IPM
INTEGRATED PEST MANAGEMENT
& PESTICIDE SAFETY EDUCATION

Turf Pest Control

K-STATE
Research and Extension

Kansas State University Agricultural Experiment Station
and Cooperative Extension Service

Category 3B

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Table of Contents

Directions for Using this Manual

This is a self-teaching manual. At the end of each major section is a list of study questions to check your understanding of the subject matter. These study questions represent the type that are on the certification examination. By studying this manual and answering the study questions, you should be able to gain sufficient knowledge to pass the Kansas Commercial Pesticide Applicators' Certification examination. Correct answers appear on page 64.

Introduction

The turfgrass industry in Kansas includes home lawns, institutional and industrial grounds, sod production, golf courses, athletic fields and other recreational turf, parks, roadsides, airports, and cemeteries. Home lawns comprise by far the greatest amount of turfgrass acreage.

Turfgrass is maintained for beautification, recreation, erosion control, and utility. In general, people appreciate and take pride in maintaining attractive and quality turf. Proper care and timely pest control are necessary for good color and density and to keep turf free of weeds, insects, and disease. Turf management involves selecting the right grass, proper mowing, watering, fertilizing, and controlling thatch.

Cultural practices are the key to maintaining turf quality and preventing problems. Pesticides can aid in management but are not a substitute. Pesticides will not offset the negative effects of improper watering, fertilization, or mowing practices, thatch accumulation, poor soil, or choosing the wrong species. Climate, soil, management, pest control, and selection of adapted species and cultivars affect growth.

The harsh Kansas climate can make it difficult to grow quality turfgrass consistently. Extreme temperature variation from summer to winter limits the kinds of grasses that will grow. Rainfall and soil pH also vary widely from eastern to western Kansas. Unpredictable combinations of temperature, rainfall, humidity, sun intensity, day length, and wind add considerable stress. Ideal growing conditions exist only a few months out of the year.

Geographically, Kansas is in the transition zone between the northern cool-season grass range and the southern warm-season grass range. Both kinds of grasses are grown in Kansas, but neither is as well adapted to conditions as it would be farther north or south. Because both cool-season grasses (bluegrass, tall fescue and ryegrass) and warm-season grasses (bermudagrass, zoysiagrass and buffalograss) can be grown, turfgrass managers should be able to identify and manage the various grasses. Management practices for cool-season and warm-season grasses are distinctly different, with each type presenting distinct problems. Many chemicals are available for use on warm-season or cool-season turf only.

Problems may arise from selection of the turfgrass species or cultivar. The wrong grass for the wrong situation can result in continual problems that are difficult to combat, even with proper management and pesticides. Problems develop when turfgrass is unable to withstand environmental stress or when good management cannot offset ill effects. In these cases, pesticides can be a valuable aid.

This manual provides detailed information on diagnosis and management of turfgrass diseases, insect pests, and weeds.

Turf Diseases

Turfgrasses are susceptible to numerous diseases and environmental stresses. Most diseases are caused by fungi. Like other plants, turfgrasses are more susceptible to disease when stressed. Damage from environmental factors such as temperature, moisture, soil fertility, soil structure, or shade can be misdiagnosed as disease. Pesticide applicators should be familiar with both kinds of problems.

Numerous fungi species infect turf. This manual describes the most common diseases in Kansas. Many fungi produce spores for reproduction and spread. Because they thrive in wet conditions, water management (both foliar and soil) is the key to disease control. In general, watering deeply and infrequently is better than watering lightly and frequently. Each fungus thrives in certain temperature ranges. Some diseases are common in cool weather, others are more common when it is hot.

Like all plants, turfgrass requires appropriate light, moisture, and fertility. The following practices will help maintain overall turfgrass health and prevent disease development.

Select appropriate turfgrass species and varieties. Do not plant grasses that are not adapted to your area or for the site's intended use. In addition, use quality seed and plant at recommended seeding rates.

Provide adequate drainage. Ensure good surface and subsurface drainage when establishing new turfgrass from seed or sod. Be particularly careful with low spots where water may stand. Excessive moisture can damage roots and affect overall plant health.

Provide appropriate fertility. Different turfgrass species and sites have different fertility requirements. Determine what is appropriate for the specific site. Consider submitting a soil sample to a testing laboratory. Some diseases thrive when fertility is too low, and some thrive when fertility is too high. It is essential to find a balance and to fertilize at the appropriate time of year, which varies between cool-season and warm-season species.

Avoid compaction. Compacted soil decreases the oxygen supply to roots and interferes with water movement, reducing plant health. Core-aerate compacted areas. Coring is a form of cultivation in which a machine with hollow tines is used to remove soil cores.

Prevent excessive thatch. Overly thick thatch is a common problem in turf stands with symptoms that can be confused with diseases. More details about thatch are provided in the section on environmental stresses.

Use appropriate mowing heights. Each species has a range of mowing heights. For example, for tall fescue or Kentucky bluegrass lawns, 2 to 3 ½ inches is recommended compared to 1 to 2 inches for zoysiagrass or bermudagrass lawns. Golf courses have unique mowing requirements. The most common problem is mowing too low. Mowing too low reduces green tissue, reducing the plant's ability to conduct photosynthesis. This leads to reduced energy reserves in the plant, making it more prone to stress and disease. Mow grass frequently so that no more than ¼ to ⅓ of the leaf area is removed at any one time. Continue to mow the lawn throughout the fall until the grass stops growing.

Improve airflow and light availability. If a site is shaded or has poor air flow, thinning or removal of surrounding shrubs and trees allows sunlight to penetrate and increases air flow. This speeds drying of the grass and aids in disease prevention. Space landscape plants properly to allow adequate air movement and to avoid excessive shade.

Disease Diagnosis

The first step in control of turfgrass problems is accurate diagnosis. Incorrect diagnosis leads to inappropriate management and may compound the problem.

Turf Diseases

Brown patch in perennial ryegrass

Brown patch lesion on tall fescue

Rhizoctonia brown patch on tall fescue

Rhizoctonia brown patch on tall fescue

Diagnosis requires knowledge of what healthy turfgrass, including roots, looks like and the symptoms of abnormal or diseased plants. Some diseases such as powdery mildew and rust are relatively easy to identify. Others, including most root and crown rot diseases, are more difficult to diagnose without considerable experience. Always keep in mind that many turfgrass problems are caused by environmental stress, not diseases.

To diagnose turfgrass problems follow these steps.

- Determine the overall distribution of the problem. Is the damage uniformly distributed across the turfgrass or is it concentrated in one area? Streaks, bands, straight lines or perfect circles are more likely to be caused by environmental, non-living factors. Clumps, patches, or random patterns are more likely caused by a disease or other living organism.
- Identify the affected turfgrass species and cultivar (if possible). Turfgrass species and even cultivars within a species may vary in their susceptibility to turfgrass diseases. Many turfgrass stands contain more than one species. By understanding the type of turfgrass affected, you can help narrow the possible causes of the problem.
- Observe symptoms on individual plants. Look for the presence, size and color of leaf spots, crown or root rotting. These help identify the disease. Also look for fungal fruiting structures.
- Determine weather conditions before and during disease development. Turfgrass diseases are weather dependent. Some develop during cool weather; others will only cause problems during hot, humid conditions.
- Knowledge of weather conditions will help you select the right disease. Certain turfgrass problems may be associated with or caused by adverse weather (excessive rain, drought, heat, cold, etc.)
- Determine potential problems with soil structure or fertility. Look for evidence of shallow soil, buried debris, compaction, soil layering, poor drainage or other physical properties of the soil that may be contributing to turfgrass decline. Many turf problems are also associated with nutrient (nitrogen, iron, others) excesses or deficiencies. Consider submitting a soil sample to a laboratory for fertility testing.
- Determine the history of cultural practices at the site. Find out what fertility, irrigation, cultivation, and other practices have been conducted at the site, and when. Problems can occur when fertilization is applied at an inappropriate rate or the wrong time of year for the type of grass at the site. In addition, too much or too little irrigation can be problematic. Mowing at the wrong height can stress turf.
- Review pesticide management practices. Get a complete record of any previous pesticide applications to the turfgrass. Check rates, application dates, application methods, and any other chemical use patterns that could indicate a problem.
- Use reference materials. Match symptoms with those described in reference books. If you are still unable to identify the problem, collect a sample of sod (at least 4 inches in diameter and deep enough to include roots) from the margin of the damaged area and submit it to a plant disease diagnostic laboratory. Work with turfgrass extension specialists.

Specific Diseases

The following section lists common turfgrass diseases in Kansas, when they occur, symptoms, and management. For information on other diseases contact your local extension agent or plant disease diagnostic laboratory.

Turf Diseases

Brown Patch

Pathogen and conditions: Brown patch, caused by the fungus *Rhizoctonia solani*, is the most common and important disease of tall fescue in Kansas. The disease also can be problematic on creeping bentgrass and perennial ryegrass. Brown patch is a summer disease. It is most likely when nighttime temperatures remain above 70°F, and during extended periods of high relative humidity and leaf wetness. Brown patch is also more severe on turfgrasses under high nitrogen fertilization. Affected turfgrass generally recovers when cooler temperatures return in late summer/early fall.

Symptoms: Brown patch appears as irregularly shaped patches of blighted turfgrass that range in size from a few inches to several feet in diameter. The blighted turf initially is purple-green but quickly fades to light brown. When the grass is wet, the diseased patches frequently have dark, purplish margins (smoke rings). The patches tend to be more diffuse and irregular, and the entire lawn may look as if it is under drought stress. Individual plants may exhibit irregularly-shaped tan to gray leaf spots bordered by a dark-brown margin.

Management: Do not over fertilize. Apply a majority of the nitrogen fertilizer in the fall, the best time for cool-season grasses. Do not fertilize when brown patch is active. When seeding new areas, avoid seeding rates greater than the recommended rate. High seeding rates result in an excess number of turfgrass plants and creates conditions favorable for the brown patch fungus. Do not irrigate susceptible turfgrass in late afternoon or evenings if possible. This extends the number of hours the leaves remain wet and increases the likelihood of brown patch. Promote good air circulation by proper pruning of trees and shrubs. None of the bentgrass or tall fescue varieties are highly resistant to brown patch, although certain cultivars of the turf-type tall fescues tend to be more seriously damaged by the disease. A preventive fungicide application program is usually necessary to prevent outbreaks of brown patch on golf course putting greens during the summer months (June through August). Preventive applications may also be needed on perennial ryegrass fairways and certain high maintenance tall fescue lawns. In other cases, fungicide treatments may be applied at the first appearance of symptoms.

Dollar Spot

Pathogen and conditions: Dollar spot, caused by the fungus *Sclerotinia homoeocarpa*, occurs on all turfgrasses grown in Kansas. It is most problematic on creeping bentgrass fairways and putting greens. Dollar spot is most severe in late spring and early fall, but it may appear throughout the summer. The disease may occur regardless of management or soil fertility, although damage usually is most severe if there is a nitrogen deficiency.

Symptoms: Dollar spot results in the formation of small, roughly circular, bleached patches of turf. In lawn-height turfgrass the patches are usually 2 to 6 inches in diameter. On putting greens, the patches are usually 1 to 2 inches in diameter. Affected plants within the spots wilt and eventually turn tan or brown. On individual infected plants, leaves develop light yellow to tan lesions with reddish-brown borders. In the early morning when dew is still present on the turfgrass, small cottony strings of the fungus can sometimes be seen growing from the diseased leaf blades.

Management: Dollar spot is more severe in nitrogen-deficient turf. Therefore, maintain an adequate fertilization program. Avoid night watering or other irrigation practices that allow the leaves to remain wet for long periods. On golf courses, fungicides are generally applied to manage dollar spot on creeping bentgrass putting greens and fairways. New cultivars of creeping bentgrass with reduced susceptibility to dollar spot are available.

Rhizoctonia brown patch on tall fescue

Dollar spot lesion

Dollar spot on tall fescue

Dollar spot on creeping bentgrass

Turf Diseases

Fairy ring, type 1

Fairy ring, type 2

Fairy ring, type 3

Drechslera on tall fescue

Fairy Ring

Pathogen and conditions: Fairy rings are caused by numerous species of fungi in the group Basidiomycetes, and they can occur in all species of turf. The fungi grow in the soil and or thatch, consuming organic matter. They are not directly pathogenic on the turfgrass plants but they do affect the turfgrass growth. After rains or heavy watering, fungal fruiting structures (mushrooms or puffballs) may appear in the ring area. In addition, white, spongy fungal growth (mycelium) may be visible in the thatch or soil underneath the ring.

Symptoms: Fairy ring symptoms are grouped into three categories. Type 1 fairy rings include turf death and are most common on sand-based putting greens. The damage to the turfgrass has been associated with high salt content and hydrophobic (water repellent) conditions in the soil, caused by the fungi. Type 2 fairy rings display a ring of lush, dark-green turf and may or may not have fungal fruiting structures (mushrooms or puffballs). Type 3 fairy rings develop a ring of fruiting bodies with no visible effect on the turfgrass. Fairy rings may range in diameter from a few inches to 50 feet or more, and they can expand over time (several inches to a few feet per year).

Management: In many cases, fairy rings do not actually damage turfgrass, symptoms are temporary, and no management is needed. In lawns or landscapes, if type 2 fairy rings are considered unsightly, the green rings can be masked with light fertilizer applications, but make sure to stay within overall fertility recommendations for the turf species and site. Mushrooms and puffballs can be destroyed by mowing. Certain fungicides are labeled for suppression of fairy rings but are primarily used on golf course putting greens. In golf course putting greens, fairy rings are more common when fertility is low, so providing adequate fertility can prevent rings from occurring. In addition, for golf courses, there are methods to help overcome the hydrophobic soils by using spiking, wetting agents, etc.

Large Patch of Zoysiagrass

Pathogen and conditions: Large patch of zoysiagrass, also called zoysia patch, is caused by a fungus called *Rhizoctonia solani*. It is related to, but distinct from, the strain of *Rhizoctonia solani,* which causes brown patch on cool-season turfgrasses in hot weather. Large patch is most common in early spring and late fall as the zoysiagrass is entering or breaking winter dormancy.

Symptoms: The disease results in relatively large, roughly circular patches (2 to 20 feet in diameter) with slightly matted areas of discolored turfgrass. Patch margins are often bright orange especially in wet conditions. Patches sometimes persist from one season to the next. Individual shoots within the patch develop pinpoint, reddish-brown to black lesions on basal leaf sheaths. In order to see the lesions, you must dig up the plant near the patch border and look at the crown area near its attachment to the stolon. Zoysiagrass slowly refills the damaged areas during the summer.

Management: Avoid overwatering, especially in the fall or early spring. Poorly drained areas are very susceptible to injury from large patch. Core aeration or verticutting in June or July helps reduce thatch accumulation and invigorates the turfgrass. The fungus may be spread on infected turf cores removed during aerification if conducted when the disease is active. Several fungicides will help suppress large patch development, but the timing of application is critical to good disease control. Preventive applications should be applied in mid- to late-September before large patch symptoms develop and as the turf begins to enter winter dormancy. A second fungicide application in mid- to late April as the turf begins to break winter dormancy may further reduce disease development.

Leaf Spot and Melting Out

Pathogen and conditions: Leaf spot and melting out is caused by several different fungi. The most common on Kentucky bluegrass and tall fescue lawns in Kansas is *Drechslera poae*.

This disease used to be highly problematic on Kentucky bluegrass but newer cultivars have some resistance. The disease is most common in spring and fall.

Symptoms: The fungus infects young succulent leaf tissue and causes small elliptical, purple spots. The spots eventually turn light gray or tan but remain bordered by a dark brown to purple margin. The leaf spot phase of the disease usually does not damage the plant significantly. However, during continuous cool, wet conditions, the fungus invades and girdles the leaf sheath. As daytime temperatures increase, leaves on crown-infected plants begin to turn light green or yellow, similar to nitrogen-deficient turf. Eventually these plants die and turn brown or straw colored. This is referred to as "melting-out." Severe melting-out can result in irregular patches of dead turf. Damaged turfgrass stands often appear thin or uneven and tend to have weed problems.

Management: The most effective means of controlling melting out is to plant resistant cultivars. Several varieties of Kentucky bluegrass are available with good resistance to this disease. Use a blend of three or more resistant cultivars. In lawns where susceptible varieties are present, consider an overseeding program with resistant cultivars. Avoid excessive nitrogen fertilization in spring which favors lush growth, but do not "starve" the lawn of nitrogen during the spring. A well-balanced fertilization program will reduce the severity of the disease. Mow turf regularly at appropriate heights. Thatch reduction will also help reduce disease severity. Fungicide applications may be useful on lawns with a history of leaf spot starting in spring when symptoms are first apparent, usually late March through April. The disease is very difficult to control once the melting-out phase has begun.

Necrotic Ringspot

Pathogen and conditions: Necrotic ringspot is a root disease caused by the soilborne fungus *Ophiosphaerella korrae*. It is primarily a problem of Kentucky bluegrass, but may also be found on red fescue and annual bluegrass.

Symptoms of necrotic ringspot usually appear in late spring or early fall, but they may continue into the summer months. The disease is worse when wet weather is followed by hot, dry conditions.

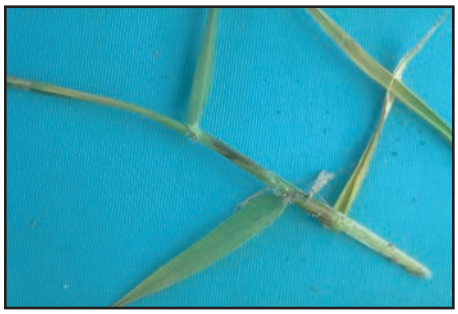
Symptoms: Necrotic ringspot causes numerous circular to arc-shaped patches of dead or dying turfgrass roughly 6 inches to 2 feet in diameter. The affected turf in the ring is slightly matted, whereas the turfgrass in the middle often remains healthy and green. Affected plants exhibit extensive root discoloration and rot. Necrotic ringspot symptoms may be confused with other diseases, including fairy ring and summer patch. Laboratory examination is usually necessary for confirmation.

