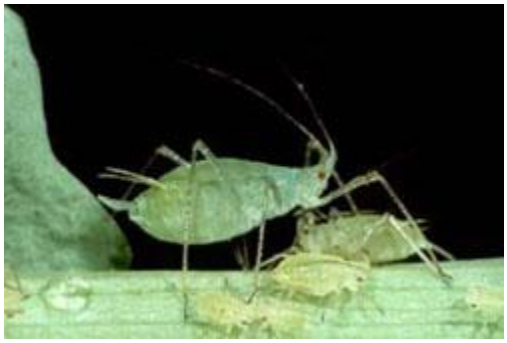


photo: Kansas State University

Aphids or "plant lice," are small, soft-bodied insects that usually c uster on stems or undersides of terminal leaves. Aphids may be green, black, or red, but sometimes their color is hidden by a white waxy coating. Much of the sap that aphids suck passes through them undigested and is excreted as "honeydew." Honeydew makes the leaves sticky, and sooty mold may grow on these deposits. Feeding by some kinds of aphids will cause leaves to pucker, curl, or twist.

During most of their lives, **scale insects** are legless and motionless and do not resemble insects at all. They may be circular, oval, or pear-shaped. Some are flat, others convex. **Two major groups of scales are most common in Kentucky.** The **armored scale** produces a waxy shell that gives the soft-bodied insect under it some protection. The **soft scales** do not produce a shell, but their bodies may be tough.

Scales reproduce by giving birth to "crawlers" or by laying eggs that hatch into crawlers. **Crawlers** have legs, eyes, and antennae, all of which allow them to move out from under the mother's shell or body and seek a suitable place of their own on the plant. Soon after inserting their beak to feed, they molt and lose their legs, eyes, and antennae and remain motionless for the rest of their lives.

Plants infested with scales may lack vigor and appear sickly. Soft scales, like aphids, produce honeydew and cause the same symptoms as mentioned for aphid honeydew. **It is easier to control most scales while they are in the crawler stage because they are not protected by a shell or waxy coat.** Treatment applied for scale control should coincide with crawler activity. A second treatment in 2 to 3 weeks oftern is recommended. Timing of systemic insecticide applications is not so critical.

On oil-tolerant plants, **oil sprays** can be used to control all stages of scales, including eggs. Summer oils may be effective during the warmer months. Apply dormant oils in winter. **Insecticidal soaps** are another alternative for controlling scale crawlers as well as aphids, mealybugs, whiteflies, thrips, and mites.

photo: Washington State University

Mites are not insects, but their damage and the methods of control are similar to those of insects. They differ from insects in that they have 8 legs, not 6, and have only 1 body region instead of 3. All mites are tiny and usually cannot be seen without the aid of a magnifying lens. **By tapping infested twigs over a sheet of white paper, the dislodged mites are much easier to detect.** They vary widely in color. Some mites spin fine, delicate webbing on the host plant. This webbing is usually easier to detect than the mites themselves.

Spider mites feed by sucking cell contents from individual leaf cells. Initial damage appears as fine light dots on the leaves. A small number of mites usually is not reason for concern but very high populations can cause significant damage.

Mite **damage often appears as a bronzing of the foliage**, which sometimes gives it a dusty appearance. Leaf drop may also occur. As feeding continues, the leaves turn yellowish or reddish and drop off. Often, large amounts of webbing cover infested leaves. Damage is usually worse when plants are under drought stress.

Many kinds of plants are attacked by the **two-spotted spider mite**, and almost all coniferous plants are hosts to the **spruce spider mite**. The **Southern red mite** is primarily a pest on broadleaf evergreens such as azaleas and camellias.

Foliage Feeders (Chewing)

Beetles vary considerably in size, shape, color, and habits but all have chewing mouthparts. One of their most distinctive features is that their front wings are hard or leathery and meet in a straight line down the center of the back.

Beetles may attack any part of a plant and in various ways. Some are typical leaf feeders and bite off pieces of leaf, while others are leaf miners or skeletonizers. With some beetles, the adults and larvae both are leaf feeders on the same plant; other beetles may be foliage feeders as adults and root feeders on other plants while in the larval stage. Some feed during the day and some feed only at night, such as the May beetles.

Beetles

photo: Clemson University - USDA Cooperative Extension Slide Series, Bugwood.org

The adult **Japanese beetle** causes serious damage to the foliage of many landscape plants.

The larvae stage of the Japanese beetle is a **white grub** that feeds below ground on plant roots and is a serious pest of turfgrasses.

photo: Daniel Herms, The Ohio State University, Bugwood.org

Some beetles, such as the **bronze birch borer**, feed as the larval stage in the cambium of trees and shrubs. This boring activity leaves "galleries" underneath the bark, usually causing serious damage to host plants. Girdled plants usually die.

Caterpillars

Caterpillars are the worm-like immature stages of moths and butterflies. They range in size from tiny to 5 inches long. They usually have a distinct head and 4 pairs of fleshy legs on the middle of the body. The body may be fuzzy, naked and smooth, or spiny.

Caterpillars are primarily foliage feeders and eat out irregular areas or they may entirely strip the leaves. Some caterpillars, because of their special habits, are also referred to as webworms, tent caterpillars, leaf rollers, leaf folders, skeletonizers, bagworms, and leafminers. Some feed as individuals; others feed in groups or colonies.

photo: Steven Katovich, USDA Forest Service, Bugwood.org

Fall webworms build tents at ends of branches. When only a few large caterpillars are present, handpicking is effective. **Webworms and tent caterpillars can either be pruned out or burned out with a torch.** If pruning would adversely affect a plant or if the infestation of any caterpillar is generally distributed over a plant, **a single treatment of an approved insecticide applied when the caterpillars are young** will usually give control.

photo: Daniel Herms, The Ohio State University, Bugwood.org

A group of small moths, usually referred to as **clearwing moths**, cause serious boring damage to certain plants. The active adults often resemble wasps. The larvae bore through the cambial layer, causing stress, decline and, occasionally, death of plants.**Dogwoods, lilacs, and ash are affected by clearwing borers.**

photo: Steven Katovich, USDA Forest Service, Bugwood.org

Sawflies are wasp-like insects and are related to typical wasps, bees, and ants. The larval stages of most sawflies resemble naked caterpillars, but they have more than 5 pairs of fleshy legs on the body while caterpillars have only 4 or fewer pairs. Some sawfly larvae are slug-like in appearance, such as the pear slug and rose slug.

photo: William A. Carothers, USDA Forest Service, Bugwood.org

Most sawfly larvae are foliage feeders that eat the entire leaf but **slug sawflies** are skeletonizers. A few types of sawflies are wood borers or leafminers. These differ further from typical sawflies in that they do not have fleshy abdominal legs. The **most serious sawfly pests in our area are those that attack coniferous shrubs and trees**. They feed in groups and can quickly defoliate a plant. This defoliation often leads to the plant's death. A single application of an approved insecticide is usually sufficient for control.

Borers

Wood-boring insects are among the most destructive pests of ornamental trees and shrubs. Borers are the larvae, or immature stage, of certain moths and beetles. They tunnel and feed under the bark in living wood, destroying water- and sap-conducting tissues. This causes girdling, branch dieback, structural weakness, and decline and eventual death of susceptible plants. Infestation sites also provide entry points for plant pathogens.