Management: Several varieties of Kentucky bluegrass exhibit reduced susceptibility to necrotic ringspot and should be used in areas where the disease has been a problem. Alternatively, use other species of turfgrass (tall fescue) that are not susceptible to the disease. On established turf stands with a history of necrotic ringspot, promote overall turf health and root growth with proper fertilization and irrigation. Avoid excessive fertilization, especially fast-release forms of nitrogen. Irrigate deeply and infrequently. Core aerate compacted soils and maintain turf at the proper mowing height. Preventive fungicide applications in fall or early spring may be effective in suppressing disease development. Because this is a root disease, fungicides need to be applied in enough water to reach the root zone or appropriately irrigated.

Pink Snow Mold/ Microdochium Patch

Pathogen and conditions: Pink snow mold or Microdochium patch, caused by the fungus *Microdochium nivale*, is common on bentgrass putting greens, newly established ryegrass fairways and occasionally on Kentucky

Large patch of zoysiagrass



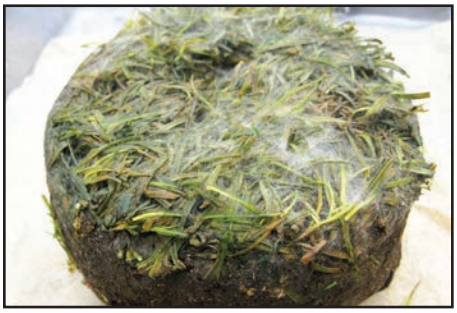
Large patch l lesion on zoysia leaf sheath

Necrotic ring spot on Kentucky bluegrass

Pink snow mold on creeping bentgrass

Turf Diseases

Powdery mildew



Pythium blight mycelium

Pythium blight

bluegrass and tall fescue in home lawns in Kansas. Pink snow mold can occur anytime during cool (below 60˚F), wet weather in fall, winter or spring. The disease does not require a snow cover for development, but it may be enhanced by it. Warm, dry weather stops disease development and allows the turfgrass to recover. Another type of snow mold called gray snow mold, or Typhula blight, requires long periods of snow cover and does not typically occur in Kansas.

Symptoms: Pink snow mold causes round, tan, gray or to reddish-brown patches that are usually less than 6 to 8 inches in diameter. Occasionally, spots may coalesce to blight larger areas. During wet, cool weather, the margins of the patches often have a pink tinge.

Management: Cultural practices can reduce pink snow mold. Avoid excessive use of fast-release nitrogen fertilizer applications in late fall, especially to fall-seeded turfgrasses. Use slow release forms of nitrogen fertilizer and mow frequently until growth has stopped. In spring, rake or mow affected areas to loosen the matted turf and promote drying. For high maintenance turf, such as golf course putting greens, fungicides may be beneficial, especially at sites with a history of the disease or sites with newly seeded turfgrass. In those cases, apply a fungicide starting in the late fall (November) when daytime temperatures remain below 60˚F and the weather is wet. Additional applications may be needed during winter and spring when cool, wet weather persists.

Powdery Mildew

Pathogen and conditions: Powdery mildew, caused by the fungus *Blumeria graminis*, is primarily a problem of Kentucky bluegrass in Kansas. The disease is most common in shaded areas of the lawn. The disease usually occurs in late spring and early fall when the relative humidity is high and temperatures are cool.

Symptoms: A powdery-like fungal growth develops on the leaf surface. Infected leaves often turn yellow and wither. Bluegrass lawns heavily infected with the mildew fungus tend to be thin. New plantings may be killed when mildew is severe.

Management: Selectively prune trees and shrubs to allow for greater sunlight penetration and improve air movement. Avoid excess nitrogen. Mow frequently at the recommended height. Consider renovating to a more shade tolerant variety.

Pythium Foliar Blight

Pathogen and conditions: Pythium foliar blight, sometimes called cottony blight, is one of the most destructive turfgrass diseases. It is distinct from Pythium root diseases which are not covered here. Pythium foliar blight is caused by several species of Pythium. Turfgrasses most commonly affected are perennial ryegrass and creeping bentgrass. Tall fescue is occasionally damaged, but injury to Kentucky bluegrass and warm-season turfgrasses is rare. Pythium blight is most active in humid, wet summer weather when air temperatures are high, especially when nighttime lows exceed 68˚F.

Symptoms: The disease first develops as small, irregularly-shaped, water-soaked, greasy patches up to 4 inches in diameter. A cottony growth may be present early in the morning when dew or other moisture is present. The patches may merge and form streaks since the pathogen is spread by water and by mowing operations. The disease is more likely to occur in wet areas or in drainage flows. The disease may spread very rapidly, killing large areas of turf in just a few days or even overnight.

Management: Maintain a proper balance of nutrients, avoiding an excess of nitrogen that stimulates lush growth. Do not overwater. Improve surface and sub-surface soil drainage. Promote air movement by proper spacing and pruning of trees and shrubs. Where feasible, delay seeding until weather is cool and dry. For high maintenance turfgrass with a history

of Pythium blight, preventative fungicide applications may be beneficial.

Rusts

Pathogen and conditions: Rust occurs to some extent on all turfgrasses grown in Kansas; however, this disease is generally most severe on susceptible cultivars of Kentucky bluegrass, tall fescue, perennial ryegrass and zoysiagrass.

Rust fungi include several species in the genus Puccinia species, and they are host specific; i.e., the rust that occurs on zoysiagrass is different than the one occurring on Kentucky bluegrass. Rust can occur in spring or fall, but normally appears in late August to early September and continues through the fall months. Rust outbreaks are dependent on favorable weather conditions and disease severity may vary widely from one year to another.

Symptoms: From a distance, rust-infected turf appears dull yellow or light brown. Individual plants may die and the turf becomes noticeably thin. The disease tends to be more severe in partially shaded areas such as under trees or along fences. Diseased plants initially develop light yellow flecks on the leaves. As the spots enlarge, the surfaces of the leaves rupture, exposing masses of powdery, brick-red fungal spores. The powdery substance easily rubs off. Continuous heavy infection causes many grass blades to turn yellow, wither and die. Severely rusted turf stands may winter kill.

Management: Turfgrass provided with appropriate levels of fertilizer and water are less likely to be damaged by rust. Irrigate early in the morning rather than at night, to reduce duration of leaf wetness, and mow at appropriate intervals. Mow frequently at appropriate mowing heights. Rust rarely reaches damaging levels. When establishing new plantings select varieties that are resistant to rust.

Spring Dead Spot

Pathogen and conditions: Spring dead spot is a root disease caused by three soilborne fungi *Ophiosphaerella herpotricha*, *O. korrae*, and *O.narmari*. It is the most common and destructive disease of bermudagrass.

The disease also occurs occasionally on buffalograss and zoysiagrass. Spring dead spot may occur on bermudagrass stands of all ages, although it typically appears three to four years after the turf has been established.

Symptoms: The disease results in the formation of circular or arc-shaped patches of dead turf in early spring as bermudagrass breaks winter dormancy. The dead patches, which are slightly depressed and straw-colored, may range in size from several inches to several feet in diameter and normally are randomly distributed throughout the stand. Roots and stolons of affected plants are often dark brown to black and are severely rotted. It may be necessary to dig up a piece of sod near the margin of the dead area and wash it in water to observe this symptom. During the summer, weeds invade and colonize the bare soil. Bermudagrass slowly recolonizes affected areas, and by late summer there may be little or no evidence of the disease. Unfortunately, enlarged dead patches reappear the following spring in the same locations. Over a number of years, the patches can become quite large, coalesce, and develop arc-like patterns in the turf stand.

Management: Several cultural methods can reduce the severity of spring dead spot. Bermudagrass should be cultivated (core aeration and/or verticutting) when the bermudagrass is actively growing to reduce thatch and promote good rooting. The appropriate time to cultivate bermudagrass (a warm-season turf) is summer. Avoid excessive nitrogen fertilization (more than 4 lbs of active nitrogen per 1,000 sq ft per season). Do not fertilize late in the growing season (after mid-August). Bermudagrass cultivars vary markedly in susceptibility to spring dead spot. Use cold-tolerant cultivars. In fungicide tests in Kansas, applications in late summer and early fall sometimes have reduced severity of

Rust pustules

Spring dead spot of bermudagrass

Turf Diseases

Slime mold

Summer patch on Kentucky bluegrass

Summer patch of annual bluegrass on putting green (Note that the creeping bentgrass is unaffected.)

Iron chlorosis

spring dead spot, but results have been inconsistent.

Slime Molds

Pathogen and conditions. Slime molds are actually not fungi and they are not pathogens of turfgrass. Slime molds utilize decaying organic material and other microorganisms in the soil as a food source. In humid weather slime molds grow out of the soil and thatch onto whatever is available for support, including turfgrass and mulch.

Symptoms: Slime molds form gray, purple, black, white or yellow powdery structures, the fruiting stage of the organism. When crushed between the fingers, they disintegrate into a powdery mass that easily rubs free from the grass blade.

Management: Slime molds frequently cause considerable alarm as they suddenly appear in spring, summer or fall following heavy rains or watering. Although they are unsightly, they do not damage the grass and do not require any specific management. They are easily removed by raking or hosing off the affected turfgrass.

Summer Patch

Pathogen and conditions: Summer patch is a root disease caused by the soilborne fungus *Magnaporthe poae*. It can be serious on Kentucky bluegrass and annual bluegrass, causing symptoms during summer heat stress.

Symptoms: Early stages of the disease may be difficult to detect. Initially, small patches of turf, 2 to 6 inches in diameter, turn dull green. Eventually, foliage changes to a dull reddish brown, then tan, and finally a light straw color. The crowns and roots of blighted plants may show a slight greenish-brown to black discoloration. To see the discoloration, gently pull plants and wash away the soil. Small fungal strands called runner hyphae may be seen on the roots with a 10× hand lens. These runner hyphae do not necessarily indicate summer patch. Certain other fungi also produce similar strands on roots. In the final stages of the disease, blighted turf areas form throughout the lawn. These patches may form elongate streaks, crescents, or circles 2 feet or more in diameter. Healthy grass may occur within the centers of patches of dead grass, giving a characteristic "frogeye" pattern. Summer patch symptoms can easily be confused with insect damage (grubs, billbug), herbicide injury, or drought stress. These possible causes should be eliminated before summer patch is diagnosed.

Management: Summer patch is an extremely difficult disease to control. Certain Kentucky bluegrass cultivars show some resistance to summer patch and should be seeded or sodded in new locations or areas where the disease has been a problem. Several cultural practices will help suppress disease development. Turfgrass should be maintained in a healthy, but not overstimulated, growing condition. A balanced fertilization program is important. Avoid excessive nitrogen fertilization during the summer months. Acidifying fertilizers may reduce disease. Maintain appropriate mowing heights Reduce thatch by yearly core aeration. Summer patch may develop even with optimal turf care, and certain cultural modifications may be necessary to save the turf. Seriously diseased turf should be watered lightly daily in the early afternoon to cool the plants and provide some moisture for the diseased roots. Preventive fungicide applications may be effective in suppressing symptoms of summer patch. A general rule is to initiate fungicide applications when soil temperatures at a 3-inch depth reach 65°F for several consecutive days, which often occurs from late April through mid-May in Kansas. Follow with several additional applications. Applications after symptoms have developed are not effective.

Environmental Stresses

Chemical Burn

Pesticides, fertilizers, household products, and other chemicals may injure grass if improperly applied. Burned areas may occur in spots or streaks, or the entire lawn may be scorched. Prevent injury by following the directions printed on the package label.

Apply fertilizers evenly in recommended amounts using a calibrated applicator.

Nutrient Deficiency

Areas or all of the turf may become yellowed and stunted. Chlorosis (yellowing) is usually caused by nitrogen deficiency or iron deficiency. Iron chlorosis is common in sites with a high soil pH. Follow recommended fertility practices for the turfgrass species and site condition. Submit soil for nutrient testing and follow directions in the report.

Buried Debris

A thin layer of soil over buried rocks, lumber, bricks, plaster, or concrete dries out rapidly in dry summer weather and may resemble disease. Wet the soil and probe with a long screwdriver or other implement. If the object is small it may be possible to dig it up and remove it.

Compacted Areas

Thin turf or bare spots appear in heavily used areas. Waterlogged and heavy-textured (clay) soils become compacted especially in areas with frequent foot or vehicle traffic. In compacted soil, pore spaces are filled, which decreases oxygen flow to the roots and interferes with water movement. Reduce compaction by aerifying the soil. Improve drainage. Reduce traffic by putting in designated walkways, paths, fences, or shrub rows.

Algae

A green to blackish algae slime may form on bare soil or thinned turf in low, wet, shaded or heavily used and compacted areas. The slimy mass of algae dries to form a thin, black crust that later cracks and peels. The presence of algae usually indicates an underlying site problem, and the best prevention is by maintaining a thick stand of turfgrass. Reduce soil compaction, improve drainage, provide appropriate water and nutrients, and conduct other good turfgrass agronomic practices.

Moss

Like algae, moss occurs where turfgrass has been thinned due to one or more site or environmental factors. Reduce soil compaction, improve drainage, provide appropriate water and nutrients, and conduct other good turfgrass agronomic practices.

Animal Urine Injury

Injury from dog or other animal urine may resemble brown patch or dollar spot. Affected areas are often more or less round and commonly up to a foot or more in diameter. These are usually bordered by a ring of lush, dark green grass. Injured grass turns brown or straw-colored and usually dies. Heavy watering to flush the salts helps spots to recover.

Thatch

Thatch is a tightly intermingled layer of decomposing stems and roots that develops between green vegetation and the soil surface. Thatch is not caused by returning clippings to the turf stand. Too much thatch keeps water from penetrating the soil, makes some disease problems worse, and inhibits root growth. Tall fescue and perennial ryegrass are bunchgrasses, which are less likely to accumulate excessive thatch than Kentucky bluegrass, zoysiagrass, or bermudagrass.

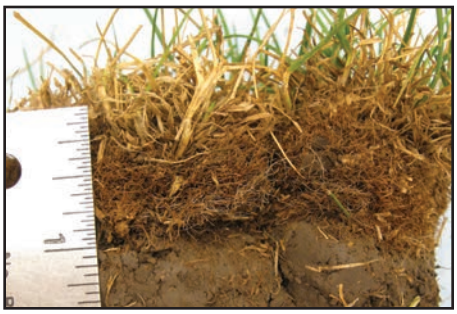
Control thatch by cultivating when a half inch or more of thatch has accumulated. The best time to cultivate cool-season grasses is in the fall. In contrast, the best time to cultivate warm-season grasses is in the summer. Core aeration, vertical mowing, and power raking are three options. Each method has pros and cons, so do some research ahead of time to determine which method is best for your site and the turf species.

Turf Diseases

Soil sterilant (herbicide) injury to tall fescue

Dry algae crust

Dog urine injury



Excessive thatch

Turf Diseases

Study Questions

1. *What is included in turfgrass management?*
   a. proper grass selection
   b. mowing
   c. thatch control
   d. all of the above

2. *An example of a cool season grass is:*
   a. bluegrass
   b. bermudagrass
   c. zoysia
   d. buffalo grass

3. *What causes most turfgrass diseases in the Midwest?*
   a. insects
   b. bacteria
   c. fungi
   d. viruses

4. *The following practices can help prevent the development of disease:*
   a. improve airflow and light availability
   b. select appropriate turf species
   c. provide appropriate fertility
   d. all of the above

5. *The first step in the control of any turfgrass disease is:*
   a. accurate diagnosis
   b. apply a fungicide
   c. apply a bactericide
   d. apply an inch of water

6. *To diagnose turfgrass diseases, the following is important:*
   a. review cultural and chemical practices
   b. determining the overall distribution of the disease
   c. observe symptoms on individual plants
   d. all the above

7. *Leaf spot and melting-out disease is caused by a:*
   a. bacteria
   b. virus
   c. fungus
   d. rodent

8. *From a distance, rust-infected turf appears:*
   a. dark green
   b. dull yellow
   c. dark brown
   d. brick red

9. *Powdery mildew can be reduced by:*
   a. frequent nitrogen applications
   b. pruning trees and shrubs to increase sunlight
   c. spraying a bactericide weekly
   d. spraying a herbicide

Study Questions

10. *In order to manage large patch fungus, it is important to:*
    a. allow thatch buildup
    b. core aerate when patch symptoms are active
    c. fertilize when the symptoms are active
    d. avoid overwatering in fall and early spring

11. *Spring dead spot is the most common and destructive disease of:*
    a. bermudagrass
    b. tall fescue
    c. zoysiagrass
    d. Kentucky bluegrass

12. *Fairy ring is caused by:*
    a. insects
    b. bacteria
    c. viruses
    d. fungi

13. *Necrotic ring spot symptoms may be confused with summer patch and* _____.
    a. Rhizoctonia large patch
    b. rust
    c. fairy ring
    d. powdery mildew

14. In lawn height turf, dollar spot causes these symptoms:
    a. rotted roots
    b. tan or bleached patches 2-6 inches in diameter
    c. tan or bleached patches less than one inch in diameter
    d. orange pustules on foliage

15. Rhizoctonia brown patch is the most common and important disease on _____.
    a. tall fescue
    b. bermuda grass
    c. Kentucky bluegrass
    d. zoysiagrass

16. In the control of brown patch _____ is important.
    a. proper fertilization
    b. proper irrigation
    c. proper air circulation
    d. all the above

17. Summer patch is:
    a. controlled by high nitrogen application
    b. extremely difficult to control
    c. easily controlled by one application of fungicide
    d. easily controlled by proper aeration

18. Slime molds are _____ parasitic on plants.
    a. seldom
    b. not
    c. always
    d. usually

19. Chlorosis is when the turf becomes _____ in color.
    a. purplish
    b. brownish
    c. yellowish
    d. reddish

Study Questions

20. Moss occurs in lawns with:
    a. low fertility
    b. poor drainage, compaction
    c. thinned turf
    d. combinations of the above

21. Which statement about thatch is NOT true:
    a. thatch interferes with water flow into the soil
    b. thatch inhibits root growth
    c. thatch is caused by returning clippings to the turf stand
    d. thatch is less likely to build up in bunchgrasses such as tall fescue

Turf Weeds

Any plant can be considered a weed if it is growing where it is not wanted. Bentgrass, for example, would be a weed in a bluegrass lawn. To plan a good weed control program, you must:

- identify the desirable turfgrass,
- identify the existing weeds, and
- combine pest control with good management practices.

Weed Life Cycles

Annual Weeds

Annual weeds complete their life cycle in less than one year. Because climatic conditions influence the timing of the life cycle, the correct time for control varies from place to place, year to year and from one species to another. In established turfgrass, the chemical control of summer annual weeds after midsummer may not be necessary or desirable.

Examples of summer annual weeds common to turfgrass:

Broadleaf Weeds	Grass Weeds
knotweed	crabgrass
spurge	goosegrass
purslane	barnyardgrass
	foxtail

Winter annuals are common in new turfgrass. After the first year, good management and dense turfgrass usually provide satisfactory control. Examples:

Broadleaf Weeds	Grass Weeds
common chickweed	downy brome
shepherd's purse	annual bluegrass
henbit	

Biennial Weeds

Biennial weeds normally occur at the same time as perennial broadleaf weeds. Controls are similar. Examples are: roundleaf mallow and wild carrot.

Perennial Weeds

Perennials, both broadleaf and grasses, occur widely as turfgrass weeds. Examples:

Broadleaf Weeds	Grass Weeds
dandelion	bermudagrass
wild garlic	bentgrass
plantain	quackgrass
mouse-ear chickweed	nimblewill
curly dock	windmill grass

Control Strategies

The presence of weeds in turfgrass does not always require the use of herbicides. In areas that contain sensitive plants, it may be better to avoid the use of herbicides than to risk injury. In some locations, any kind of plant cover may be better than dead plants or bare ground.

Granular formulations are effective for preemergence herbicides. Sprays are better for postemergence control where foliar coverage is needed.

Broadleaf Weeds—Several postemergence herbicides are used to selectively control annual, biennial and perennial broadleaf weeds in turfgrasses. They can be used alone or as combinations of more than one active ingredient. Spring and fall applications of postemergence herbicides normally give satisfactory control and reduce the possibility of damage to nontarget plants. Young weeds are usually more susceptible to herbicides. Spot treatments are best for scattered weed populations. Weather conditions affect control results.

Grass Weeds—Control of annual grasses is best achieved with preemergence herbicides for general infestations and spot treatment with postemergence herbicides for localized infestations.

Few herbicides are safe for use on newly seeded turfgrass. Some preemergence herbicides applied in the spring may adversely affect germination of turfgrasses seeded in the fall. Certain varieties of turfgrasses are more prone to injury by herbicides. Check labels for precautions.

Turf Weeds

Barnyardgrass

Spreading bermudagrass

Field bindweed

Field bindweed

Perennial grass weeds are the most difficult to control. No herbicides are available which will control these weeds without damaging cool-season turfgrass. Some will selectively control them in warm-season turfgrass. Soil fumigants and nonselective herbicides are sometimes used.

Turfgrass Management

The presence of weeds in turfgrass does not always require the use of herbicides. Proper management can do much to encourage lawn grasses and discourage weeds.

Mowing at a height of 2 to 3 inches shades the soil and protects cool-season grass roots from damaging effects of summer heat. High mowing is an excellent deterrent to the germination and growth of many annual weed species. However, bermudagrass and zoysiagrass perform best when mowed less than 2 inches.

Feeding programs that furnish lawn grasses with necessary plant food elements throughout the growing season tend to discourage weeds through competition furnished by more vigorous turf. Fertilize cool-season grasses primarily in the fall, secondarily in the spring and only sparingly during the summer months.

Withhold spring fertilization of warm-season zoysia, buffalo, and Bermuda until mid-May; do not fertilize them after mid-August.

Watering will help grass survive drought periods. Water as soon as the grass develops a blue-green cast. Application of water before moisture shortage symptoms appear is desirable. Soak the soil slightly deeper than the depth of root penetration. Avoid light, frequent sprinklings.

Seed and sod free of weed seed and off-type grasses is one of the first steps in weed control. Many lawns contain undesirable coarse grasses and weeds because they were present in the sod or seed. If you buy grass seed, study the label to make certain undesirable weeds and grasses are not present. Cultivated sod, inspected and treated to reduce weeds, is becoming more plentiful.

Common Weeds in Kansas Turfgrass

Before selecting a control method, identify the weed.

Barnyardgrass (*Echinochloa crusgalli*)

A coarse warm-season annual grass with a flattened stem, especially near the base. Lower portion of the plant tends to be reddish purple. The seed head branches into six to eight short compact segments. Ligule and auricles are absent.

Bermudagrass (*Cynodon dactylon*)

Warm-season perennial that produces both rhizomes and stolons that lie flat and creep across an area, rooting at the nodes. Flowering culms, flattened erect or ascending 4 to 15 inches tall; ligule features a conspicuous ring of white hairs. A serious pest of cool-season grasses.

Bindweed, field (*Convolvulus arvensis*)

A deep-rooted perennial vine common throughout most of the region. It is one of the more difficult weeds to control. The spade-shaped leaves have rounded tips and vary in size. The funnel shaped flowers vary from white to light pink and are about the size of a nickel. The plants readily climb over shrubs and other ornamentals. It spreads by both seed and roots.

Other common names: Creeping jenny; perennial morning glory.

Bluegrass, annual (*Poa annua*)

A low-growing, compact, tufted winter annual. Some flattened stems may lie close to the ground. It does not have rhizomes. Leaves are soft, light-green and boat-shaped at the tip. Starts growth from seed in early fall and often grows throughout winter. Can produce seed heads when mowed at 3⁄16 inch. May die suddenly during summer months.

Turf Weeds

Carpetweed (*Mollugo verticillata*)
A late-starting, rapidly growing summer annual. The green, smooth stems branch from the root in all directions, forming a flat circular mat on the soil surface. The light-green, smooth, tongue-like leaves are grouped five to six together forming whorls at each joint on the stem. Flowers are small, white, with several at each joint.

Chickweed, common (*Stellaria media*)
A hardy, low-growing annual or winter annual with creeping stems that root at the nodes. It has a delicate appearance and is found in green form most of the year in milder climates. The small, opposite leaves are oval-shaped and smooth. The small star-like flowers are white. Common chickweed is most often found in the shade of trees and shrubs, especially on the north side of buildings.

Clover, white (*Trifolium repens*)
A cool-season perennial legume that spreads by underground and above ground stems. May or may not be objectionable in lawns, depending on individual preference. Flowers are white, sometimes tinged with pink. Seeds live for 20 years or more in the soil.

Other common names: White Dutch clover.

Crabgrass *(Digitaria spp.)*
Crabgrass is one of the most common warm-season annual grassy weeds. The stems grow mostly prostrate, branch freely and send down roots where each joint comes into contact with the soil or moist grass. Seed head is divided into several finger-like segments. Two principal species are large crabgrass (*Digitaria sanguinalis*), sometimes known as hairy crabgrass, and smooth crabgrass (*Digitaria ischaemum*). Smooth crabgrass tends to be smaller and less hairy with purple stems.

Dandelion (*Taraxacum officinale* spp.)
Cool-season perennial common throughout the region. The yellow flowers occur from early spring to late fall. The thick fleshy taproot, often branched, can give rise to new shoots. Seedlings may appear throughout the spring and summer and are often abundant in the fall.

Dock (*Rumex* spp.)
The dock plant forms a large rosette but rarely flowers when growing in lawns. Curly dock (*Rumex crispus*) is most common. The leaves have crinkled edges, often tinted red or purple. Leaves of pale dock, also known as tall dock (*Rumex altissimus*), tend to be flatter and broader. Both species have flowering stalks that can grow up to 3 feet tall.

Fescue, tall (*Festuca arundinacea*)
A coarse, cool-season perennial bunch grass. Scattered clumps are objectionable in fine-textured turfgrasses. Leaf veins are fibrous. When mowed, fibers show on the cut edge, especially if mowers are not well sharpened. Mature leaf blades may be ½ inch wide, ribbed on top, and shiny smooth below. The lower portions of the stems are reddish purple, particularly in the spring and fall.

A similar grass, meadow fescue, (*Festuca elatior*) is also a frequent weed in bluegrass lawns.

Foxtail (*Setaria* spp.)
Foxtails are warm-season annuals. Yellow foxtail (*Setaria glauca*) has flattened stems, often reddish, on the lower portion. Stems of green foxtail (*Setaria viridis*) are round. The seed of yellow foxtail is four times as large as green foxtail. Giant foxtail (*Setaria faberili*) may be found in some lawns.

Garlic, wild (*Allium vineale*)
The slender, smooth leaves are hollow and attached to the lower portion of the waxy stems. Both bulbs and bulblets are produced underground. Green to purple flowers are often replaced with bulblets. There is a characteristic onion-garlic odor.

Carpetweed

White clover

Dandelion

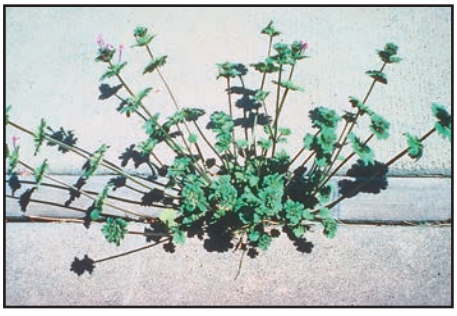
Curly dock

Turf Weeds

Wild garlic

Foxtail crabgrass

Goosegrass



Henbit

Wild onion is similar to wild garlic but does not produce underground bulblets or have hollow leaves.

Goosegrass (*Eleusine indica*)

A decidedly warm-season annual most often found growing where cool-season grass stands are thin. Germinates later than crabgrass. The stems tend to be flattened and white near the base. Flower heads are thicker and more robust than on common crabgrass. The extensive fibrous root system makes it difficult to pull.

Henbit (*Lamium amplexicaule*)

A winter annual that starts growing in September. Characteristics include squarish stems on upright plants, lavender to blue flowers, and opposite leaves. A few plants may bloom in the fall, but most blossom in early spring.

Knotweed, prostrate (*Polygonum aviculare*)

An annual that germinates in early spring and thrives into late fall. It grows flat from a long white taproot. Individual plants may spread two feet or more. Stems are wiry and leafy with a thin, papery sheath at each leaf node. Leaves often have a bluish cast. Seeds are three-cornered, light-brown early, and shiny black when mature.

Mallow, purple poppy (*Callirhoa involucrata*)

Perennial that spreads by seed and underground root. Reddish-purple flowers are borne in clusters and have five petals. Leaves alternate. They are 2 to 3 inches long, lobed, with large oval stipules at the base. Lawns started with pasture sod or soil may be infested.

Nimblewill (*Muhlenbergia schreberi*)

A warm-season perennial grass with wiry fine stems that root at the nodes. Root system is shallow and fibrous. It forms circular patches or may be distributed throughout lawn. Objectionable in cool-season lawns because of delayed spring growth and early dormancy in the fall.

Nutsedge, yellow (*Cyperus esculentus*)

Triangular stems of this warm-season perennial produce three-ranked leaves from near the ground. Leaves are light yellow-green. Lower portion of the plant is fibrous and brown. Roots often terminate with small nutlets about the size of a popcorn kernel. Seed heads resemble burs. Plants grow rapidly in spring and early summer. Several sedge species are common in this region, but this one is most prevalent in lawns.

Plantain, blackseed and broadleaf

Cool-season perennials that form rosettes with prominently veined leaves. The leaves of blackseed (*Plantago rugelii*) are oval and 2 to 3 inches across with purplish stalks. Broadleaf plantain (*Plantago major*) has smaller leaves without purplish coloration. Both species have rattail seed heads several inches long.

Plantain, buckhorn (*Plantago lanceolata*)

Slender, narrow leaves of this perennial are about 1 inch across with three to five prominent veins. The seed head is a short cylindrical spike.

Poison Ivy (*Rhus radicans*)

This woody perennial reproduces by seed and root and is found mostly in woods and shady places. Leaves are divided into three oval leaflets. Seeds are borne in white berries. All plant parts contain a toxic substance that may be irritating to people. This plant is usually not a problem in turf, except in natural areas.

Puncturevine (*Tribulus terrestris*)

A prostrate, freely branching warm-season annual that is slightly hairy. Some stems may be 4 or 5 feet long. It has a taproot, bright-green leaflets, and yellow flowers. Seeds are angled, with two stout spines that resemble a Texas longhorn.

Turf Weeds

Purslane, common (*Portulaca oleracea*)
This warm-season annual has fleshy or succulent leaves and stems, reddish in color. It grows prostrate, and the root system tends to be fibrous. Stems root where they touch the ground, particularly if the main root has been destroyed. Plant has small yellow flowers and small black seeds.

Quackgrass (*Agropyron repens*)
A cool-season perennial wheatgrass that spreads extensively by long white rhizomes (underground stems). Leaf blades are twice the width of bluegrass and tend to be rough in texture. A claw-like protrusion of the leaf called an auricle clasps the stem. The lower leaf sheath of the stem is hairy.

Other common names: Crouchgrass.

Sandbur (*Cenchrus* spp.)
A warm-season annual grass most often found in sandy turf areas that have been on low maintenance programs. Stems are flattened and branched; may be confused with yellow foxtail before the formation of the spiny burs.

Shepherd's purse (*Capsella bursa-pastoris*)
A winter annual with deeply lobed leaves that form rosettes in the fall. It may be confused with dandelions, except the leaves lack the milky sap. This plant blooms in early spring. White flowers develop into triangular seedpods filled with numerous tiny reddish-brown seeds. Individual seedpods held by small stems resemble the purse once carried by shepherds.

Speedwell (*Veronica* spp.)
Several weedy species exist, with most being winter or early spring annuals. Plants are low growing. Leaf shapes vary depending on species but are generally small and numerous. Flowers are light blue with white throats. Seedpods are divided and almost heart-shaped.

Spurge, prostrate (*Euphorbia supina*)
A warm-season annual most prominent in July, August, and September. Plant characteristics include prostrate growth habit, silky sap, and leaves with or without reddish-brown spots. Seeds are carried in capsules in groups of three.

Other common names: Milk spurge.

Thistle (various genera and species)
Biennial or perennial that reproduces by seed or fleshy root system. Dark-green or white leaves are 2 to 4 inches long with spiny edges. May occur in turf as a rosette.

Violets (*Viola* spp.)
Cool-season perennials that are among the first to bloom in the spring. Prefer at least partial shade. Flower color varies from very light blue to deep purple. Occasionally become troublesome in lawns. Numerous species are common in this region.

Windmill Grass (*Chloris verticillata*)
Perennial with flattened, keeled leaf sheath and grayish-green blades, ¼ to ½ inch wide. Panicles of two or three whorls with stiff, spreading spikes. Primarily occurs in range and pasture areas. Lawns started with pasture sod or topsoil may be infested.

Woodsorrel, yellow (*Oxalis stricta*)
Classified as a perennial but more often performs as a warm-season annual. Stems branch from the base. The leaves are palmately divided into three leaflets and resemble a clover. Funnel-form flowers are yellow (violet in some species). The seedpod is cylindrical, five-sided, and pointed. Plants contain soluble oxalates that give it a rather pleasing sour taste.

Yarrow, common *(Achillea millefolium)*
Perennial that grows 1 or 2 feet tall. Leaves are soft, finely divided,

Henbit

Prostrate knotweed

Yellow nutsedge

Broadleaf plantain

Buckhorn plantain

Poison ivy

Puncturevine

Common purslane

and fern-like. Stems and leaves are covered with grayish-green fine hairs. Flowers are mostly white, forming a flat flower cluster. Entire plant is rather strongly scented.

Western yarrow (*Achillea lanulosa*) is also common in the region.

Weed Control Methods

Mechanical Control

Digging and pulling are simple, effective ways of controlling a few scattered weeds. Dandelions should be cut 2 to 4 inches below the crown to reduce regrowth. Pulling of most species works best following a heavy rain or after deep watering.

Undercut and cut around small patches of undesirable grass with a sharp spade. Lift the undesirable patch and use it as a pattern to cut out a placement piece the same thickness from an inconspicuous place elsewhere in the lawn. Make certain the replacement sod is firmed into place and well watered until it becomes established.

Preemergence Weed Control

Chemicals applied to the soil to stop growth of seed are preemergence herbicides. They work best on annuals and also control some perennials starting from seed. Most preemergence products have little effect on emerged seedlings.

Proper lawn preparation is essential for optimum performance of preemergence products. Preparation for preemergence chemicals includes three simple steps:

1. Remove trash, leaves and excess dead grass from the lawn. If power raking is planned, do it as part of the lawn preparation for preemergence chemicals.
2. Apply the preemergence product as directed on the bag or container. Distribute evenly. Double coverage at half rate in two directions assures more even distribution than a full rate applied in a single application.
3. After application, water the lawn. Watering moves the chemical into the soil where it can perform the intended job on germinating weed seeds.