Clearwing (moth) and flatheaded borers (beetles) are the two main types that attack woody ornamentals.

photo: Bob Oakes, USDA Forest Service, Bugwood.org

photo: Eric R. Day, Virginia Polytechnic Institute and State University, Bugwood.org

Flatheaded borers are so named because their first body segment, behind the head, is flattened laterally. The adults are fast-moving, flattened, metallic-colored beetles with short antennae. The whitish, legless larvae make winding tunnels beneath the bark, destroying phloem and cambium and girdling the trunk or branches. The tunnels may be visible externally as spiral ridges or cankers on the limbs or trunks. Unlike clearwing borers,

which expel frass from cracks in the bark, **flatheaded borers pack their fine, sawdust-like frass in their tunnels**. Examples are the emerald ash borer, bronze birch borer, and flatheaded appletree borer.

photo: Whitney Cranshaw, Bugwood.org

Adult **clearwing borers** are delicate, day-flying moths that resemble small wasps. The moths feed only on nectar or not at all, so they do not cause damage. The larvae are whitish, hairless caterpillars with a brown head. There are a number of different species, but **the most damaging clearwing borers are associated with dogwood, lilac, ash, oak, rhododendron, and ornamental Prunus species, including flowering peach, plums, and cherries**.

These groups differ somewhat in their habits and host preferences, but similar management tactics are used for both. The keys to controlling these pests are to keep plants healthy and, if necessary, to treat during those brief times of the year when the insects are vulnerable to insecticides.

Borers rarely infest healthy plants growing in their natural environments. However, **when trees or shrubs are transplanted into the landscape, stresses such as drought, soil compaction, sun scald, or injuries can weaken them and make them more susceptible to attack**. Research has shown that the adults may locate suitable egg-laying sites by responding to volatile chemicals that emanate from stressed trees. **The invasive emerald ash borer is an exception. It attacks healthy ash trees.**

Adult borers emerge from infested trees in the spring or summer. After mating, the females fly to a suitable host and lay eggs on the bark, often in crevices or around wounds. Hatching occurs about 10 days to 2 weeks later, and the young larvae quickly tunnel beneath the bark where they feed and grow. **Once inside the tree, borer larvae are no longer vulnerable to insecticide sprays and are seldom detected until serious damage has been done.** Systemic insecticides can protect some trees and shrubs from attack by some borers.

Several species of clearwing and flatheaded borers can infest landscape plants. While some are attracted to a wide range of hosts, most attack only particular kinds of trees and shrubs. **In order for treatment to be effective, it is important to know when the adults of each species are active and which plants are vulnerable.**

Gall Makers

When some insects or mites lay eggs in tissue, they may inject a chemical into the plant that causes it to grow abnormally, producing a **gall**. Plant parts affected include roots, crown, bark, branches, twigs, buds, and leaves. **Each species of insect or mite produces a characteristic gall on host plants**. With the exception of horned and gouty oak galls, **most galls do not harm tree health**.

Insect Pests of Turf

Lawns often include a variety of insects, some of which are direct pests of grass, or nuisances and pests to humans and pets. Some may be predators or parasites of other insects, or harmless scavengers. Through complex interactions between the insects and other factors, the lawn ecosystem becomes more or less balanced. If we are not satisfied with the balance, we may use maintenance practices to improve our lawns.

However, the solution may trade one problem for another. For instance, fertilization to increase grass lushness may favor the development of certain insect and disease problems. Insecticidal control for one kind of insect may kill predators or alter competition, allowing a different insect pest to flourish. **Often, the side effects of management practices cannot be precisely predicted, so lawn situations need to be monitored over time and maintenance practices modified, if necessary.** Some of these interactions and problems are demonstrated in the case of white grubs as lawn pests in Kentucky.

photo: Alton N. Sparks, Jr., University of Georgia, Bugwood.org

White grubs are the larval stages of scarab beetles such as masked chafers, rose chafer, May beetles, green June beetle, and Japanese beetle. White grubs look more or less alike. They have brown distinct heads and thoracic legs, and the body is whitish, fat, and usually curled into a C-shape. Size varies from 1/8 to 1-1/2 inches long depending on the age and species. The grubs occur in large patches of sod an inch or so below the soil line where they consume the anchoring roots of grass. During dry weather, the infested sod may die for lack of water.

Soil insecticides for white grub control should be applied in August before the grubs cause serious damage. Most instances of control failures are a result of poor timing or techniques of insecticide applications.

photo: Michigan State University Extension

Sod webworms graze baseball-sized patches of grass that turn brown and die. Patches of grass that are clipped off at the soil surface may be numerous and run together to form large dead areas. **Dirty silk tubes containing the inch-long caterpillar or pupa can usually be found in the thatch of killed spots**. The **adult stage of the pest is a small buff moth** that is often seen fluttering over lawns at dusk and at night around lighted doorways about two weeks before larvae become numerous. There are up to three generations per year.

photo: Frank Peairs, Colorado State University, Bugwood.org

Armyworms, including the **true armyworm** and the **fall armyworm**, are characteristic caterpillars about 1-1/2 inches long when full grown. They vary in intensity from year to year, but during outbreaks they may move across an area in army fashion completely stripping grasses in their path. Fescue is more often attacked than bluegrass. These insects are also important pests of grain crops.

photo: Clemson University - USDA Cooperative Extension Slide Series, Bugwood.org

Various species of **cutworms** occur in turf and some are hard to distinguish from armyworms based on body characteristics. However, they never occur in large numbers as do armyworms.

Beneficial Insects

Beneficial insects can help to regulate pest populations. Predators generally are not very selective and may feed on non-pest species. Some species of wasps and flies are very selective in the prey that they attack including leaf feeding caterpillars and wood boring beetles. Four species of lady beetles feed on soft-bodied insects such as aphids and scale crawlers.

Photo: R. Bessin, University of Kentucky

The pink spotted lady beetle has a medium-sized, oblong pink to red body marked with black spots. Adults and larvae are important aphid predators but they also eat mites, insect eggs, and small larvae. Unlike most lady beetles, plant pollen may make up to 50% of the diet.

Photo: R. Bessin, University of Kentucky

Multicolored Asian lady beetle is a large orange lady beetle with a variable number of spots. It can be recognized by the black 'M' on the white segment over the head. Aggregations of these insects find their way into homes In the fall, where the beetles are a nuisance. Their secretions can ruin rugs and other furniture. Fortunately, they do not breed or feed inside the home.

Photo: R. Bessin, University of Kentucky

The convergent lady beetle is an important natural enemy of aphids, scales, thrips, and other soft-bodied insects. It will also feed on pollen and nectar from flowers when prey is scarce. Larger larvae are voracious feeders and may consume between 30 and 50 aphids per day.

Photo: R. Bessin, University of Kentucky

The seven-spotted lady beetle is a medium-sized, orange beetle with seven black spots. It is a European species that was introduced into the US to aid in managing some aphid pests.

Jumping spider with grasshopper
Photo: Black Diamond Pest Control

Spiders are general predators that feed on many types of prey including pest and beneficial species.

Beneficial wasp laying its eggs in a caterpillar
Photo: S. Bauer, USDA

The larvae of many beneficial wasps develop in the bodies of caterpillars. Adult wasps can be very selective when choosing prey.

Other Pests

Worm castings on golf course
(Penn State)

Earthworms and nightcrawlers are not insects but they can be abundant in soil. These annelids help to recycle organic matter and their burrows allow oxygen and water to enter the soil more easily. However, when many are present, their activities and casting can cause the surface to be very lumpy. In addition, new species (green stinkworms, Asian yellowworms) are beginning to appear in some locations. These worms can cause significant problems in lawns, athletic fields and on golf greens.