The table on page 31 shows the most effective times of application. In general, preemergence products should be applied in the very early spring for the control of cool-season weeds and in mid spring for warm-season annuals.

Products designed for preemergence weed control may be labeled "Preemergence," Preemergent," or "Preventer." Most preemergence herbicides sold for home lawn use are bought as granules ready for application.

Product Labels

The following herbicides labeled for use on lawns and other turf were registered with the Environmental Protection Agency (EPA) at the time of publication. The registration status of herbicides and other pesticides is continuously reviewed by manufacturers and EPA and is subject to change. Read the product label before purchasing to make sure it is registered for your needs. Most farm and ranch herbicides are not labeled for use on turf. Applying such products to turf would be inconsistent with labeling and a violate the Federal Environmental Pesticide Control Act.

Some products are sold under several trade names, so this list is not all-inclusive. Common names are given in parentheses. These products are primarily for annual grass control unless otherwise noted. Some products also control certain annual broadleaf species. Products have varying residuals and seeding must be delayed for several months after applying. Check the label.

Barricade (prodiamine). Can be used on most species grown in Kansas. Season-long control is possible with a single application.

Betasan (bensulide). Can be used on cool-season grasses including bentgrass greens; also bermudagrass and zoysiagrass.

Devrinol (napropamide). For use on tall fescue and bermudagrass only.

Dimension (dithiopyr). Safe for all species grown in Kansas, including bentgrass greens. Season-long control is possible with a single application.

Gallery (isoxaben). This product is primarily designed to control annual broadleaf weeds. It will also prevent dandelion seed from germinating. It is not effective on crabgrass.

Kerb (pronamide). For use on bermudagrass only.

Pendimethalin. Can be used on all Kansas lawn species, except bentgrass.

Princep (simazine). Labeled for use on zoysia and bermuda only.

Prograss (ethofumesate). Primarily used for pre- and post-emergence annual bluegrass control on perennial ryegrass golf course fairway turf.

Ronstar (oxadiazon). Not for use on home lawns. Particularly effective against goosegrass. Can be used safely on newly sprigged or plugged warm-season turfgrass.

Surflan (oryzalin). For use on tall fescue and warm-season grasses only.

Team (benefin + trifluralin). For use on all Kansas species, except bentgrass and buffalograss.

Tupersan (siduron). Can be used at time of seeding to control crabgrass and foxtail in the seedbed. Not for use on warm-season grasses.

XL (benefin + oryzalin). For use on tall fescue and warm-season grasses only.

Postemergence Chemical Control

The application of weed killers to unwanted emerged plants is referred to as postemergence weed control. 2,4-D is an example of a selective postemergence herbicide. These herbicides selectively control either broadleaf or grassy weeds and have little or no effect on desirable lawn grasses.

Many selective herbicides are growth regulators. They interfere with the normal processes within some plants by upsetting delicate hormone balances. These imbalances result in distorted growth and ruptured cells. Food movement is impaired, and eventually death results. Control is most likely if the herbicides are applied when the weedy plants are young.

Hormone-type herbicides, if not properly used, can cause injury or kill desirable flowers, shrubs, trees and gardens.

Ester formulations should be used cautiously because they are highly volatile and may damage non-target plants nearby.

Common postemergence broadleaf herbicides include (common names in parentheses where applicable):

2,4-D. A growth-regulating phenoxy herbicide that acts like a hormone. Formulated principally as amine salts and esters and sold under a wide variety of trade names. It is available in liquid or granular form. Very effective against dandelions and many other broadleaf weeds.

2,4-DP. A phenoxy herbicide similar in chemistry to 2,4-D.

Confront (triclopyr + clopyralid). A very effective non-phenoxy broad-spectrum herbicide. Excellent against clover. Confront cannot be used on home lawns.

Dicamba. A very effective non-phenoxy broad-spectrum herbicide. Should be used with caution around landscape plants as it can be taken up through their roots. Do not use inside the drip-line of trees.

Image (imazaquin). Controls variety of broadleaf weeds as well as wild garlic and wild onion. For use on bermudagrass and zoysiagrass only.

Escalade II (2,4-D + fluroxypyr + Dicamba). Controls a wide variety of broadleaf weeds. Not labeled for buffalograss.

Manor (metsulfuron). Controls a variety of annual and perennial weedy grasses and broadleaf weeds. Labeled for Kentucky bluegrass, bermdagrass buffalograss and zoysiagrass.

Field sandbur

Shepherd's purse

Veronica

Prostrate spurge

Turf Weeds

Thistle

Windmill grass

Oxalis

Common yarrow

MCPA. A phenoxy herbicide usually formulated in combination with other herbicides to increase the spectrum of control.

MCPP. A phenoxy herbicide, often formulated in combination with other herbicides, but sometimes formulated alone. More effective on clover than 2,4-D.

Monument (2-pyridinesulfonamide). Excellent on nutsedge. Labeled for home lawns. For use on bermudagrass and zoysiagrass only.

Q4 (Quinclorac + sulfentrazone + 2,4-D + Dicamba). Controls a wide variety of broadleaf and grassy weeds.

Quicksilver (carfentrazone). Good product for moss control.

SpeedZone (Carfentrazone + 2,4-D + MCPP + Dicamba). Controls wide variety of broadleaf weeds. Good activity under cool (50 degrees F) conditions

Surge (Sulfentrazone + 2,4-D + MCPP + Dicamba). Control a wide variety of broadleaf weeds.

Turflon (triclopyr). A non-phenoxy herbicide with broad-spectrum control.

T-Zone (triclopyr + sulfentrazone + 2,4-D + Dicamba). Formulated for tougher to control weeds such as spurge and white clover.

Common postemergence grassy herbicides include (common names in parentheses where applicable):

Acclaim (fenoxaprop). Very effective control of annual grasses. Not for use on bentgrass or bermudagrass. In fact, Acclaim will suppress bermudagrass that has invaded other lawn species. May temporarily discolor desirable lawn grasses, especially Kentucky bluegrass and zoysiagrass, however recovery normally occurs in 10 to 14 days.

Drive (quinclorac). Effective control of crabgrass and has good activity on field bindweed, black medic, and clover. It does little to nothing to goosegrass.

Fusilade II (fluazifop). Can be used for bermudagrass suppression in tall fescue or zoysiagrass lawns. Control may be possibly achieved with several repeat treatments. Desirable grasses will likely be temporarily discolored.

Tenacity (mesotrione). Labeled for tall fescue, Kentucky bluegrass, perennial ryegrass and buffalograss. Can be applied pre or post seeding. Windmill grass and nimblewill as well as many other weeds are listed on the label.

Nutsedge control

Certainty (sulfosulfuron). Good control. For use on warm-season grasses only.

Dismiss (sulfentrazone). Quick initial knock down but repeat applications needed for control.

Monument (2-pyridinesulfonamide). Excellent control. For use on warm-season grasses only.

SedgeHammer (halosulfuron). Very effective product that can be used on all Kansas turfgrasses except buffalograss.

Solitaire (quinclorac + sulfentrazone). Quick initial knockdown but repeat applications needed for control.

Nonselective control (total vegetation control)

Diquat. Works strictly by contact; treated plants will be desiccated but will eventually regrow from the crown or other growing points.

Finale (glufosinate-ammonium). For non-selective weed control of emerged weeds. No soil residual. Works both by contact and systemically. Effects show up somewhat sooner than with glyphosate.

Roundup (glyphosate). The industry standard for total vegetation control since the early 1970s. Systemic action with no soil residual. Usually takes seven to 10 days to see visual effects.

Herbicide Formulations

Postemergence herbicides may be applied as liquids or granules.

Liquids – esters and salts

Liquids of the hormone type are normally esters or amine salts. Esters formulated for turf release a minimum amount of fumes at temperatures below 85°F. Air temperatures can be misleading since temperatures at the lawn surface may be 20 to 40 degrees higher. Salt formulations — lithium and amine — are less hazardous because they do not give off damaging fumes.

No ester formulation is safe to use around ornamentals because of volatilization or vapor hazards. Wind movement of spray particles is equal on both esters and amine salts. Carefully read labels and select the very safest formulations and products available. Proper use begins with selection of the correct weed killer and a safe formulation.

Granules

Solid formulations are most commonly formulated as granules. These formulations provide effective weed control and reduce risk to desirable ornamentals and vegetable gardens.

Granular formulations work most satisfactorily when applied in late evening or early morning, when weed species are damp. Sprinkling with water before application also provides the necessary conditions for granular adherence and effective control.

Liquid Application

Liquid applicators can be classified into two groups—gravity flow and pressure.

Gravity flow

Gravity flow liquid applicators are most desirable for the average homeowner. They are simple to operate, low in upkeep and initial cost, and eliminate drift of fine droplets of spray which could cause damage to ornamentals, fruits and vegetables.

The simplest and least expensive gravity flow applicator is a plastic sprinkle nozzle that fits into a gallon jug. The jug is filled with the proper mixture of water and weed killer. When inverted, the mixture comes out in a uniform spray. Precision application can be obtained by first making a test run with water to determine the area covered at the normal walking speed.

Cane tubes equipped with a push-type dispenser on the bottom end are popular for treating a few scattered weeds. Cane tubes are usually about 30 inches long. They are filled with water and herbicide. When the cane tube is pressed down on a plant, the dispenser releases a squirt of weed killer mixture. Premeasured weed killer tablets are available for use in cane tubes; however, liquid formulations will serve just as satisfactorily.

Liquid spreaders work on the same principle as granular applicators. The most successful type employs a whirling disc which throws the weed killer mixture in a precision pattern.

Brush and can systems are convenient methods for treating small patches or a few individual plants. The herbicide mixture is simply painted or daubed on plants marked for elimination. The brush and can method works well for spot treating unwanted clumps or patches of grass. Use an inexpensive paint brush or a cloth or sponge dauber.

Pressure systems

Pressure applicators are of two types—air pressure and water pressure. Air pressure sprayers require a sealed tank, pump and nozzle. Water pressure sprayers are commonly known as hose-end sprayers. They use water pressure to force distribution of the material.

Misuse of pressure-type applicators accounts for a considerable share of the weed-killer spray drift injury that occurs in urban neighborhoods. When using pressure sprayers, operate the equipment with as low a pressure as possible. Lower pressure increases spray droplet size and thereby reduces the possibility of drift. Never operate pressure spray equipment in urban areas when wind movement is 10 mph or more.

Herbicide applications are difficult to control with hose-end units. Wrestling with the water hose and lack of precision can result in

Oxalis

Chickweed

Chickweed

misapplication. Save hose-end units for the application of insecticides, fungicides, and liquid fertilizers.

Considerations

Herbicide effectiveness may vary from year to year or area to area. Factors that influence weed control using soil-applied herbicides include:

- kinds of weeds
- application rates
- application uniformity
- herbicide solubility
- herbicide volatility
- rainfall
- soil type
- organic matter

Factors that influence weed control using foliage-applied herbicides include:

- kinds of weeds
- application rates
- application uniformity
- spray additives
- stage and rate of weed or crop growth
- loss due to rain or degradation by sunlight
- retention on leaves

Understanding factors that influence herbicide effectiveness can help applicators select the appropriate herbicide for a particular weed. Additional information can be found on the label, or by asking the dealer or your local extension agent.

Proper Use of Herbicides

Herbicides control weeds more effectively when growing conditions are favorable, but they also may cause more crop damage. Effects on a weed and on a crop plant usually vary with different herbicides. A thorough understanding of a herbicide is necessary to use it properly. Safe, proper use requires consideration of the following guidelines:

1. **Selection:**
   Selecting a herbicide depends on the crop being grown—such as potatoes, strawberries, annual flowers or turf. The choice also depends on the expected weed infestation, length of weed control desired, cropping sequence and cost.
2. **Registered Uses:**
   Use only a herbicide that has been registered for use on the crop to be grown. Herbicides named in this publication (as of printing date) have been registered for uses suggested. Uses described on current container labels also are registered.
3. **Labels on Herbicide Containers: READ AND FOLLOW ALL LABEL DIRECTIONS AND PRECAUTIONS.** Labels on herbicide containers are written with great care to give needed information. Herbicides sold in interstate commerce must be registered by the Environmental Protection Agency (EPA). Pesticides used on raw agricultural products also must have a residue tolerance established by the Environmental Protection Agency. The label of a registered herbicide must carry the following information: brand name or product name, ingredient statement giving the name and percentage of each active ingredient, warning or caution statement on toxicity of the chemical, and directions for use including rates and time to apply. The label also contains a statement of net weight or measure of content, name and address of manufacturer and EPA registration numbers.

4. **Application Rates:**
Apply at the rate recommended for your soil or for the stage of crop and(or) weed growth. Do not exceed the recommended amount. Apply uniformly over the treated area. Equipment must be calibrated to attain the recommended application rate.

5. **Spray Drift:**
Minimize drift and possible damage to susceptible plants by applying chemicals when the wind is blowing lightly (less than 10 mph). Apply spray at low pressure, not more than 25 to 30 pounds per square inch for boom sprayers.

6. **2,4-D and Other Phenoxy Herbicides:**
Horticultural crops and numerous other economic plants frequently are damaged by careless or indiscriminate use of phenoxy herbicides. Each year professional horticulturists, herbicide specialists and county Extension agents receive many questions and complaints about twisted and distorted plants. Misuse of 2,4-D or other phenoxy herbicides can cause much damage. Prevent damage to your own or your neighbors' susceptible plants from phenoxy herbicides by following these rules:

- Use a phenoxy herbicide only when specifically needed. In some cases use of other herbicides that are less hazardous can effectively control broadleaf weeds.
- Use the amine salt formulation when possible and when temperatures are expected to exceed 85°F. If the ester formulation must be used, apply when air temperatures are expected to be below 85°F for several hours. Ester formulations rapidly release vapors or fumes at about 90°F.
- Apply all formulations when winds are less than 10 mph. Spray drift from 2,4-D can injure susceptible plants a significant distance downwind.
- Use low spray pressure to minimize spray drift.
- Use a separate sprayer for phenoxy herbicides and use another sprayer for other pesticides unless the sprayer can be thoroughly cleaned.

7. **Cleaning Sprayers:**
Immediately clean spraying equipment after use. For greatest safety with susceptible crops, apply pesticides with equipment that has not been used previously for phenoxy herbicides. Sprayers previously used for herbicides must be thoroughly cleaned before they are used for insecticides or fungicides on susceptible plants.

   To clean sprayers contaminated with a herbicide, first drain the sprayer, hoses and boom. Then run water through the hoses and boom. Wash down the spray tank and then drain it. Repeat the rinsing procedure several times.

   Follow label directions for sprayer clean-up procedures.

   If the sprayer has been contaminated with phenoxy herbicides, fill the tank to near capacity with water, add 1 quart of ammonia for each 25 gallons of water (3 tablespoons per gallon). Pump enough spray to fill hoses and nozzles, fill the tank, close and let the sprayer soak for 24 hours. Drain and rinse tank and hoses with water. Finally, fill the tank with water and drain just before using. NOTE: This is time-consuming but the only alternative is to have a separate sprayer for phenoxy herbicides.

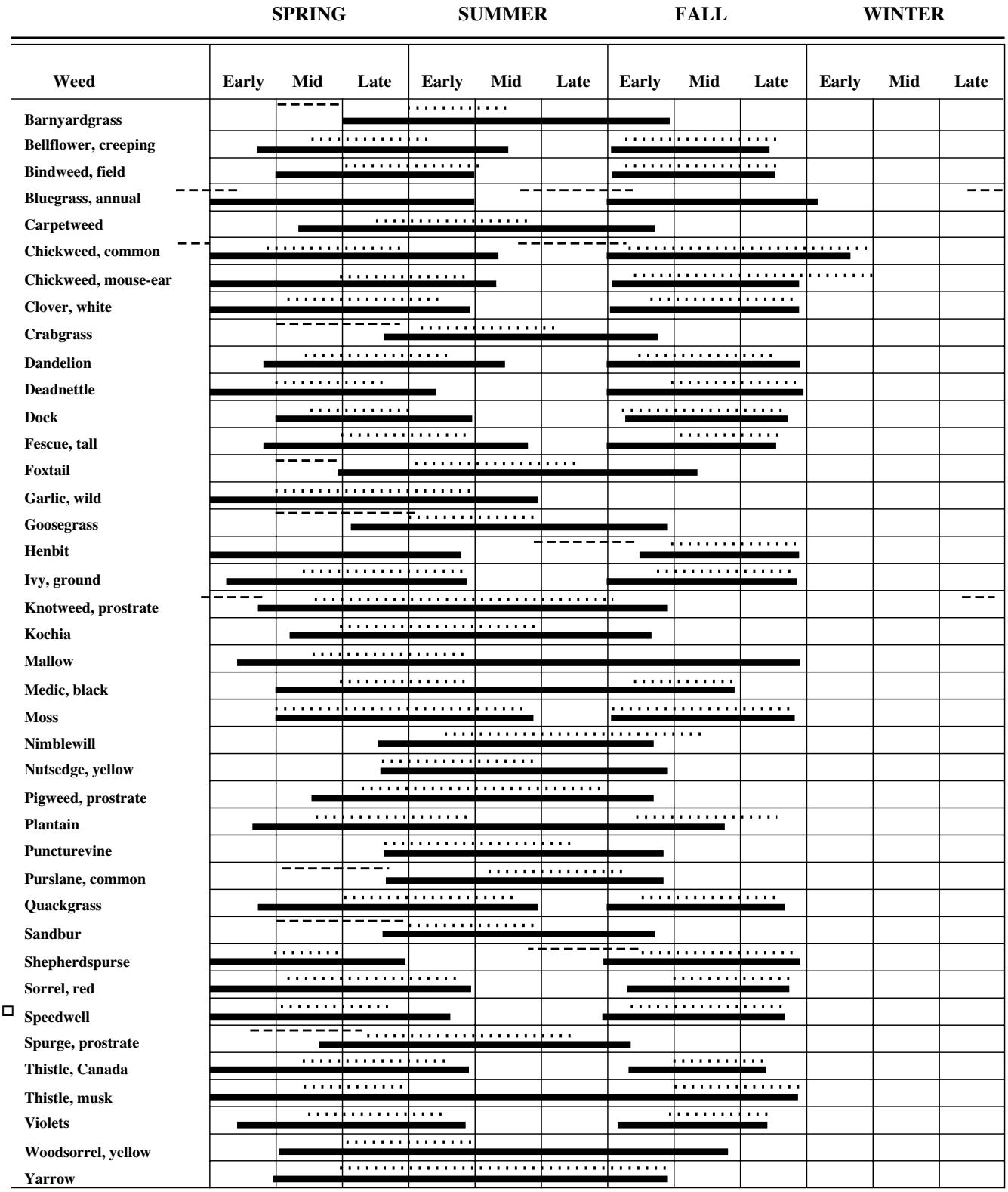
8. **Sprayer Nozzle Tips:**
Use the correct nozzle tips for the sprayer. Tips vary in amounts of material they discharge and spray patterns they produce.

   When applying a herbicide in a band, use only nozzle tips designed specifically for band application—those that apply a uniform spray pattern across a band. Standard, flat-spray nozzle tips should not be used; they give a feathered pattern at the edges

Turf Weeds

Weed Response to Herbicides			
Weed	**Preemergence control**	**Postemergence control**	
		1st choice	**2nd choice**
Barnyardgrass	Yes	Drive	Acclaim
Bellflower, creeping	No	Dicamba	2,4-D+MCPP+ Dicamba
Bindweed, field	No	Drive	2,4-D + MCPP + Dicamba
Bluegrass, annual	Yes, but difficult especially on golf courses	Prograss	
Carpetweed	Some	2,4-D	Dicamba
Chickweed, common	Some	Dicamba	MCPP
Chickweed, mousear	Gallery	Dicamba	MCPP
Clover, white	No	Drive, Escalade II, Confront	MCPP, Dicamba
Crabgrass	Yes	Drive	Acclaim
Dandelion	Gallery	2,4-D, MCPP, Dicamba, Confrort	
Deadnettle	Some	2,4-D + MCPP + Dicamba, Escalade II	Dicamba
Dock	No	Manor	Confront, 2,4-D + MCPP + Dicamba
Fescue, tall	No	Roundup, Finale (spot treat)	
Foxtail	Yes	Acclaim	
Garlic, wild	No	Q4, Surge	2,4-D + MCPP + Dicamba
Goosegrass	Yes	Acclaim	
Henbit	Some	2,4-D + MCPP + Dicamba, 2,4-D + MCPP + Dicamba + Carfentrazone	MCPP
Ivy, ground	No	2,4-D, Escalade II	Turflon Ester
Knotweed, prostrate	Yes	2,4-D + MCPP + Dicamba	2,4-DP
Kochia	No	2,4-D, Dicamba, Escort,	Confront
Mallow	No	4-D + MCPP + Dicamba, Speed Zone, Surge	Turflon Ester
Medic, black	No	Dicamba	Confront
Moss	No	Quicksilver	
Nimblewill	No	Tenacity	Roundup or Finale
Nutsedge, yellow	No	Sedgehammer, Monument	Dismiss, Solitaire
Pigweed, prostrate	Some	2,4-D, MCPP, Dicamba	
Plantain	Gallery	2,4-D + MCPP + Dicamba	
Puncturevine	No	2,4-D + MCPP + Dicamba	2,4-D (early)
Purslane, common	Yes	2,4-D + MCPP + Dicamba, Speed Zone	Escalade II, Confront, Manor
Quackgrass	No	Roundup, Finale (spot treat)	
Sandbur	Yes	Acclaim	MSMA, DSMA
Shepherdspurse	Some	2,4-D + MCPP + Dicamba	2,4-D
Sorrel, red	Gallery	Confront	2,4-D + MCPP + Dicamba
Speedwell	Gallery	2,4-D + MCPP + Dicamba, Surge, Speed Zone	Dicamba
Spurge, prostrate	Gallery	T-Zone, Momentum, Manor	2,4-D + MCPP + Dicamba, Q4, Speed Zone
Thistle, Canada	No	2,4-D + MCPP + Dicamba, Turflon Ester	Dicamba
Violet	No	T-Zone, Manor	Turflon Ester, Confront
Woodsorrel, yellow	Gallery	T-Zone, Manor, Monument	
Windmillgrass	Gallery	Tenacity	
Yarrow	No	T-Zone, Escalade II	Dicamba

Growth and treatment periods



= Active period of plant growth. Varies from year to year and from north to south.□

= Apply preemergence chemicals.□

= Apply postemergence treatments. Approximate periods may vary two weeks from season to season.

and an uneven application across the band.

9. **Storage:**
   Store unused herbicides in a locked room or cabinet, or at least out of the reach of children, pets and livestock. Do not store near seed, feed or fertilizer. Never store herbicides in hot houses or greenhouses. Store all herbicides in original labeled containers. Store volatile herbicides in vapor-tight containers. Be sure liquid formulations do not freeze.

10. **Disposal:**
    Pesticide wastes are toxic. Improper disposal of unused pesticide, spray mixture, or rinsate is a violation of Federal and State laws. Triple rinse plastic and metal containers and recycle them if possible. Otherwise, puncture them and dispose of them (along with paper containers) in a sanitary landfill, or by other appropriate methods (see label).

Herbicide Residues in Soils

Some herbicides may remain in the soil for a few days, while others remain much longer. Persistence of a herbicide depends on decomposition and leaching characteristics of the chemical, soil type, rainfall, soil temperature, soil microorganisms and application rate.

Injury to future crops and surrounding plants will depend on the persistence of the herbicide and susceptibility of the plants. Check and follow precautions on labels for limitations, if any, before you select a herbicide. Plan a planting sequence and herbicide program that will avoid soil residues that could adversely affect susceptible crops in the sequence.

Application Equipment

Low-Pressure Sprayers

Low-pressure sprayers are typically used to apply pesticide to turf to control weeds, insects, and diseases. Low-pressure sprayers may be tractor- or truck-mounted, pull-type or self-propelled. Each type is available in many models. All sprayers are composed of several basic components including a pump, a tank, an agitation system, a flow-control assembly and a distribution system with adequate controls.

High-Pressure Sprayers

High-pressure sprayers are primarily used for tree disease and insect control. They are capable of up to 800 psi pressure, enough to drive spray through heavy foliage or to the tops of tall trees. Equipped with a boom and proper pressure regulators, high-pressure sprayers can also perform the same functions as low-pressure sprayers. Equipped with spray guns, they can also be used for spot treatments, spraying fencerows, roadsides, ornamentals, turf, and washing equipment.

High- and low-pressure sprayers are similar in design, but high-pressure sprayers have piston or diaphragm pumps that can deliver up to 50 gallons per minute. Because components must be designed for high pressure, they are heavier and more expensive than low-pressure units.

Spray guns that can handle pressures up to 1,000 psi are available for high-pressure sprayers. These devices have a range of capabilities, from a low rate with a wide cone spray pattern to a high flow rate with a straight stream pattern. Spray guns are not recommended for spraying turf areas such as lawn or golf greens because of the difficulty in obtaining uniform coverage. If it is not possible to use a conventional sprayer with a boom, the applicator should use a hand or walking boom with conventional nozzles. If a spray gun must be used in a rough or irregularly shaped area, the applicator should understand the difficulty of achieving uniform coverage at the proper rate.

Study Questions

1. *Knotweed and spurge are examples of:*
   a. herbicides
   b. broadleaf summer annual weeds
   c. winter annual grasses
   d. perennials

2. _____ *are the most difficult weeds to control in turfgrass.*
   a. perennial broadleaf weeds
   b. summer annual broadleaf weeds
   c. biennials
   d. perennial grass weeds

3. *When should warm season grasses be fertilized?*
   a. between mid-May and mid-August
   b. early spring
   c. August through September
   d. anytime

4. _____ *is a low-growing, compact, tufted winter annual that does not have rhizomes and has leaves that are soft light green and boat-shaped at the tip.*
   a. barnyardgrass
   b. annual bluegrass
   c. foxtail
   d. crabgrass

5. *Common chickweed:*
   a. is a perennial
   b. is found frequently in the shade
   c. is the same as mouse-ear chickweed
   d. is a legume

6. _____*forms a large rosette with reddish leaves and crinkled edges. It does not usually flower when growing in lawns.*
   a. goosegrass
   b. common chickweed
   c. curly dock
   d. white clover

7. _____ *is a warm-season grass found frequently in thin bluegrass stands. It has flattened stems that are white near the base and a fibrous root system that makes it difficult to pull.*
   a. goosegrass
   b. deadnettle
   c. dandelion
   d. fescue

8. *Henbit:*
   a. usually blossoms in the early spring
   b. is a perennial
   c. starts growing in early summer
   d. has white flowers

9. _____*is a winter annual and may be confused with dandelions because the leaves form a rosette in the fall.*
   a. common purslane
   b. red sorrel
   c. shepherdspurse
   d. puncturevine

10. *The thistle is a:*
    a. perennial
    b. biennial
    c. summer annual
    d. a or b

11. *The common yarrow is:*

Study Questions

a. a low growing, ground-cover type weed

b. a biennial

c. an annual weed

d. strongly scented

12. *A preemergence herbicide:*

a. is applied to the soil

b. works best on annuals

c. stops growth of the seed

d. all of the above

13. *2,4-D is an example of a:*

a. preemergence herbicide

b. selective postemergence herbicide

c. herbicides that control grassy weeds

d. a product usually harmful to desirable lawn grasses

14. *Why is it dangerous to apply ester formulations around ornamentals?*

a. translocation of herbicide caused root injury

b. volatilization or vapor hazards

c. persistent residues in soil kill plants nearby

d. the ornamental plants will become poisonous to humans

15. *When are granular formulations of postemergence herbicides more effective?*

a. when weeds are damp

b. when applied during mid-day

c. when applied in late evening or early morning

d. a and c

16. *The following is true concerning gravity flow liquid applicators:*

a. difficult to operate

b. eliminate drifting

c. high initial cost

d. undersirable for homeowners

17. *A hose-end sprayer is a common name used for:*

a. air pressure applicators

b. water pressure applicators

c. gravity flow liquid applicators

d. 'brush and can' systems

18. *A common factor influencing weed control with soil- and foliage-applied herbicides is:*

a. stage and rate of weed or crop growth

b. spray additives

c. uniformity of application

d. organic matter

19. *How can spray drift and possible damage to nontarget plants be minimized?*

a. apply spray at high pressures

b. apply spray when wind is less than 10 miles per hour

c. use high concentrations of chemicals

d. all of the above

20. *Spraying equipment used for phenoxy herbicides:*

a. can be used for other pesticides without cleaning

b. should be cleaned monthly

c. should not be used for other pesticides unless thoroughly cleaned

d. a and b

Study Questions

21. *Where should pesticides not be stored?*
    a. in a locked room
    b. in greenhouses
    c. in original labeled containers
    d. in locked cabinets

22. *Low-pressure sprayers are:*
    a. used to control weeds only
    b. self propelled and come in only a few models
    c. used mainly on turf
    d. heavier than high-pressure sprayers

23. *High-pressure sprayer handguns are not usually recommended for:*
    a. washing equipment
    b. golf greens
    c. roadsides
    d. fence rows

Turf Insects

Many insects and other arthropods commonly inhabit lawns and turfgrasses. Although only a few are harmful, their damage may result in considerable repair and replacement.

Proper management is the first line of defense against insect pests. Healthy turfgrass is less susceptible to problems than weak turfgrass. To manage insect pests effectively, commercial pesticide applicators should possess basic knowledge of insect life cycles and habits and realize it is not possible, or practical, to eliminate all insects. Good management practices, which include applying insecticides when needed, will reduce turfgrass damage.

Pest Management Steps

Successfully managing pests requires recognizing problems, taking appropriate action, and making a follow-up assessment. Here are five steps to reduce insect pest problems:

1. Inspect turfgrass regularly.
2. Learn to identify important pests and their damage.
3. Develop a sound pest management strategy.
4. Select and apply insecticides when necessary.
5. Evaluate the success of the management program.

Periodic inspection. To detect insect infestations and accurately assess damage potential, conduct regular, systematic inspections. Examine blades and stems for feeding injury. Check for aboveground insects by applying a mixture of 1 quart water and 1 tablespoon of laundry detergent over a 4-foot square area. (One teaspoon of pyrethrum can be used in place of detergent.) Within 10 minutes, insects should move to the surface where they can be collected and counted. Use this technique in several places to determine the average number of insects present.

To inspect for root damage, pull a handful of turfgrass. If it can be pulled back easily, the roots have been damaged. If it stays in place or blades detach easily, aboveground portions may be injured.

To look belowground, cut a 1-foot-square section 4 inches deep on three sides and roll turfgrass back to expose the root zone. Shake soil off the roots to look for grubs or other root feeders. Replace turfgrass and water to re-establish root-to-soil contact.

Identification. Determine whether symptoms are insect related. This may not be easy because other factors — fertilizer burn, diseases, improper mowing, turfgrass variety, dry weather, dog or cat urine, or improper insecticide, fungicide, or herbicide use — can resemble insect damage.

If the problem is insect related, it is important to determine which insect pest is involved because each pest may require a different control strategy based on seasonal occurrence, life cycle, habits, and damage severity.

Correct identification is also important to separate nondestructive insects from destructive ones. For example, some insects may benefit turfgrass because they prey or feed on destructive insects or decaying organic matter, which helps improve the soil. Others may be only temporary and are neither harmful nor beneficial. For example, leafhoppers and clover mites occasionally inhabit turfgrass, but usually do not cause significant damage.

Develop a sound management strategy. Once the problem has been linked to an insect, a pest management decision can be made. Determine actual and potential damage before deciding whether to treat with insecticides and how to to maximize the effectiveness of the application. Depending on the problem and time of year, insecticide applications may or may not be helpful.

Chemical control. Insecticides should not be applied based only on existing damage without first determining whether pests are present in sufficient numbers to cause additional damage.

After determining which insecticide to use, apply the insecticide at the proper

label rate and in sufficient quantity to permit thorough coverage. Some pests may have more than one generation, so repeated applications may be needed. Insecticides should be applied when the most susceptible life stages, such as nymphs and adults, are present. *Always read and follow label directions.*

After applying an insecticide, clean equipment and store properly. Rinse spray equipment thoroughly after use. Insecticides should be sealed tightly in original containers and locked in a cool, dry, clearly marked location.

Evaluation. Conduct a thorough evaluation to determine whether the application was successful. It may take two to three days for aboveground insects and two to four weeks for soil insects to be killed, so do not expect immediate results. If the application was not effective, determine the cause.

Thatch

Thatch is a tightly interwoven layer of living and dead roots, stems, leaves and stolons (underground stems) of turfgrass that develops between green vegetation and the soil surface.

A thatch layer of more than ½ inch may reduce effectiveness of insecticides applied for control of soil insects such as white grubs and billbugs. Thatch chemically and physically prevents insecticides from moving into the soil where insects are feeding.

These effects may be reduced by using granular insecticides or by wetting thatch before applying liquids, and then watering heavily (½ inch or more) immediately afterward. Better results can be achieved by power raking, top dressing, or applying lime.

Insecticide–Fertilizer Mixtures

Insecticide–fertilizer combinations fertilize turfgrass and control insects simultaneously. Because fertilizer and insecticides are not always needed at the same time, applying either when it is not needed is not environmentally sound or cost effective.

Some insecticides work better on certain insect pests than others. It is most economical to use the best insecticide for a particular pest only when it is causing problems.

Common Turfgrass-Damaging Insects

Insects that damage turfgrass can be categorized as aboveground or underground pests. The two groups feed on different parts of the turfgrass and require different control strategies.

Aboveground pests, such as sod webworms, armyworms, cutworms, and chinch bugs, feed on turfgrass blades and stems. Insecticide applications should remain on blades and stems to kill insects as they crawl around or feed on the turfgrass. Underground pests, such as white grubs and billbugs, primarily feed on the roots. Insecticides should be applied and watered into the soil about a ½ inch where the insects live.

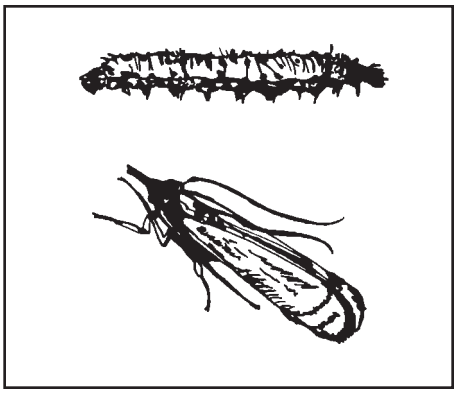
Aboveground Pests

Bluegrass Sod Webworm

The bluegrass sod webworm is one of the most destructive turfgrass pests in Kansas. Infestations often damage bluegrass or mixtures of bluegrass and tall fescue. This webworm attacks bentgrass golf course greens, tall fescue, and occasionally bermudagrass. Bermudagrass usually grows vigorously enough to minimize serious problems.