Earthworms and night crawlers are generally found in the top 12" to 18" of the soil because this is where food is most abundant. They swallow soil and organic matter and grind it in the gizzard section of the digestive tract. Undigested material (castings) is used to line the burrow or is eliminated on the surface. They are most active when the soil is warm and moist. The worms move deeper as the soil dries in summer. Control strategies for these pests are being developed.

photo: Alfred Viola, Northeastern University, Bugwood.org

Skunks damage turf when they discover abundant white grub populations. Skunks dig through the sod and feed on the white grubs, thereby uprooting the sod and aggravating the damage already begun by the grubs. Skunks also may spray a disagreeable smelling substance on unwary people or pets who disturb them.

photo: Terry L. Spivey Photography, Bugwood.org

Birds, especially crows, starlings, and grackles, commonly tear up infested turf in search of grubs. Flocks of blackbirds frequenting a turf site, or holes left in the turf by their beaks, may indicate a grub problem.

Moles feed primarily on earthworms, but they may also feed on white grubs, wireworms, beetles, and many other invertebrates. They do not feed on plant roots or other underground plant growth.

However, as they tunnel along in their surface runs, moles damage turf roots and may destroy newly seeded lawns. In established turf, the mower may skin the tops of the runs and dull the mower blade as well as create gaps in the sod. Moles also tunnel deep, throwing the excavated soil out of surface openings, thus forming molehills.

Pests of Ornamentals and Turfgrass

Plant Diseases - Fundamentals

A plant disease is any harmful condition that affects a plant's appearance or function. Common pathogens that cause diseases include: fungi, bacteria, and viruses. Some nematodes are plant disease agents. Temperature extremes or nutrient deficiencies are examples of disorders caused by non-infectious factors.

Pathogens are fungi, fungus-like water molds, bacteria, viruses, and nematodes that cause infectious diseases of ornamentals and turf. They are microscopic. Plant disease pathogens may be spread in many ways:

- wind;
- rain;
- animals;
- soil;
- nursery grafts;
- vegetative propagation;
- contaminated equipment and tools;
- infected seed stock;
- pollen;
- dust storms;
- irrigation water; and
- people.

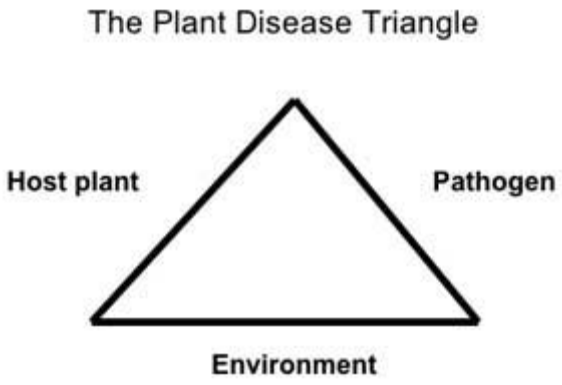
Infection begins when the pathogen enters the plant. The disease process starts when it arrives at a part of a plant where infection can occur. If environmental conditions are favorable, the pathogen begins to develop. The plant is diseased when it responds.

Symptoms are the usually visible reactions of plants affected by these organisms. They may include leaf spots, chlorosis, cankers, galls, wilting, or root decay. Several types of pathogens can cause similar disease symptoms, so proper identification is very important.

Host-specific pathogens only infect certain hosts. If a host plant is not susceptible to infection, then the disease will not develop.

Also, **environmental conditions** must be right for infection. Most pathogens require wet conditions or high humidity so disease is usually much lower during very dry summers. On the other hand, rainy seasons usually produce more disease.

The **disease triangle** is a fundamental concept in plant pathology. **Disease occurs only when all three sides of the triangle are present: a *susceptible host*, a *pathogen* (the agent that causes disease), and an *environment* favorable for disease to develop.** Plant diseases are managed by manipulating the disease triangle: the plant, the pathogen, and/or the environment.



Plants respond to disease in 3 main ways:

overdevelopment of tissue - galls, swellings, or leaf curls;

underdevelopment of tissue - stunting, lack of chlorophyll, or incomplete development of organs; or

tissue death - blight, leaf spot, wilting, and cankers.

Sometimes, adverse growing conditions or environmental factors produce symptoms similar to those of plant diseases. These **abiotic problems (caused by non-living factors) need to be distinguished from plant diseases for proper management.** For example, fungicide applications cannot correct frost injury, dog urine burn, nutrient deficiencies, drought, girdling roots, changes in grade, chemical injury, air pollution injury, and mechanical damage.

Knowing the disease-causing organisms allows selection of the proper chemical or cultural practice to control the problem. For example, a root problem identified as a root rot when it is actually a nematode infestation will not be cured by applying a fungicide; a nematicide is required.

Accurate identification and diagnosis is an art, as well as a science, and experience is essential. This section will acquaint you with the general symptoms of diseases. For more accurate disease diagnosis, consult your county Extension agent.

Diagnosis of Plant Diseases

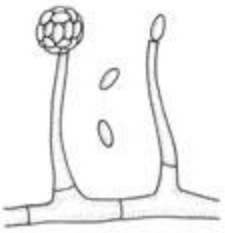
A correct diagnosis is the first step in disease management. You can recognize diseased plants by comparing them with healthy ones. To recognize a disease condition, you must know the plant's normal growth habits. When you are trying to identify the cause of a plant disease, you need to look for **symptoms - the host plant's reaction to the disease agent**, and **signs - visible presence of the disease agent**.

Many different plant diseases cause similar symptoms. Different pathogens and agents that are not pathogens can cause leaf spots, wilts, root galls, or stunted growth. For example, similar symptoms may be a result of mechanical injury, improperly applied fertilizers and pesticides, or frost. Often, the only way to pinpoint the cause is to find the observable signs that the particular disease agent is present -- such as fungal spores and mycelium or bacterial ooze.

Pests of Ornamentals and Turfgrass

Diseases of Ornamentals

Accurate identification and diagnosis of plant diseases is an art, as well as a science, and experience is essential. This section will acquaint you with the general symptoms of diseases of ornamentals. For more accurate disease diagnosis, consult your county Extension agent.



Fungi are multi-celled microbes that can either feed on living green plants or on dead organic matter. Disease occurs when pathogenic fungi attack living plants. Fungi usually produce spores which can cause infections when carried to a susceptible plant. Spores can be moved by wind, water, insects, and tools.

Fungal spores require adequate moisture and the optimal air temperature in order to begin new infections. Many fungal diseases are common during wet, humid seasons. Some pathogens infect directly into healthy plant tissue, while others require a wound or other plant injury in order to invade plant tissue. Chemicals used to control fungi are fungicides. Usually, fungicides are applied to prevent, not cure, fungus disease.

Leaf Spots

Anthracnose of Maple (top) and Sycamore (bottom)
photo: Univ. of Kentucky Nursery IPM

Black spot on Rose
photo: Purdue University

Fungal leaf spots (such as anthracnose, scab, leaf blotch, or shot hole) can vary in size, shape, and color. Some spots have distinct margins and may be surrounded by yellow halos. Other types of spots may be angular or blotchy. Spots or dead areas may enlarge to cover an entire leaf. As the spots become more abundant, leaves may yellow, die, and drop. Usually, leaf spots occur first on the lower leaves and progress up the plant. Fungal growth in the spot may consist of tiny pimple-like structures or a moldy growth of spores. You may need a hand lens or microscope to see the symptoms.