Description and life cycle. Sod webworms are the caterpillars of lawn moths. Moths (adults) are small (½-inch long) and whitish-gray. At rest, they hold their wings close to their bodies with mouthparts projecting forward like a snout. Moths usually are noticed when flushed out by a lawn mower or people walking. When disturbed, they fly in a jerky zig-zag pattern and quickly return to the turfgrass to hide. Around dusk, females may be seen flying a few feet above the turfgrass and dropping eggs. In a few days eggs hatch into the small caterpillars that damage turfgrass.

Caterpillars (larvae) generally have dark heads and rows of light-brown spots arranged in rings around greenish-gray bodies. They live near the soil surface in silken shelters covered



Bluegrass sod webworm (lawn moth)

with turfgrass with webs created from thatch woven into a mat. Larvae clip grass blades close to the ground and pull them into the silken runways. Most feeding occurs while webworms are protected. After several weeks, mature ¾-inch larvae, change into pupae and emerge as moths. Two generations occur each year. First-generation adults appear in June, and second-generation adults in late July and August. Second-generation larvae tend to cause the greatest amount of turfgrass damage in Kansas.

Damage and detection. Close clipping by sod webworm larva does not kill turfgrass directly, but exposes the crown to excessive sunlight. Damage is worse during hot, dry weather. As the caterpillar grows, it can damage an area of turfgrass about the size of a softball. If the infestation is severe, spots may enlarge. Webworm feeding damage symptoms may be confused with other causes of spots. These include fertilizer burn, diseases, improper mowing, grass variety characteristics, dry weather, cat and dog urine, improper pesticide use or damage associated with underground feeding of insects such as white grubs or billbugs.

If lawn moths are abundant, watch for caterpillar feeding over the next seven to 14 days. An abundance of moths does not necessarily mean that damaging larval populations will develop. Another sign of a sod webworm infestation is the presence of large numbers of birds, particularly starlings that peck holes in turfgrass looking for caterpillars.

Often, caterpillars can be found feeding at the periphery of a damaged area. Look for green fecal pellets and webs covered with clippings in the thatch near the soil line.

Apply a detergent or pyrethroid insecticide mixture as outlined in "Periodic inspection" section on page 36. Count the number of larvae present. If fewer than eight caterpillars are found per square foot, insecticide treatment is probably not warranted unless turfgrass is highly stressed. Healthy turfgrass may tolerate more webworms because it has a much better chance of recovering from feeding.

Chemical control. Insecticide applications should be considered when two to four webworms per square foot of sod are detected. Mowing turfgrass before applying insecticide will minimize the amount of post-spray contact. Using a grass catcher to catch clippings will reduce the amount of insecticide intercepted. Contact your K-State Research and Extension entomologist for insecticide recommendations for sod webworm.

One method of timing spray applications is to apply the insecticide seven to 10 days after moth numbers peak. Treat to control first-generation larvae in June, but only if necessary. High moth numbers do not necessarily translate into a serious problem with larvae. Lawns are often treated unnecessarily to suppress first-generation larvae. This is especially true of pure fescue turfgrass. To avoid overapplication of insecticides, initiate a routine inspection program to detect damage. Apply insecticides only when infestations have been confirmed. Use enough water to thoroughly moisten turfgrass and thatch, but not to the point of runoff. After applying an insecticide, irrigate lightly to move material to the turfgrass crown. Avoid irrigating heavily for two days.

When using a granular insecticide apply ½ to 1 inch of water within 24 hours of treatment. Do not mow afterwards. Check the label to determine the minimum interval between applications, which will vary depending on the application rate.

Even if the first generation was treated, another application may be necessary to control the second generation. A late July or August application may be needed because many insecticides applied for the first generation work only from one to four weeks. Moths from untreated lawns in the area may reinfest turfgrass by laying eggs for the second generation. A posttreatment evaluation should be done to determine whether the insecticide was effective.

Children and pets must be prevented from entering treated areas until sprays have dried. Check the label for other precautions. Clean all equipment after use and store insecticides in areas not accessible to children.

Other controls. Removing thatch in autumn will destroy overwintering eggs and prevent populations from building up the following season.

Buffalograss Sod Webworm

The buffalograss sod webworm is a pest in western Kansas with a different life cycle and biology than the bluegrass sod webworm.

Description and life cycle. Adults are about ¾ inch long and light to dark brown. They are active at dusk and reside in turfgrass during the day. Mature caterpillars are about 1¼ inches long. They have a light-brown heads and light-brown spots arranged in rings around grayish bodies.

In the spring, caterpillars that overwintered begin to feed on buffalograss. During the day, caterpillars live in an extensive silken runway near the soil surface. They rarely leave this protective habitat and extend the system laterally to access new grass blades, which are severed and pulled into the habitat for eating. Caterpillars feed throughout the summer and pupate in August. Female moths do not fly readily so they usually lay eggs in short buffalograss or bare areas close to where they emerged from the pupal case. After they hatch, the small caterpillars find secluded places in the soil near the roots of turfgrass to spend the winter. There is one generation per year.

Damage and detection. The first signs of damage are spots with leaf blades missing and silk tubes across the soil surface. Heavy infestations may result in spots exceeding 10 feet in diameter. Pulling on infested turfgrass may not remove roots because the damaged stems break off with little resistance. The loss of leaves (defoliation) exposes turfgrass stems and possibly the crown to sunlight. Damage is much more severe during hot, dry weather and on berms or elevated locations.

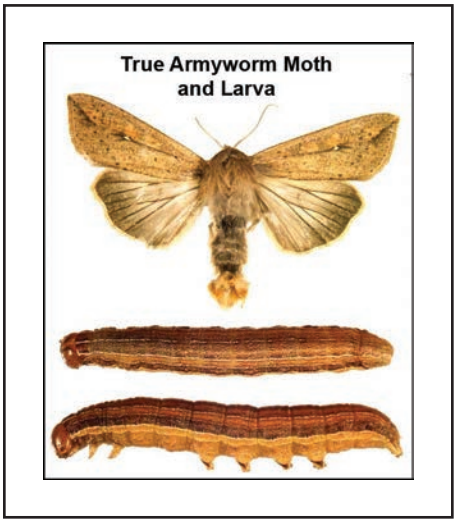
Chemical control. Implement control measures when there is one defoliated spot per square yard of buffalograss. Buffalograss sod webworm caterpillars cannot be detected using the water-detergent mixture because they hide in tunnels near the soil surface.

Buffalograss sod webworm caterpillars are difficult to control using insecticides labeled for sod webworms. Apply insecticides in mid-May to kill the young caterpillars as they gather food at night. Two applications may be needed, with the second application 10 to 14 days after the first.

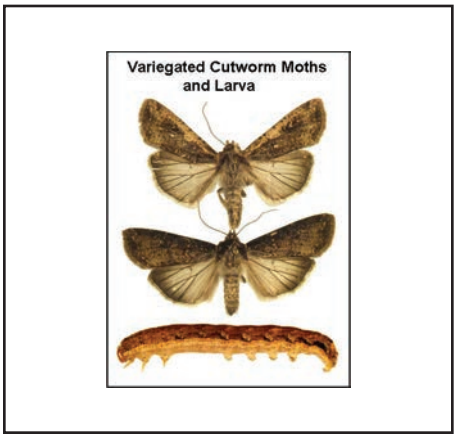
To determine if the insecticide application was effective, crouch down when the turfgrass is dry a few days after treatment and look for dead webworm larvae. A large number of larvae that receive a fatal dose of insecticide may leave the webbing and die. If no dead larvae are found, and large numbers of live larvae are present and doing damage one week after treatment, check the label to determine if insecticide was properly applied using sufficient water volume. If there were no issues with the application technique and the weather was not rainy or cool (some insecticides are not effective when applied during cool temperatures), it may be necessary to use another product or consult with your local extension agent.

Cutworms and Armyworms

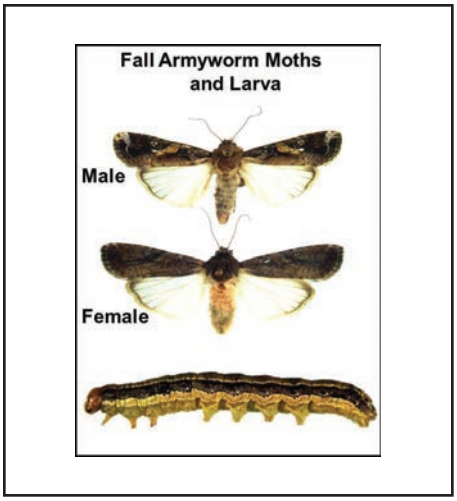
Description and life cycle. Cutworms and armyworms are the caterpillars of several species of night-flying moths. Cutworms are plump, smooth and often greasy-looking. Cutworms typically curl up tightly when disturbed. They have green, brown, gray, or striped bodies up to 1¾ inches long. Although about the same size, armyworms differ in appearance. True armyworms are plump, sparsely-haired, generally green to brown larvae with dark stripes down the sides and back. In contrast, fall armyworm larvae have more conspicuous, longer hairs located on definite black tubercles and



True armyworm



Variegated cutworm



Fall armyworm

an inverted Y-shaped suture located at the front of the head. These caterpillars feed on the aboveground plant parts of many turfgrasses and are a pest of many garden and field crops.

Cutworm larvae are typically noticed early in the growing season or not until late summer when subsequent generations begin feeding. Adult cutworm and true armyworm moths appear between April and July, whereas fall armyworms may not be present until late July. Females lay about 500 eggs on the lower leaves over a two- to three-week period. Caterpillars usually remain hidden during the day and feed at night. A second or third generation of cutworms may emerge in the summer and early fall. The caterpillars stop feeding and seek concealed areas to spend the winter. In contrast, armyworms cannot successfully overwinter in Kansas.

Damage and detection. Cutworms feed on blades and cut plants off near the soil surface. Grasses appear ragged and may turn brown from the feeding of these larvae. Damage is more likely if the lawn borders large untended fields. Armyworms, in particular, seem to be attracted to areas of lush vegetation. When vegetation in nearby areas has been removed and caterpillars are forced to seek new food, inspect turfgrass more frequently. If cutworms are suspected, check damaged areas several hours after dark. Depending on the species, larvae may feed on plant foliage near the crown. Damage near the crown is much more serious than simple foliar feeding.

Chemical control. Insecticides may be used to control both cutworm and armyworm larvae. Carefully evaluate the infestation by assessing the damaged area to determine larval density. Apply insecticide near dusk. Both liquid or granular formulations can be used. Read the label and follow procedures.

Chinch Bugs

Chinch bugs are common in zoysiagrass but seldom cause significant damage. Occasionally they feed on bermudagrass and bluegrass.

Description and life cycle. Chinch bugs remove plant fluid from turfgrass blades. They are ⅛ inch long black to gray in color with white markings. Large numbers may develop and remain unnoticed for some time until damage is evident. Adults overwinter in bunch grasses and feed on various other grasses in the spring. Females lay about 200 eggs over three to five weeks. After eggs hatch, nymphs begin feeding. A second generation occurs in the summer. As nymphs mature, a white waistband becomes noticeable. Big-eyed bugs, which are predators, may be mistaken for chinch bugs resulting in an unnecessary application of insecticide. For more information on natural enemies contact your local extension agent.

Damage and detection. Most damage is caused by red nymphs that remove plant fluids from zoysiagrass. Chinch bug feeding causes yellow patches, usually located in sunny areas. A distinctive odor, similar to vinegar, may be noticeable. Chinch bugs concentrate feeding efforts at the edge of dying patches of turfgrass. They thrive under hot and dry conditions and may be killed by a fungus in wet weather.

During hot and dry weather, five to 10 chinch bugs per square foot may weaken zoysiagrass and reduce disease resistance. On warm days, inspect turfgrass for chinch bugs in the morning. They typically enter cracks in the soil at the edges of sidewalks, driveways, and curbs in the afternoon. A coffee can opened on both ends can be used to monitor for chinch bugs. Insert the can into the turfgrass at the edge of a damaged area and fill with water. Chinch bugs will float to the surface. The detergent method (see page 36) can also be used. Close inspections should be conducted when initial signs of damage are observed.

Insecticides can be used against chinch bugs. Application timing, coverage, and frequency are important. Contact your local extension agent or K-State entomologist for recommendations.

Water before spraying to enhance the movement of the insecticide to the target site. After applying the insecticide, water enough (½ inch) to move the insecticide into the thatch layer where most chinch bugs are located. To prevent insecticide from leaching down below the zone where chinch bugs reside, do not overwater. Follow label directions to determine application rates. Do not re-enter the treated area until turfgrass has dried.

Ants

Description and habits. Ants may be red, yellow, brown or black and may be winged or wingless. They have narrow waistlines and elbowed, or bent, antennae. Ants are 1/32 to ½ inch in length, depending on the species. Colonies or nests are usually located in the soil alongside a foundation or in the yard. Occasionally, the nest may be under a concrete slab or in the crawl space of a house.

Ant colonies include a queen, workers, soldiers, eggs, legless larvae and pupae. Worker ants attend the queen and forage for food, while soldiers protect the colony from predators. When foraging, ants may enter homes inadvertently. Infestations in homes may be associated with turfgrass located close to the foundation. Therefore, treating the turfgrass with an insecticide or placing mulch between the foundation and turfgrass may prohibit the movement of ants into homes.

Damage and detection. Ants build nests in the ground and form mounds around the nest openings. The unsightly mounds make it difficult to mow turfgrass and sometimes smother a portion of the surrounding turfgrass. In addition, turfgrass stands may be weakened by ants that feed on the seeds and roots of turfgrass.

Chemical control. Insecticides are available for ant control. For home use, bait formulations are most effective and less harmful to children and pets. For more information, contact your local extension agent or K-State entomologist. Always follow the label.

Mowing before applying an insecticide exposes more of the mounds and minimizes the need to enter the treated area sooner than necessary. Apply spray or granules to ant mounds. Then water thoroughly. Exclude pets and people from the area until turfgrass has dried.

Underground Pests

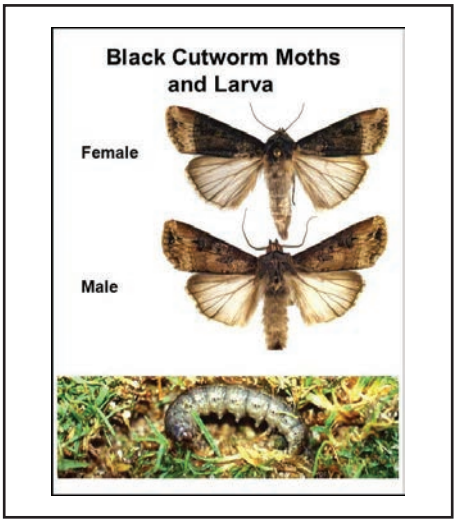
White Grubs

White grubs refers to the larval stage of a number of very destructive insect species. Three major groups are present in Kansas: May beetles or June bugs (also known as *Phyllophaga*); southern masked chafers (or *Cyclocephala*); and black turfgrass ataenius.

Description and life cycle. Adults vary from light brown to nearly black. Foliage feeding occurs at night from April through June. Many trees and shrubs are also attacked but usually damage is inconsequential. Females deposit eggs in turfgrass during the day. Eggs hatch within three to four weeks into small grubs. These grubs are c-shaped and vary from white to light-brown. They have a brown heads, six legs, and a dark area on the abdomen or hind end. Mature white grubs are up to 1 inch long. Billbug grubs are similar in shape but white, legless, and smaller.

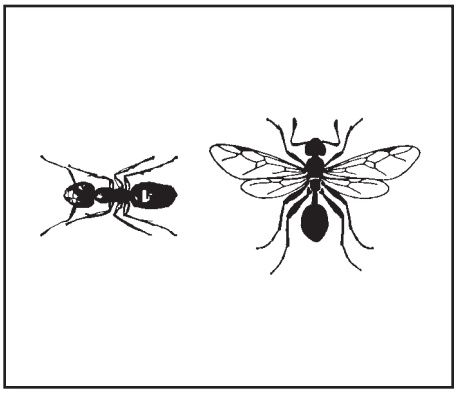
May beetles or June bugs require three years to complete their life cycle *(Figure 1).* Grubs feed on roots, then tunnel below the frost line to overwinter. In the spring of the second year, grubs migrate to the root zone and resume feeding. Turfgrass may be severely damaged during this time. In the fall, they again burrow down below the frost line to overwinter. Third-year feeding stops by mid-June, when a pupal cell is formed. Adults emerge from pupae in July and August but do not appear above ground until April or May of the following year.

The southern masked chafer has become a common pest of Kansas turfgrass, especially turf with heavy thatch accumulation. This insect has a one-year life cycle (Figure 1). Eggs are laid in July and hatch into grubs in early August. Grubs do the most damage to turfgrass during August and September. By mid-October,



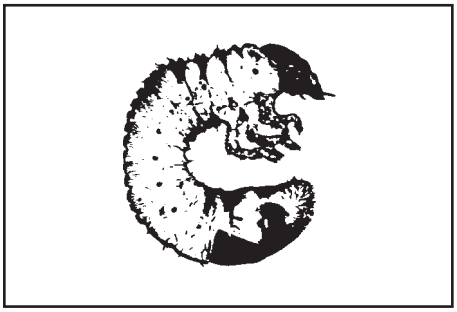
Black cutworm

Chinch bugs

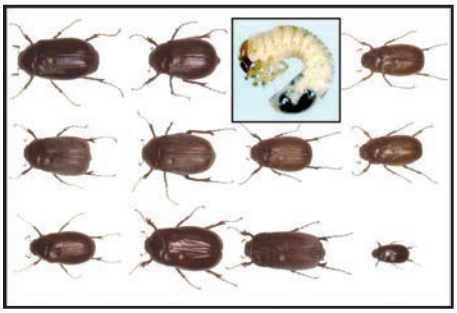


Ants

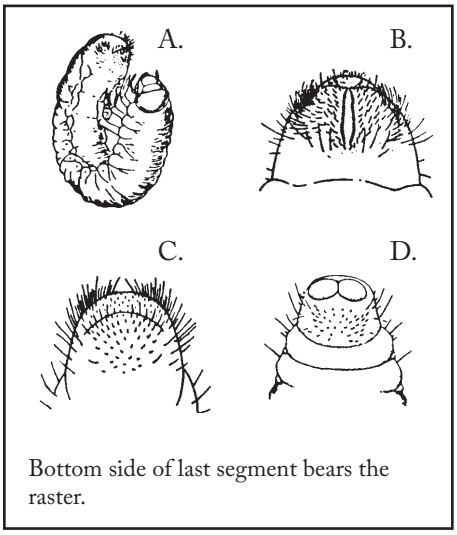
Turf Insects



White grub



May or June beetles



A. typical grub; B. May or June beetle; C. masked chafer; D. black turfgrass ataenius

grubs have moved down into the soil to form cells for overwintering. In April, grubs migrate upward again to feed on roots. Unless numbers are excessive, turfgrass damage may be minimal. Pupation occurs in May, and adults emerge in late June through early July.

Damage and detection. Damaged turfgrass may wilt, turn brown, and die even under conditions of minimal water stress. Turfgrass can be pulled with minimal resistance, and a section of sod can be rolled back like a carpet because grubs have substantially damaged the roots. C-shaped grubs may be present in the area. Although damage may be difficult to detect, infested stems may have tunnels caused by small billbug grubs.

Grub-infested turfgrass often attracts skunks, raccoons and birds, which feed on the grubs. In addition, these vertebrates may destroy turfgrass in the process of searching for grubs. Inspect the root zone for grubs if dead areas appear in August or September. Other types of damage that can be confused with grub infestation include fertilizer burn, diseases, improper mowing, dry weather, spots caused by dog and cat urine, improper pesticide (insecticide, fungicide, or herbicide) use, or damage from aboveground insect feeding, sod webworms, or cutworms.

Chemical control. Insecticides are available for white grub control. They should be applied before eggs hatch because young grubs are more susceptible than mature or older grubs. For more information, contact your local K-State Research and Extension agent or entomologist.

Three or more grubs per square foot may justify applying an insecticide. Eight to 10 grubs per square foot usually results in severe turfgrass damage and warrants treatment. Treatment thresholds may be helpful in determining when to apply insecticide. If turfgrass is monitored, these levels should never be reached. When they are, multiple applications of an insecticide are required.

To control or regulate annual white grub populations (larvae of the southern masked chafer), apply insecticides when grubs are small and feeding in the upper 2 inches of the soil. Insecticide applications will be most effective three to four weeks after peak adult flight.

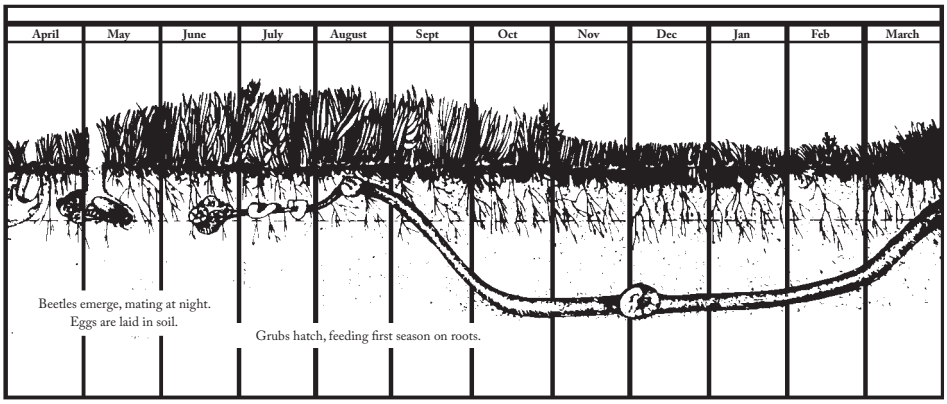
Infestation levels may vary depending on environmental conditions such as temperature, moisture, and soil conditions (dry vs. wet). Turfgrass damage is more pronounced during late summer (August-September) as grubs increase in size and populations.

Successful control is possible if insecticides are applied in early August. In some situations, applying insecticides preventively by mid to late July may increase effectiveness. Before applying an insecticide be sure to remove thatch so treatment will penetrate the root zone where grubs are located. Do not treat annual white grubs early to mid summer because only the adults are present at this time.

If the problem is caused by *Phyllophaga* grubs (three-year grubs known as May beetles or June bugs), the treatment period is less well defined because grub age may be an important factor. Active feeding can be expected throughout the season if *Phyllophaga* spp. grubs are less than an inch and in the second calendar year of their life cycle. Insecticide applications may be effective from mid-May through September. If most 3-year grubs are an inch or more, they are probably in the third year of larval development. This means that damage should be minimal by mid-June. Insecticide should be applied before substantial damage is noticeable.

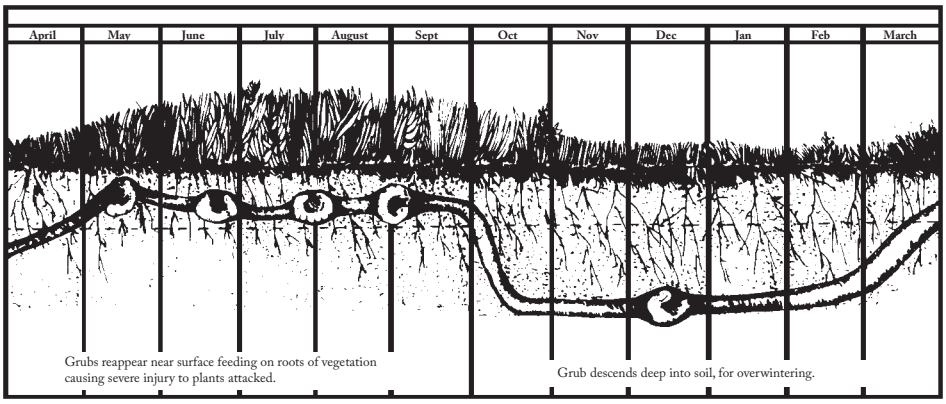
White grubs can be identified by the pattern of hairs on the raster, or anus. See figure, left.

Figure 1: Life cycles of May beetle or June bug and masked chafer.

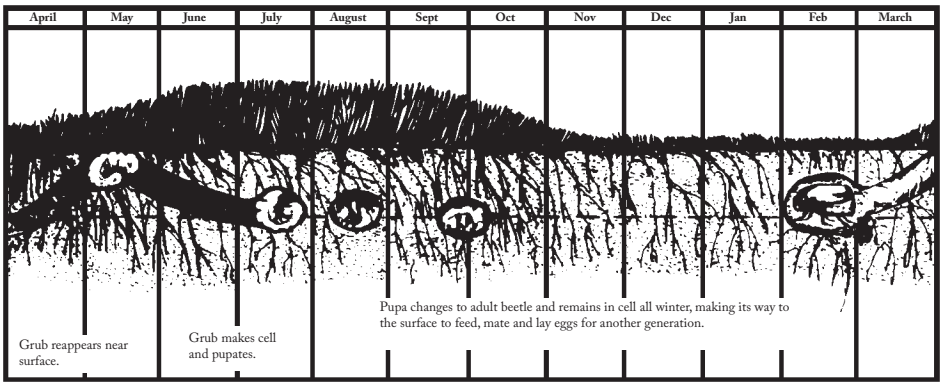


May beetle or June bug first year.

Masked chafer

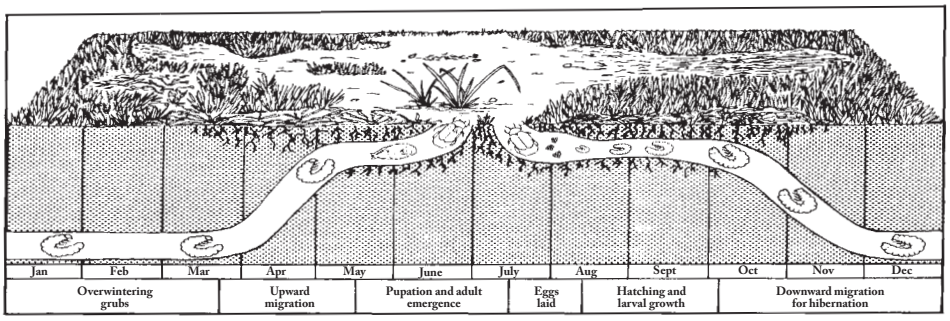


May beetle or June bug second year.



Life cycle of the June beetle in its third year.

May beetle or June bug third year.



Adapted from, R. McMillen–Sticht, NYSAES

Masked chafer 1–year life cycle.

Turf Insects

Billbug

Billbugs

Billbugs may infest zoysiagrass in eastern and southern Kansas. They have also been found in bermudagrass and bluegrass.

Description and life cycle. Damage is caused by the grubs, or larvae, which are ¼ to ½ inch long, white, and legless. They have a dark brown or yellow heads. Grubs can be distinguished from white grubs, which have six legs. Billbugs have none. Billbug grubs feed on stems, stolons, and roots of zoysiagrass.

Adults are ¼ to ⅜ inch long with long snouts or mouthparts. They are usually located near stems at the soil surface. The life cycle in Kansas is not well understood; both adults and grubs may be found at various times throughout the year. Most grubs reach maturity in early summer. Damage from new infestations may be noticeable from August to early September. There may be two or more generations in southern Kansas.

Damage and detection. Symptoms which include small patches of brown or damaged turfgrass, resemble those of white grubs. Tunnels bored in stems may be difficult to detect. In zoysiagrass, stolons (underground stems) may show signs of feeding and tunneling. Grubs and adults may or may not be present when damage is evident. Most damage occurs when grubs initiate root feeding.

Chemical control. Insecticides are available for controlling or regulating billbug populations. For more information, contact your local K-State Research and Extension agent or entomologist.

To control billbugs, apply insecticides when adults and newly hatched grubs are present. Once young grubs begin tunneling into stems, they are difficult to kill with contact insecticides. Where billbugs are a common problem on zoyiagrass, apply insecticide from late May to early June to target adults and young grubs before they become established. Insecticides can be applied in July to control grubs that are feeding on roots. To enhance effectiveness, remove thatch, especially if thick. This allows treatment to penetrate the zone where grubs and adults are located.

Black Turfgrass Ataenius

The black turfgrass grub (*Ataenius spretulus*) is a pest of bentgrass golf course greens in many states east of Kansas. It has been found in metropolitan Kansas City, and has been recorded in Missouri, Nebraska and Colorado. It may be present in other portions of Kansas.

The larva looks similar to a white grub. Grubs are about ¼ inch long when mature. Adult beetles are black and 3⁄16 inch long. Adults overwinter under leaves and other debris around golf courses. They return to the greens in March and may be seen flying over turfgrass late afternoon on warm days. Females begin laying eggs in late April and continue through May. Clusters of about 10 eggs may be laid in just beneath the thatch. In June, grubs tunnel 1 to 3 inches into the soil to feed on roots. Adults appear in August, and females lay eggs for the second generation. The adults are attracted to lights on golf courses. As many as 250 to 300 grubs per square foot have been found in bentgrass. Second-generation grubs pupate in September. Adults emerge in October and leave golf greens to find places to overwinter.

Insecticides are available to regulate black turfgrass ataenius populations. Contact your local K-State Research and Extension agent or entomologist for information.

Study Questions

1. *The following is true concerning turfgrass pest management:*
   a. most of the insects in turfgrass cause damage
   b. healthy turfgrass has no advantage over weak turfgrass when attacked by insects
   c. insecticides are the only means to control insects
   d. a working knowledge of common pests is important to control them

2. *What other problems can resemble insect damage to turfgrass:*
   a. improper mowing
   b. fertilizer burn
   c. improper pesticide use
   d. all of the above

3. *To determine if the insecticide application was successful or not is known as:*
   a. evaluation
   b. prescription
   c. application
   d. postscription

4. *The following is true concerning thatch in turfgrass:*
   a. it augments the effectiveness of insecticides
   b. it is conducive to turfgrass diseases
   c. it develops directly beneath the soil surface
   d. it can be avoided by using large amounts of fertilizer

5. *The most destructive turfgrass pest in Kansas is the:*
   a. German cockroach
   b. bluegrass sod webworm
   c. chinch bug
   d. fescue rootworm

6. *How do sod webworms damage turfgrass?*
   a. they chew off blades near the soil and expose the crown to sunlight
   b. they create sticky webs which kill the turfgrass
   c. they burrow in the soil and damage the root systems
   d. they vector the deadly dutch turfgrass disease

7. *When should insecticide applications for sod webworm larvae be considered?*
   a. when two to four webworms per 10 square feet are detected
   b. when two to four webworms per 6 square feet are detected
   c. when two to four webworms per 4 square feet are detected
   d. when two to four webworms per 1 square foot are detected

8. *The buffalograss sod webworm is a pest in:*
   a. northern Kansas
   b. southern Kansas
   c. eastern Kansas
   d. western Kansas

9. *When is damage from the buffalo grass sod webworm more severe?*
   a. hot, dry weather
   b. cool, dry weather
   c. cool, moist weather
   d. hot, moist weather

Study Questions

10. *Why is it hard to detect buffalograss sod webworm caterpillars?*
    a. they are microscopic in size
    b. they hide in tunnels underground
    c. they are not affected by the water-detergent mixture, which exposes most insect pests
    d. b and c

11. *When should you treat turfgrass for cutworms?*
    a. May to June
    b. June to mid-July
    c. July to late August
    d. there is no set time; you should watch for damage

12. _____ *are frequently confused with chinch bugs; however they prey on other small insects and should be protected.*
    a. big-eyed bugs
    b. billbugs
    c. white grubs
    d. June bugs

13. *Chinch bugs are usually most-damaging during:*
    a. cool, dry weather
    b. hot, dry weather
    c. warm, wet weather
    d. cool, wet weather

14. *The following is true concerning ants:*
    a. they are either red or black
    b. some species are 2 inches long
    c. they have a narrow waist-line and may be winged or wingless
    d. all of the above

15. *How many summers can 'May beetle' white grubs feed on turf-grass before they become adults?*
    a. 3
    b. 4
    c. 5
    d. 6

16. *Turfgrass infested with the C-shaped white grubs often attract _____, which may destroy the turfgrass when-searching for them.*
    a. dogs and cats
    b. raccoons and skunks
    c. rats and snakes
    d. rabbits

17. *When applying granular insecti-cides to treat white grubs:*
    a. water before and after treatment
    b. thatch will reduce effectiveness
    c. cut holes in the turfgrass to apply insecticides
    d. apply insecticide during June and July

18. *What are the differences between white grubs and billbug grubs?*
    a. billbug larvae are black, and white grubs are white
    b. billbug larvae have spotted bodies, and white grubs are all white
    c. billbug larvae have no legs, and white grubs have six
    d. billbug larvae are twice as long as white grubs

Study Questions

19. *Symptoms of billbug larval infestation:*
    a. resemble white grub damage
    b. are small patches of brown or dead turfgrass
    c. are usually noticed during August and September
    d. a and b above

20. *The black turfgrass ataenius (Ataenius spretulus) is:*
    a. a pest of bentgrass golf course greens
    b. only a pest in western Kansas
    c. a black grub but light brown as an adult
    d. about twice as long as a white grub

Calibration

To be effective, pesticides should be applied uniformly at the recommended rate. Sparse application or missed areas may result in inadequate control. Exceeding the labeled rate can leave excessive residues or injure turfgrass.

For some herbicides there is a narrow margin between the amount needed to control weeds safely and the amount that will harm plants. Applicators should use properly functioning and accurately calibrated equipment, regardless of whether it is large power equipment or a small handheld applicator.

Calibration is the process of determining the spray volume that will be applied to a given area under specific conditions. The conditions associated with power sprayers are speed (engine and ground), nozzle type and size, pressure uniformity, and equipment maintenance.

Field Sprayers

A sprayer that is not properly calibrated can injure plants and create a hazard. It can be costly in terms of wasted pesticide. Sprayers should be calibrated at the start of the season and recalibrated routinely throughout. Tests have shown that wettable powders wear nozzle tips, increasing the discharge rate after 10 hours of spraying. Some new nozzles also tend to wear. Discharge increases by a small percentage during the first hour or two.

Before calibrating, check the sprayer carefully. Be sure nozzle tips are not plugged. If necessary, clean them with a soft-bristled brush or toothpick. Do not use a nail or pocket knife to clean the sprayer. This may damage or increase the tip opening and disrupt spray patterns. With the sprayer operating, hold a plastic or glass jar under each nozzle and measure the time it takes to fill the jar. Calculate the mean of the results and replace nozzles that vary more than 20 percent. Nozzles that discharge 20 percent more than specified by the nozzle manufacturer are likely worn and should be replaced. Inspect all hoses for leaks and cracks.

Calibrate when the sprayer is operating properly. There are many techniques for calibrating a sprayer. All require the applicator to determine the volume of pesticide applied to a measured area.

Calibration Jar Method

1. With the sprayer stationary, operate at the same pressure that will be used in the field. Use clean water for calibration unless you are using a pesticide that changes the viscosity of the water. Hold a 1-quart jar under each nozzle and measure the average number of seconds required to fill the jar.
2. Calculate the flow rate of each nozzle using the formula:

$$gpm = \frac{15}{s}$$

   Where:

   gpm = gallons per minute delivered by nozzle

   s = number of seconds required to fill a 1-quart jar.