Leaf spots are more common in during early spring and fall when the moisture needed for infection is present. Fungal spores may overwinter in the infected leaves that drop around a plant. During spring, these pathogens produce infective spores that blow or splash onto healthy plants. If carried to healthy plants, these spores can begin a new infection under appropriate environmental conditions. Leaf spots occur on virtually all ornamental plants but not all leaf spot diseases affect plant health.

Leaf Blights

Dogwood anthracnose
photo: John Hartman, University of Kentucky, Bugwood.org

Leaf blights may have the same effect on plants as leaf spots but are **generally larger diseased areas and have less regular shapes**.

Dogwood anthracnose disease may begin as a leaf spot, become a leaf blight, and even progress to twigs and branches, causing dieback.

Rusts

Cedar-apple rust with telial "horns" (left) and cedar-quince rust (right)
photo: Univ. of Georgia

Cedar apple rust on apple foliage and fruit
photo: Univ. of Illinois

Rusts often produce spots called pustules that are similar to leaf spots. Pustules may be on the upper and/or lower leaf surface. They contain brown, reddish brown, orange, or yellow spores. Rust pustules are usually raised above the leaf surface. Rubbing the affected leaf surface will leave a dusty rust color (caused by the spores) on your fingers. Rust fungi may also attack twigs, branches, and fruit. They are often carried by wind and can be blown from infected plants to healthy plants, spreading the infection.

Rust diseases can have very complicated life cycles and, in many cases, require two separate hosts to complete their life cycle. In such cases, removing either one of the hosts can break the cycle and stop rust. Cedar-apple rust and related rusts are common ornamental disease problems.

Powdery Mildew

Dogwood powdery mildew
photo: UkNTrees

Powdery mildew The most common symptom is the white or gray layer of fungal growth produced on surfaces of the plant leaves and stems. Crooked stems or bubbled and curled leaves may develop If plant buds or very young tissue are infected.

Wind or rain splash can carry powdery mildew spores to new plants. During fall, the fungi produce small, black, overwintering structures that can overwinter in leaf debris or in cracks on bark.

Powdery mildew fungi are host specific, so different species infect different plant types. For example, powdery mildew fungi on dogwood will not infect Hydrangea, etc. Roses, oaks, tulip poplars, lilacs, zinnias, and euonymous are commonly affected by powdery mildew.

Leaf Gall Diseases

Leaf gall on lowbush blueberry
photo: Bruce Watt, University of Maine, Bugwood.org

Leaf gall diseases are caused by fungi and are favored by cool, moist weather. However, most galls seen on plants are caused by insects or mites.

Leaf galls caused by fungi can usually be seen shortly after new growth begins in the spring. Parts of leaves become distorted with a pale green to whitish bladder-like thickening. Young, thickened, fleshy leaves are covered with a white growth.

As galls age, they turn brown, dry up, and fall to the ground. If disease is severe, plant vigor can be affected due to leaf loss.

Dead, dry leaves that fall to the ground will be a source of spores for infection the following season. Leaf galls occur on azalea, camellia, and plum.

Root Rot

Phytophthora Root Rot
photo: John Ruter, University of Georgia, Bugwood.org

The first symptoms generally appear on above-ground plant parts as a gradual loss of vigor, yellowing of leaves, or wilting. Attempts to correct the problem with fertilizers and water generally yield little or no response.

In order to diagnose root rot diseases, plants must be dug carefully and soil washed from the roots. Diseased roots appear decayed, generally brown to black, and may be mushy or spongy.

The fungus-like water molds *Pythium* and *Phytophthora* and the fungi *Fusarium*, *Rhizoctonia*, and *Thielaviopsis* are common root rotting organisms.

Excess soil moisture favors root rot disease on ornamental plants. Once soilborne fungi build up in landscapes, it is difficult to disinfest soil.

Stem Rot / Stem Blight

Stem Rot
photo: Matt Montgomery, Sangamon-Menard Extension

The pathogens commonly associated with stem rot of ornamentals include the fungus-like water molds *Pythium* and *Phytophthora*, and the fungi *Rhizoctonia*, *Sclerotium*, and *Botrytis*. All are common soil-inhabiting fungi.

They can be spread in infected debris, on cuttings, or when soil is moved. Once soilborne fungi build up in landscapes, it is difficult to disinfest soil.

Plants infected with stem rot fungi often show early symptoms of wilt. During advanced stages of disease, plants become more severely wilted and eventually die. The stems may be brown and shrunken at the soil line. Under extremely moist conditions, the white, cottony fungus mycelium may be visible on the surface of the stem.

Chrysanthemums, geraniums, petunias, and other herbaceous ornamental plants are very susceptible to stem rot.

Damping-off, a similar disease of seedlings, kills ornamental seedlings during the first few weeks after seed germination.

Cankers

Stem canker on Japanese rose
photo: Elizabeth Bush, Virginia Polytechnic Institute and State University, Bugwood.org

Canker on Walnut
photo: Paul A. Mistretta, USDA Forest Service, Bugwood.org

Cankers are localized sunken lesions areas on trunks, stems, or branches of woody plants. Canker diseases cause bark tissues to shrink and die. The dead tissues often crack open and expose the wood underneath.

Cankers begin as small, discolored yellow, brown, or red spots that sometimes appear water-soaked, although some canker disease are not visible outside of the bark. As cankers enlarge, their centers may become tan or gray. Small, black, pimple-like structures (fungal fruiting bodies that contain spores) may form in the canker. Cankers can enlarge and girdle stems, causing death to parts of the plant above the canker.

Fungi causing cankers usually infect through a wound or injury to the bark or wood. Rose canker is a common example of a disease showing this symptom.

Vascular Wilt Diseases

The Verticillium dahliae fungus causes this vascular wilt disease on hundreds of woody plants
photo: JW Pscheidt, U Mass.

Fungal pathogens such as *Fusarium*, *Verticillium*, and *Ophiostoma* can cause wilting of many ornamental species by restricting the water flow to leaves and stems. The wilting caused by such pathogens is sometimes due to the toxins they produce. Other pathogens can build up within water-conducting vessels, which become plugged by fungal growth.

Vascular wilt diseases often affect one side of the plant first, causing individual limbs or branches to wilt and die back. *Fusarium* and *Verticillium* infections usually begin in roots and gradually spread internally throughout the infected plant. Verticillium wilt of maple is an example.

Other wilt fungi infect through upper plant parts. Symptoms of vascular wilt disease often include discolored streaks in the wood of infected branches, which are visible upon cross-sectioning infected wood.

Bacteria

Bacterial leaf scorch
photo: John Hartman, University of Kentucky, Bugwood.org

Bacteria are single-celled organisms that usually reproduce by simple cell division, some as often as every 30 minutes. They can build up quickly under warm, humid weather conditions. Leaf, growing shoots, and fruit diseases are the most common types in Kentucky.

Bacteria can be carried from plant to plant in water droplets, by wind, rain splash, insects, or on equipment. They often survive between growing seasons in crop residue, in seeds or cuttings, or in weeds.

Viruses

Rose mosaic virus
photo :William M. Brown Jr., Bugwood.org

Viruses are too small to see with a microscope. Generally, they are recognized by their effects on plants. These include stunted growth; change in plant color; abnormal formation of infected roots, stems, leaves, or fruit. Mosaic diseases, characterized by light and dark blotchy patterns, usually are caused by viruses.

It can be difficult to distinguish between diseases caused by viruses and those caused by other plant disease agents, such as fungi and bacteria. A positive diagnosis requires sophisticated testing, such as inoculating indicator plants and observing the results or using specifically identified antibodies to test for the presence of the organism.

Viruses depend upon living organisms for food and reproduction; they cannot exist very long outside a host. They are commonly spread from plant to plant by mites, aphids, leafhoppers, or whiteflies. A few are spread in the seeds of the infected plant.

Nematodes

Foliar nematode damage on Hosta
photo: Department of Plant Pathology, North Carolina State University, Bugwood.org

The life cycle of a nematode includes an egg, several larval stages, and an adult. Most larvae look like small adults.

In adverse conditions, females of some species form inactive, resistant forms called **cysts**. The cyst is the hard, leathery, egg-filled body of the dead female, which is difficult to penetrate with pesticides. A cyst may protect eggs for as long as 10 years.

Pests of Ornamentals and Turfgrass

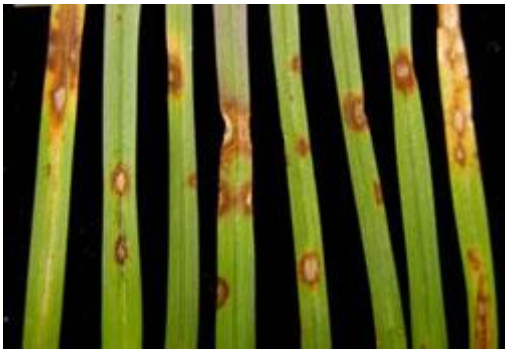
Diseases of Turfgrass

Accurate identification and diagnosis of plant diseases is an art, as well as a science, and experience is essential. This section will acquaint you with the general symptoms of diseases of turfgrass. For more accurate disease diagnosis, consult your county Extension agent.

Numerous disease problems occur on turfgrass in Kentucky and these frequently cause extensive damage. In many cases, a disease is blamed for poor quality turf when, in reality, it may be only a contributing factor or not involved at all. Frequently, dead and dying grass is caused by improper fertilization, chemical burn, mower problems, dog or insect injury, dry or wet spots, thatch, competition from other plants, or from any other improper management. Accurate diagnosis of the problem is essential for proper control.

Two types of pathogens (fungi and nematodes) are found in turf in Kentucky. Observation of symptoms is an important aid in determining which pathogen is causing a disease. The following information will explain the identification and biology of some common turf diseases.

Helminthosporium Leaf Spot



"Football" shaped leaf lesions of leaf spot and melting out of Kentucky bluegrass
photo: S. Tirpak, Rutgers

Helminthosporium leaf spot is a common disease problem of Kentucky bluegrass and is often referred to as "melting-out." Other *Helminthosporium* leaf spots are important on fescues and bermudagrass. From a distance, leaf spot-affected areas appear chlorotic or yellowed. Individual spots on the leaves have dark margins with tan centers. The spotting is most noticeable in spring and early summer.

Infection in the crown of the plant during the summer can lead to the death of plants (thus "melting-out"). Cool, wet weather during spring followed by drought during summer accentuates the damage from this disease.

Dollar Spot

Dollar spot appears as sunken round, bleached-out or straw-colored spots.
photo: Michigan State Plant Pathology

Dollar spot affects a wide variety of grasses, including Kentucky bluegrass, bermuda grass, perennial ryegrass, zoysia, tall fescue, and bentgrasses. The fungus is active throughout the growing season, especially when there is low soil moisture and an excess of dew or fog. It is most prevalent in the spring.

The disease is characterized by small white patches, one to three inches in diameter. A large number of spots can come together and form larger dead areas. Leaf spots are usually found along the edges of the grass blade and may come together across the blade, causing the tip to die. Individual leaf spots are tan with reddish margins.

Pythium Blight

Pythium blight
photo: William M. Brown, Jr., Bugwood.org

Pythium blight is caused by a number of species of the fungus *Pythium*. The fungus primarily attacks perennial ryegrass and bentgrass although other grasses can be affected. Conditions that favor *Pythium* blight include abundant moisture and poor air circulation. The disease is most active in hot, humid weather when the night temperature does not go below 70°F.

The blight appears first as small spots a few inches in diameter. Diseased leaves are at first water-soaked, soft, and slimy, and may mat together. Dense, cottony fungal growths often are apparent in affected areas during a heavy dew. The leaves soon shrivel and the color of the patch soon fades to light brown as dew dries. The shape of the diseased area may be streaked following the drainage flow of water over the turf.

Brown Patch

Brown patch on bentgrass
photo: U Mass

Brown patch is a common fungal disease of fescues, perennial ryegrass and bentgrass. It develops most readily when daytime highs exceed 80°F and nighttime lows are in the mid-60's°F or higher.

Brown patch is one of the more common turf diseases, especially in tall fescue. In addition to ideal temperatures and humid weather, heavy applications of nitrogen fertilizer favor disease development.

Brown patch is characterized by nearly circular areas of dead leaves that may be a few inches to several feet in diameter. On closely mown turf, the edges of the dead area may have a gray, smoky color, particularly in early morning. Affected areas are generally tan or brownish in bent and ryegrass. Affected fescues usually have straw-colored leaves.

Summer Patch

Summer Patch
photo: Mary Ann Hansen, Virginia Polytechnic Institute and State University, Bugwood.org

Summer patch affects Kentucky bluegrass and annual bluegrass. Circular to irregular patches of dead turf up to 1-2 feet in diameter develop during hot weather in mid- to late-summer. Below ground, roots and crowns of affected plants are brown and decayed, a result of fungal colonization. A tuft of healthy, green grass is sometimes evident in the center of affected patches, giving them a characteristic "donut" appearance.

Necrotic Ring Spot

Necrotic Ring Spot
photo: Howard F. Schwartz, Colorado State University, Bugwood.org

Necrotic ring spot is another disease of bluegrasses with symptoms similar to summer patch. In contrast to summer patch, symptoms of necrotic ring spot can develop following cool, wet weather in late spring or mid-autumn. Necrotic ring spot is less common in Kentucky than summer patch.

Rust

Rust pustules on turfgrass
photo: Iowa State

Rust is sometimes a problem on Kentucky bluegrass, fescue, zoysia, perennial ryegrass, and bermuda grasses. Rust infection results from rust spores which are blown to the plant from distant areas or from nearby alternate hosts. Large numbers of spores are produced in the leaf spot (pustule). These spores are then the source of new infections.

The disease is most frequently found during cool, humid weather during autumn. Grass varieties differ in susceptibility to rust.

Red Thread

Red thread
photo: Bruce Watt, University of Maine, Bugwood.org

Red thread is seen as irregularly shaped patches of blighted turfgrass, ranging from a few inches to a few feet in diameter. Often, as diseased leaves turn brown, pink or reddish fungal growth can be observed on the leaf surface or emerging from the cut ends of leaves. This disease affects most of the common grasses grown in Kentucky and is often found during spring and early summer. The disease is favored by conditions of low nitrogen fertility.

Mushroom Fairy Ring

Mushroom fairy ring
photo: Clemson University - USDA Cooperative Extension Slide Series, Bugwood.org

Mushroom fairy ring can occur in any turf. The ring appears as a circular discoloration of grass from several inches to many yards in diameter. Mushrooms (toadstools) may appear at the edge of the ring during warm, moist periods).

The ring of grass is generally a darker green than the grass inside and outside the ring. During periods of moisture stress, the grass inside the ring may die. This general decline of grass inside the ring adds to the unsightliness of the fairy ring problem. Fairy rings gradually increase in size.

Slime Molds

Dog vomit slime mold
photo: Sandra Jensen, Cornell University, Bugwood.org

Slime molds are commonly found on lawns in warm, moist weather. This fungal growth on grass leaves may be either a small, crust-like, light to dark mass with a sooty appearance, or a tan to orange shapeless mass.

The fungus causing this unsightly problem does not infect the grass blade; it simply uses it for support. The only effect it has on the plant is to temporarily reduce food production by the grass leaf as a result of shading.

Nematodes

Root-gall nematodes on Kentucky bluegrass
photo: Bonsak Hammeraas, NIBIO - The Norwegian Institute of Bioeconomy Research, Bugwood.org

Nematodes weaken and reduce the vigor of turfgrass by restricting the development of the root system. The symptoms of nematode injury may be confused with nutritional problems, insufficient water, hardpan, or any factor that restricts root development.

Symptoms commonly associated with nematode injury include thinned or completely killed areas, pale green to chlorotic color, excessive wilting during drought stress, poor response to fertilization, and a greater weed problem due to sparse grass.

The intensity of the symptoms will vary with the grass variety, the kinds of nematodes present, the nematode population level, and the fertilization-watering program being practiced. The most reliable method for determining whether a nematode problem exists is by a soil assay. Nematode damage to turfgrass is uncommon in Kentucky.

Pesticide Application Equipment and Methods

The application method you choose depends on such factors as the nature and habits of the target pest, characteristics of the target site, and properties of the pesticide formulation. You also must consider the suitability of the application equipment, cost, and efficiency of alternative methods.

Here are some common pesticide application methods:

	**Band** —applied along fence rows or borders, often with a non-selective herbicide to kill all vegetation.
	**Broadcast**—the pesticide is uniformly applied over a large area of turfgrass on foot or with motorized equipment.
	**Drench** applications are used to treat specific areas usually with systemic products that are taken up by the root system and moved throughout the plant.

	**Foliar** —directed to the leafy portions of a plant.
	**Soil** —placed directly on or in the soil instead of on a growing plant.
	**Space treatment** — applied in an enclosed area.
	**Spot treatment** - is an efficient way to treat specific problem areas without treating the entire turf area. Be careful to not walk through sprayed areas when using non-selective herbicides like glyphosate and watch for dripping from the nozzle while walking from site to site to treat.

Wiper applicator — can be used to wipe a non-selective herbicide (glyphosate) to selectively kill individual weeds. The wiper's wetness must be less than dripping and handled carefully to avoid accidentally treating desired plants.

Safety Systems

Pesticide Containment Pad

If you often store, handle, mix and load pesticides, or clean equipment at the same location, you may have to install a pesticide containment pad. Check EPA and Kentucky state regulations to determine when a containment pad is required. These pads are designed to contain spills, leaks, overflows, and wastewater for reuse by the applicator or for disposal by a commercial waste management contractor. They make it easier to clean up spills and help to prevent environmental contamination.

Impervious containment pad

Generally, the containment pad **must be made of impermeable material**. It should be **concave or have curbs, berms, or walls high enough to hold the largest amount of spill, leak, or equipment wash water** likely to occur at the site. It also must have a **system to remove and recover spilled, leaked, or released material** by either an automatic sump system or a manually operated pump. Smaller, portable pads and lightweight trays made of heavy-duty plastic may be used when mixing and loading at the application site.

Hydraulic Sprayers

The application equipment or device **must be able to apply the pesticide to the intended target at the proper rate.** The label specifies the legal application rate and may suggest the appropriate equipment for use with the product.

Hydraulic sprayers range from powered units with a multiple-nozzle boom to a hand-pumped backpack sprayer. In all cases, pressure from either a pump or compressed gas or air is used to atomize the spray mix at the nozzle. High pressure pumps are needed to provide good spray coverage on large trees. Manual sprayers are designed for spot treatments and for areas unsuitable for larger units. They are relatively inexpensive, simple to operate and maneuver, and easy to clean and store. Adjustable spray guns are often used for lawn care sprays.

Broadcast sprayer (BASF)

Backpack sprayer (Solo)

Lawn spray (Md Dept Ag)

Tree sprayer (Massspray.com)

Sprayer Components

Tank

Strainer and screens

Pump

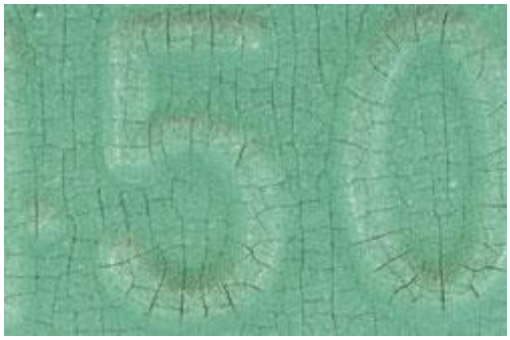
Nozzles

Tank

A **tank** is necessary to contain the spray mix. **Choose one made of, or coated with, a material that does not corrode and that can be cleaned easily.** Cleaning prevents accumulations of corrosion and dirt that clog screens and nozzles, increasing wear on the equipment. Large tanks require an opening in the bottom to aid in cleaning and draining. A large top opening is useful for filling, cleaning, and inspecting the tank. The opening must have a watertight cover to prevent spills. A **tank agitation system/device** is useful for most sprayable formulations, especially for wettable powders or dry flowables. Constant mixing of a pesticide and liquid carrier produces a uniform spray mixture (suspension) and results in an even application of the chemical.

Exposure to sunlight and corrosive chemicals can shorten the life of polyethylene tanks.

Three common signs of wear and potential tank failure are:



- **Scratches** are on the surface and can be seen and felt
- **Crazing** is a network of fine lines or cracks that may look like a patchwork, but often cannot be seen with a visual inspection. Crazing can be seen when using one of the testing methods explained below. **Crazing occurs within the tank wall and can be a sign of deterioration of the plastic, which may lead to cracks.** Tanks that show signs of crazing will still hold liquids, but the integrity of the tank is questionable. For this

reason, caution should be used when putting any hazardous substance in tanks that show crazing.*(Photo: omafra.gov.ca)*

- **Cracks** extend through the plastic wall and can be visually seen and felt. Cracks may run parallel or at right angles to each other.

Pump

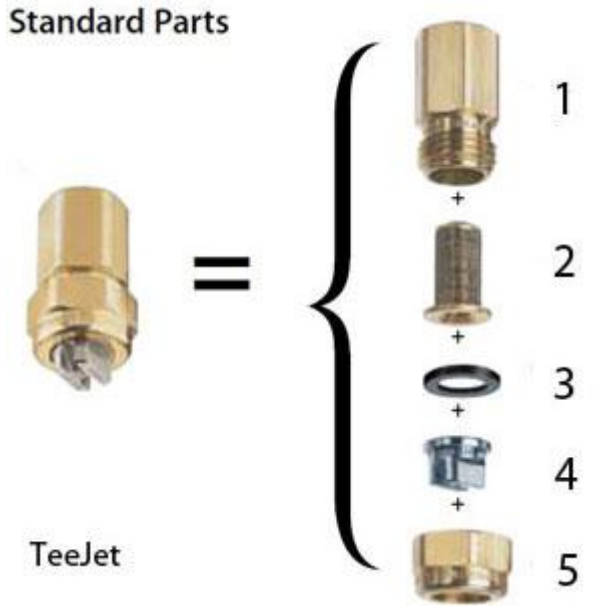
A **pump** agitates the spray mixture and produces a steady flow to the nozzles. Pump parts must resist corrosion and abrasion, especially when wettable powders or similar formulations are used. Never operate a sprayer pump at speeds or pressures above those recommended by the manufacturer. You may damage the pump if it is operated dry or with a restricted flow at the inlet or outlet. Pumps depend on the spray liquid for lubrication and to prevent overheating.

Nozzles

The proper selection of a **nozzle** type and size is essential for proper pesticide application. **The nozzle is a major factor in determining the amount of spray applied to an area, the uniformity of application, the coverage obtained on the target surface, and the amount of potential drift.**

Nozzles break the liquid into droplets, form the spray pattern, and propel the droplets in the proper direction. Nozzles determine the amount of spray volume at a given operating pressure, travel speed, and spacing. Drift can be minimized by selecting nozzles that produce the largest droplet size while providing adequate coverage at the intended application rate and pressure.

Nozzle parts:



1) The **nozzle body** holds the strainer and tip;

2) The **strainer** screen prevents a clogged nozzle. It is the best defense against nozzle plugging and pump wear. The screen can remove dirt and rust flakes from the spray liquid before it reaches the nozzle.

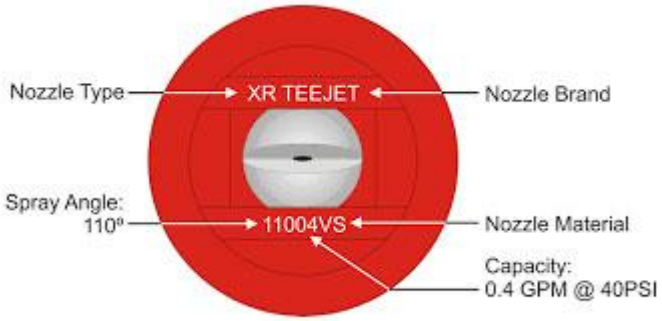
3) **Tip gasket**

4) The **spray tip** determines the flow rate and droplet pattern;

5) The **cap** holds the nozzle body and tip in place.

The Spray Tip

The **spray tip** determines the flow rate and droplet pattern.



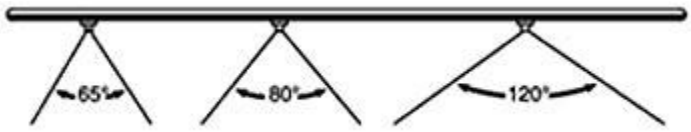
11004 nozzle

110 is the spray angle in degrees, 04 is the output - 0.4 gallons per minute at 40 psi (Source: TeeJet)

Equip nozzle tips with **check valves** to help prevent dripping when the pump is off. Be sure the spring-loaded ball valves are working properly.

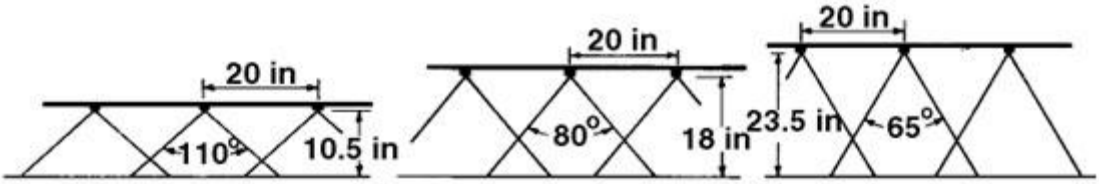
Nozzle Spray Angle, Spacing, and Boom Height

Nozzle spray angle is formed by the edges of the spray pattern. Common angles are 65°, 80°, and 120°. A wide-angle nozzle (110°) produces a thinner sheet of water with smaller droplets than a narrow angle nozzle (65°) with the same delivery rate.



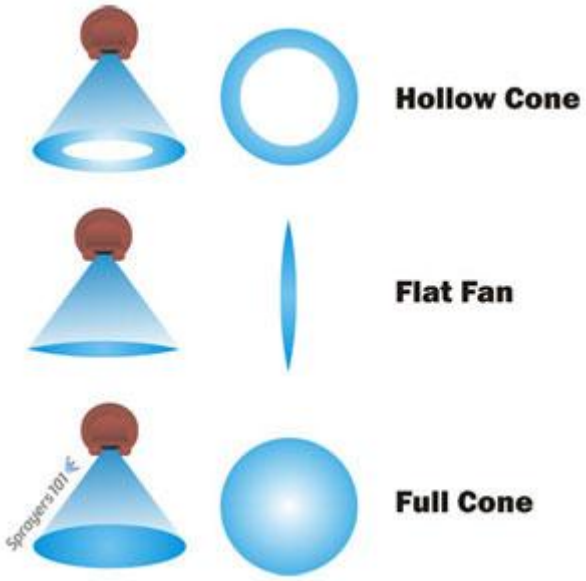
Nozzle spacing on the boom, spray angle, and boom height determine proper overlap of the spray. The drawing below shows the effect of nozzle spray angle on nozzle height, need for proper overlap, and spray coverage. Notice the height difference between the 110°, 80°,

and 65° nozzles. Wide angle nozzles are placed closer to the target for proper overlap. A lower nozzle height reduces the risk of spray drift.



Flow meters and other devices measure the uniformity of nozzle flow rate from nozzles along a boom. They are very useful when calibrating sprayers with multiple nozzles.

Common Nozzle Spray Patterns



Three common nozzle spray patterns: hollow cone, full cone and flat fan.(sprayers101.com)

Hollow cone nozzles produce a fine spray pattern to completely cover leaf surfaces. **Full cone nozzles** produce large, evenly distributed droplets at high flow rates. These two cone nozzles are best suited to apply fungicides and insecticides. **Flat fan nozzles** form narrow, oval patterns with tapered ends. They are spaced along a boom and overlap by 30% to 50 % for even broadcast spray distribution to the soil surface or plant canopy.

Nozzle Maintenance

Nozzles are available in various materials: brass, aluminum, plastic, stainless steel, hardened stainless steel, and ceramic. Select the material best suited for the pesticide formulation being used.

Never use brass or aluminum tips to apply abrasive materials (such as wettable powders and dry flowables) because they wear too fast. This wear increases the opening size of the nozzle, which increases its output. Reduce wear by using nozzle tips made of a hard, wear-resistant material: plastic, hardened stainless steel, or ceramics.

Be sure you have the correct screen size for each nozzle.

Clean nozzle tips carefully with a soft brush, not wire or a knife tip.

Sprayer Cleanup

Spray equipment should be cleaned in the field after the spray job has been completed. Some pesticide labels provide specific information on cleaning spray equipment; consult the label for guidelines. **Do not clean spray equipment in areas where rinse water will contaminate water supplies, streams, or injure susceptible plants**.

Pay special attention to areas that can be missed or are difficult to clean:

- Spray surfaces or components **where buildup of dried pesticides might occur**
- Sprayer **sumps and pumps**
- **Inside the top of the spray tank** and **around baffles**
- **Irregular surfaces** inside tanks caused by baffles
- **Plumbing fixtures**, agitation units, etc.
- **Collection points** where the hoses connect to the nozzle fittings in dry boom sprayers.

Flushing spray equipment with water may be sufficient to remove potentially harmful amounts of many pesticides. However, certain groups of pesticides may require special attention. **Thorough clean-out procedures can be critically important when switching**

applications between crops to help avoid significant crop injury. As a rule, a sprayer that has been used to apply 2,4-D or other growth regulator type herbicides should not be used to treat susceptible plants. A triple rinse – water, then ammonia, then water again – minimizes the risk of injury from dicamba and 2,4-D.

Types of Sprayers

The **backpack sprayer** is a simple but useful piece of application equipment made up of a tank, pump, sray wand and nozzles. It is useful for treating small areas, spot sprays, or hard to reach locations. The main spray options are broadcast, band, and spot.

Broadcast and band spraying spraying are used to treat areas uniformly. They require determining spray pressure, walking speed, nozzle tip, and height. Spray pressure is maintained by hand pumping. Determine a comfortable constant walking speed for the slope and terrain you will be covering. Select a nozzle tip for the volume of mixed spray that you will be applying. In many cases, the spray rate is given in teaspoons or ounces per 1,000 square feet.

Spot spraying is common for treating scattered clumps of weeds or brush. In many cases, you mix a specific concentration, such as a tablespoon per gallon of water and apply it until the foliage is wet but not dripping.

Hose reel lawn care sprayers allow efficient, even application of pesticides and fertilizers to turf. However, practice, experience, and attention to walking speed and application technique are essential for effective applications. *(photo source: Turfsprayers.com)*

Common outputs for spray gun nozzles are 1.5, 3, and 4 gallons per minute. *(photo source: krittenhouse.com)*

Inconsistent applications can result in control failures or injury to turf or landscape plants. Things to watch for when using this type of application:

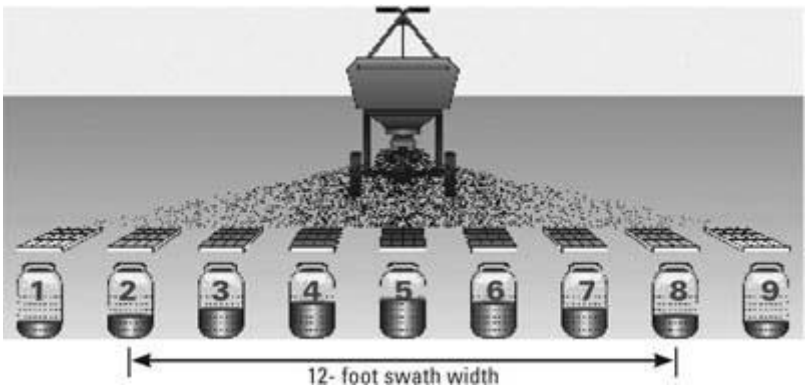
- Pump pressure is set correctly
- Consistent, accurate walking speed
- Nozzle is correct for desired flow rate
- No partially blocked nozzle openings
- Hose is not kinked
- Strainer screen is not clogged

Granular Applicators

Rotary and drop spreaders (Penn State Univ.)

Rotary and drop spreaders are used to apply granular fertilizers and pesticides to turf. The spreaders have several holes in the bottom of the hoppers with moveable gates which can be set to regulate product flow. Gate openings are adjusted during the calibration process to give the proper delivery rate.

The swath of the rotary spreader (above) is 12 feet but the distribution of the granules from it is uneven. You must overlap swaths to get an even application. The amount of overlap varies among spreaders. You need to measure the "effective swath width" of your spreader to determine the amount of overlap that is needed for uniform coverage.



Uneven distribution of granules from a rotary spreader (Pesticide Environmental stewardship - CIPM)

Lawn care products applied by <u>drop</u> spreaders fall directly beneath the equipment. Leaving a gap between swaths can result in streaking while overlap will double the rate.


Uneven fertilizer application: gaps between passes with a drop spreader (Donnan.com)

Non-spray Alternatives to Treating Trees

(source: modified from Utah State Univ. pub NR/FF/020)

Pesticides can be applied to tree trunks, branches, and foliage. This approach has been used extensively in recent years to protect ash trees from the emerald ash borer. Differences in chemical characteristics of products and advances in alternative application methods allow trunk implantation, trunk injection, soil injection/drenching, and trunk basal sprays. **These approaches allow more efficient use of pesticides, more effective placement, especially against some borers, and elimination of drift. However, movement of some chemicals in to nectar and/or pollen can cause significant harm to pollinators.**

Trunk Implants

Trunk implants or injections work by placing water soluble pesticides at or in the cambium where they can be carried through the tree mainly in xylem sap. The **pesticide must be placed in the correct tree tissue at the right time of year and at an effective concentration**. This tends to be a **good way to treat many sap feeding insects, borers, and some caterpillars**. Implantation involves placing capsules of pesticide into the outer xylem or sapwood. The product coating is dissolved by transpiration water and the chemical moved to the target site. Implants tend to require relatively large holes. *(photo source: Gardenersedge.com)*

Trunk Injection

Trunk injection involves placing pesticides into the tree for direct uptake. **Injections are necessary for large trees and can be used on sites where soil treatments may not be practical, effective or appropriate,** including trees growing on excessively wet, sandy, compacted or restricted soil environments. Trunk injections generally involve drilling through the bark and into the outer sapwood at the base of the tree. Drilling wounds could cause long-term damage, especially if treatments are applied annually.

Setting up a trunk injection (moorparktreeservice.com)

Application methods that rely on high pressure injections of insecticide through needles inserted into small holes **may damage the tree if the pressure causes the bark to bulge and separate from the cambium.** This is most likely to occur in spring and can cause larger wounds that result from death of the vascular tissue at the point of separation.

Uptake of trunk-injected insecticides will be most efficient when trees are actively transpiring. Best results are usually obtained by injecting trees in the morning when soil is moist but not saturated. Uptake will be slowed by hot afternoon temperatures and dry

soil conditions. Irrigating trees during droughty conditions will help with insecticide uptake and translocation within the tree. Products applied as trunk injections are typically absorbed and transported within the tree more quickly than soil applications. **Allow at least two and preferably three to four weeks for most trunk-injected products to move through the tree.**

Soil Injection

Soil injection relies on placing the pesticide, diluted in water, into the soil for uptake by the root system of the tree. While no holes need to be drilled, as with implants or injections, these applications generally **must be made several weeks before the pest is active to all allow time for uptake and dispersal of the chemical into the tree.** In general, there is a limit to the size (diameter) of trees that can be treated by this procedure. They require specialized equipment, but offer the advantage of placing the insecticide below mulch or turf and directly into the root zone of the tree. This also can help to prevent runoff on slopes. **Injections should be made just deep enough to place the insecticide beneath the soil surface (2-4 inches).**Soil injections should be made within 18 inches of the trunk. Studies have shown uptake is higher and the **treatment more effective when the product is applied at the base of the trunk where the density of fine roots is highest.**

Hand operated soil injection device (Va Tech)

No soil applications of systemic insecticide should be made where there are roots of flowering plants that are visited by bees and other pollinators. This situation is most likely to occur where flowering plants are established around the base of an ash tree. In these situations the flowering plants should either be destroyed or insecticide should be applied via trunk injection to ensure the toxins will not be taken up by the flowering plants.

Trunk Basal Spray

The **trunk basal spray** alternative is based on thoroughly wetting the lower 5 feet of the trunk with a water soluble pesticide. The chemical is absorbed through the bark and distributed by the vascular system of the tree. The basal trunk spray offers the advantage of being **quick and easy to apply and requires no special equipment** other than a garden sprayer. This application technique does not wound the tree, and when applied correctly, the insecticide does not enter the soil. Sprayers must be calibrated to ensure the appropriate amount of the formulated product is applied to each tree.

(source: utahpests.usu.edu)

There are advantages and disadvantages to each alternative but **all require largely intact vascular systems to move the pesticide.**