3. Measure a distance of 176 feet and time the unit over that distance while operating at the same gear and speed that will be used in the field. If possible, do this in the actual field to be sprayed so field conditions will be consistent.
4. Determine the speed of the sprayer in miles per hour using the formula:

$$mph = \frac{120}{t}$$

   Where:

   mph = speed in miles per hour

   t = number of seconds required to travel 176 feet.

5. Now, determine the application rate using the formula:

$$mph = \frac{gpm \times 5{,}940}{mph \times w}$$

Where:

gpa = application rate in gallons per acre (treated area)

gpm = gallons per minute delivered by nozzle

mph = speed of tractor in miles per hour

w = width. For broadcast spraying, W is nozzle spacing in inches. For band spraying, W is band width in inches.

6. Divide tank capacity by the gallons per acre determined in step 5. This is the number of acres covered by one spray tank.
7. To determine the amount of pesticide to add to each tank, multiply the recommended labeled rate of application by the number of acres covered per tank.

Some rates given in this publication are for active ingredients. To determine the amount of dry formulation needed, divide the amount of active ingredient by the percentage of active ingredient stated on the product label. For a liquid formulation, divide the amount of active ingredient by the pounds per gallon stated on the product label.

Examples:

1. Dry formulation: 16 pounds of active ingredient is needed. An 80 percent active ingredient wettable powder is available for use.

$\frac{16}{.80}$ = 20 pounds of commercial product is required.

2. Liquid formulation: 15 pounds of active ingredient is required. A liquid product containing 3 pounds of active ingredient per gallon is available for use.

$\frac{15}{3}$ = 5 gallons of commercial product is required.

Caution: When making a band treatment, be sure to use tips specifically designed for band application. These are usually called "even spray nozzle tips." Do not use standard flat spray nozzle tips because their feathered pattern at the edges gives an uneven application across the band.

Hand or Small Power Equipment

With hand or small power equipment, it is difficult to obtain either proper application rates or uniform distribution of herbicides. Practice spraying water on a concrete 10 ft x 10 ft area and observe the evaporating water to determine the uniformity of application. It is necessary to calibrate this equipment to apply the pesticide accurately.

Before applying a pesticide, completely read the label on the container and follow its recommendations and safety precautions. Check the mechanical condition of the application equipment for tight connections and cleanliness. Nozzle tips should deliver a uniform spray pattern. To determine the output of your hand sprayer, follow the steps outlined under the calibration of liquid sprayers.

Liquid Sprayers

Calibration of liquid sprayers is relatively easy. When spraying hold the nozzle at a steady, constant height and spray back and forth in swaths or swing the nozzle back and forth at a uniform speed in a sweeping, overlapping motion. A uniform walking speed must be maintained during application.

This calibration procedure is only for spraying ground areas. For spraying trees or shrubs use the recommended

Calibration

concentration (i.e., tablespoons per gallon) and spray until the leaves are wet.

1. Measure and mark area of known size on concrete or asphalt (i.e., 10 ft × 10 ft = 100 sq ft or 20 ft × 25 ft = 500 sq ft). Using only water, practice spraying the area. Areas of excessive or deficient application rates will be apparent. Adjusting the spraying technique should result in a uniform distribution over the marked area.
2. Fill the sprayer with water to a marked level, spray the area using the refined technique from step 1, and measure the amount of water that has to be added to return the water to the original marked level. The application rate can then be computed.

   Example:

   measured area = 20 ft × 25 ft = 500 sq ft

   water sprayed = 0.75 gallons

   application rate = 0.75 gal/500 sq ft or 1.5 gal/1,000 sq ft
3. Recommendations on the pesticide label are sometimes given only in pounds (or quarts) of product per acre rather than in ounces per 1,000 sq ft, so the following conversions may be useful:

   dry products—oz/1,000 sq ft = recommended lb/acre × 0.37

   liquid products—oz/1,000 sq ft = recommended qt/acre × 0.73
4. Determine the proper amount of pesticide and add it to the water in the spray tank by:

   See No. 1 below.

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

   First:

   oz./1000 sq ft = lb/acre × 0.37 = 4 × 0.37 = 1.5 oz/1,000 sq ft

   Then:

   See No. 2 below.

   Avoid spraying near sensitive plants. Check weather conditions and spray only when wind speed is less than 5 mph to prevent drift. Do not use higher pressure than needed. If there is any pesticide solution remaining after completing the application, dispose of it according to label directions. After application, clean the sprayer thoroughly with detergent and water.

1.

$$\text{oz pesticide/tank} = \frac{\text{gal/tank} \times \text{oz pesticide/1,000 sq ft}}{\text{gal applied/1,000 sq ft}}$$

2.

$$\text{oz pesticide/tank} = \frac{\text{gal/tank} \times \text{oz pesticide/1,000 sq ft}}{\text{gal applied/1,000 sq ft}}$$

$$= \frac{3 \text{ gal} \times 1.5 \text{ oz/1,000 sq ft}}{1.5 \text{ gal/1,000 sq ft}}$$

$$= 3 \text{ oz/tank}$$

Granular Applicators

Calibration of granular applications is less safe because the pesticide to be applied must be used in the calibration process. Except for the orifice or metering gate setting, ground speed is the most significant factor affecting the application rate. To obtain uniform application, cover the area twice, with the second application at right angles to the first.

1. Read the pesticide label to determine the application rate, and set the applicator at the setting recommended by the operator's manual. Set gate openings from one direction only, such as from closed to open, to eliminate any variations in setting.
2. Fill the hopper with the pesticide to determined level designated by a mark drawn across the tank.
3. Apply to a known area within the total acreage to be treated.
4. Refill the hopper to the designated mark, weighing the pesticide container before and after filling to determine the amount used.
5. The application rate can now be calculated.

Example:

swath area = 5 ft. wide × 100 ft long = 500 sq ft

amount applied = 1 lb

application rate = 1 lb/500 sq ft or 2 lbs/1,000 sq ft

or if the recommendation is given in pounds per acre:

Example:

swath area = 5 ft wide × 100 ft long = 500 sq ft

amount applied = 1 lb

1 acre = 43,560 sq ft

First: ***See no. 3 below.***

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

   Granular formulations may differ in density, size, and carrier used. Be sure to calibrate for each different formulation and be aware of any changes in application rate. Humidity can have a major effect on the application rate. Product bridging may occur in the application hopper. A good practice is to mark hoppers in a specific measure such as quarts. These measurements allow you to check the amount of pesticide used at each filling against the area covered.

3.

$$\text{Acres covered} = \frac{\text{distance traveled (ft)} \times \text{swath width (ft)}}{\text{43,560 sq ft/acre}}$$

$$= \frac{\text{5 ft} \times \text{100 ft}}{\text{43,560}} = 0.011 \text{ acre}$$

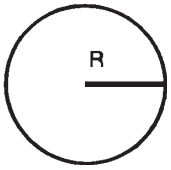
Then:

$$\text{Application rate} = \frac{\text{amount used (pounds)}}{\text{acres covered}}$$

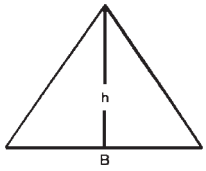
$$= \frac{\text{1 lb}}{\text{0.011 acre}} = 87 \text{ lbs/acre}$$

Calibration

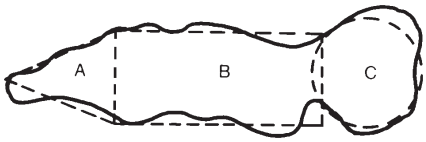
Rectangle



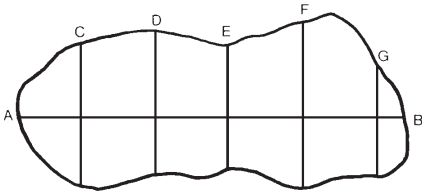
Circle



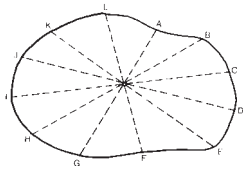
Triangle



Irregular Shape



Irregular Shape



Irregular Shape

Application Method Selection

Application methods vary with:

- the type of pesticide
- host plant
- target pest

Applications must ensure thorough coverage of all plant parts using the correct amount of pesticide.

Low pressure, low volume sprayers or granular applicators can be used against:

- soil or aboveground foliage pests of ornamentals
- diseases or insects on turfgrass
- weeds

High pressure hydraulic or airblast sprayers are not typically used on ornamentals or turfgrass. They can be used for spraying large trees.

Measurement Calculations

Area

To determine how much pesticide is required, it is important to measure the area to be treated. If the area is a rectangle, circle or triangle, simple formulas may be used.

Rectangle: The area of a rectangle is determined by multiplying the length by the width.

Area = Length × Width.

Circle: The area of a circle is the radius (one-half the diameter) squared, then multiplied by 3.14.

Area = 3.14 × the radius × the radius.

Triangle: The area of a triangle is the

$$\text{Area} = \frac{b \times h}{2}$$

base (b) multiplied by the height (h), divided by 2 .

Irregularly shaped turfgrass areas often can be reduced to one or more of these common shapes. Calculate the area of each, and then add them together to obtain the total area.

Example:

Area A + B + C = Total Area

Another way is to establish a line down the middle of the property for the length, and then measure from side to side at several points along this line. Areas with irregular shape require more side to side measurements. The average of the side measurements can be used as the width. The area is then calculated similar to a rectangle.

Length = line AB

$$\text{Width} = \frac{\text{line C+D+E+F+G}}{5}$$

Area = Length × Width.

Example:

A third method is to convert the area into a circle. From a center point measure distance to the edge of the area in 10 to 20 increments. Average these measurements to find the average radius. Then calculate the

$$\text{Area} = (3.14) \times \left(\frac{\text{line A+B+ .... +K+L}}{\text{Number of Increments}}\right)^2$$

area, using the formula for a circle. Area = 3.14 × the radius squared.

Example:

Weights

1 ounce = 28.35 grams

16 ounces = 1 pound = 453.59 grams

1 gallon water = 8.34 pounds = 3.785 liters = 3.78 kilograms

Liquid Measures

1 fluid ounce = 2 tablespoons = 29.573 milliliters

16 fluid ounces = 1 pint = 0.473 liter

2 pints = 1 quart = 0.946 liter

8 pints = 4 quarts = 1 gallon = 3.785 liters

Length

1 foot = 30.48 centimeters

3 feet = 1 yard = 0.9144 meter

16½ feet = 1 rod = 5.029 meters

5,280 feet = 320 rods = 1 mile = 1.6 kilometers

Area

1 square foot = 929.03 centimeters

9 square feet = 1 square yard = 0.836 square meter

43,560 square feet = 160 square rods = 1 acre = 0.405 hectare

Speed

1.466 feet per second = 88 feet per minute = 1 mph = 1.6 kilometers per hour (kph)

Volume

27 cubic feet = 1 cubic yard = 0.765 cubic meter

1 cubic foot = 7.5 gallons = 28.317 cubic decimeters

Pesticide Safety

When applying any pesticide, follow the label recommendations for personal protective equipment. At a minimum, wear closely woven fabric clothing consisting of a hat, long-sleeved shirt, long pants or coveralls, and waterproof boots. When mixing the pesticide, wear rubber gloves and a face shield or goggles to protect the eyes. Some pesticides require the use of a respirator.

Read pesticide container label and follow recommendations and safety precautions. Check the mechanical condition of the application equipment for tight connections and cleanliness.

Calibration

Calibration

Study Questions

1. *Calibration is:*
   a. determining the amount of spray material to apply to specified area
   b. determining the pesticide concentration
   c. estimating the number of pests to be treated
   d. repairing the application equipment

2. *Replace nozzles when the discharge rate varies more than _____ from the average of the total nozzle discharge rate.*
   a. 5%
   b. 10%
   c. 15%
   d. 20%

3. *How can you determine the number of acres covered by one spray tank?*
   a. divide tank capacity by the gallons per acre (application rate)
   b. multiply tank capacity by the application rate
   c. multiply tractor speed during application by swath width
   d. divide application rate of one nozzle by swath width

4. *When calibrating liquid hand sprayers,*
   a. hold the nozzle at a constant height while spraying
   b. stand in one place and spray back and forth in an even motion
   c. spray back and forth in swaths while walking at an even pace
   d. a and c

5. *Recommendations on the label may be given in:*
   a. pounds of pesticide per acre
   b. quarts of pesticide per acre
   c. ounces of pesticide per 1,000 square feet
   d. all of the above

6. *Why is calibration of granular applicators more hazardous than calibration of liquid sprayers?*
   a. granular applicators are more difficult to operate
   b. pesticides to be applied must be used during calibration of a granular applicator
   c. granular pesticides are more toxic than liquid pesticides
   d. a and c

7. *High-pressure hydraulic or airblast sprayers are commonly used on:*
   a. ornamentals
   b. turfgrass
   c. large trees
   d. all of the above

8. *If you had a triangular patch of turfgrass to be sprayed, what formula should you use to measure the area?*
   a. $L \times W$
   b. $3.14 \times r^2$
   c. $\frac{b \times h}{2}$
   d. $A + B + C$

Vertebrate Pests

Vertebrate animals may damage larger areas of turfgrass while searching for grubs or other soil-infesting insects, seeds, or plant parts. They include:

- mice
- voles
- skunks
- moles
- gophers
- raccoons
- foxes
- squirrels
- birds
- badgers
- armadillos

Control of wildlife causing damage in turf requires habitat changes such as turf height, moisture levels, varieties or the control of insects or invertebrates that are consumed.

Skunks

Two species of skunks in Kansas are the striped skunk and the eastern spotted skunk. The striped skunk is common and the one most often in conflict with humans. Skunks are classified as furbearers, which provides them with legal protection except during the hunting and trapping season or when they are causing damage. The eastern spotted skunk is rarely found. It is protected by regulation and should not be destroyed.

Skunks are unpopular because of the disagreeable musk they discharge when provoked. Yet, they are beneficial, consuming a diet of one-half insects, one-fifth fruit, and one-fifth mice. They are particularly fond of potato beetles, grasshoppers, and white grubs.

A skunk's raised tail is a warning. Ordinarily, there is no discharge, but if the animal feels threatened, one spray will not empty the reservoir. To neutralize odor, wash everything with ammonia water. Neutroleum alpha mixed 2 ounces to a gallon of water is another product that effectively masks skunk odor.

Skunks have a habit of burrowing in lawns and golf courses to search for beetle larvae and other insects. Damage is often attributed to moles or gophers. As a result, control efforts are misguided and fruitless.

Control

Control is best achieved by exclusion or removing the food supply. Skunks may carry rabies or other serious diseases. They should not be trapped alive and relocated. Animals that appear to be sick or acting abnormally should be avoided. Symptoms that may indicate the presence of rabies or other neurological diseases of mammals include unprovoked aggression, impaired movement, paralysis or lack of coordination, unusually friendly behavior and disorientation. If you see these behaviors, avoid the animal and notify your local animal control officer.

Skunks may be of limited value to the fur market when skins are prime. In Kansas, they are the primary wildlife carrier of rabies and may also carry other diseases that can be transmitted to humans. Because of disease risks, the American Veterinary Medical Association and the Council of State and Territorial Epidemiologists do not recommend relocation. In most cases, wanton destruction is unwarranted and not desirable.

Trapping and relocation or euthanasia. Use cage or solid-sided traps to remove individual skunks or families. Traps that kill or maim may result in serious odor problems.

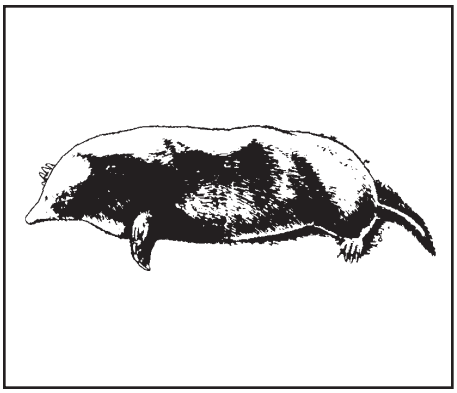
Bait box or cage traps with a chicken head, dead mouse, or canned pet food with a meat or fish base, canned or fresh raw fish, bacon, chicken parts, or whole eggs.

Skunks are relatively easy to trap. If the trap is handled with a minimum of jarring or shaking, animals can be transported to a remote area and released with little concern about being sprayed or bitten.

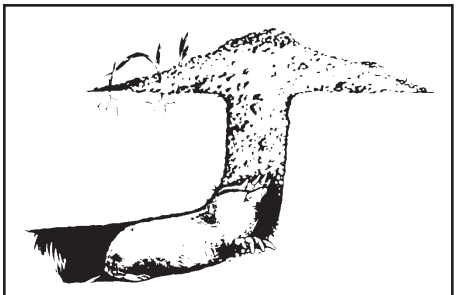
Striped skunk

Spotted skunk

Vertebrate Pests



Mole



Mole pushing dirt through tunnel onto surface.

Only moles tunnel through the surface of the ground leaving ridges on soil surfaces.

Exclusion. Properly constructed foundations will prevent skunks from denning beneath buildings. In lieu of continuous foundations, screening with ¼-inch hardware cloth is effective.

Moles

The eastern mole is the only mole found in Kansas. Moles prefer moist soil. Moles' habits and diet differ from those of pocket gophers. Different control methods are needed. Both animals live in the soil, creating underground tunnels and leaving mounded earth on the surface.

Moles dig two kinds of tunnels. One type an inch or two belowground is created by the mole swimming through loose topsoil. The runway leaves a ridge of earth on the ground surface. More permanent tunnels can be found 6 to 10 inches belowground. Moles burrow without leaving a ridge on the surface but pushing up mounds at intervals. Tunnels are often confused with those made by pocket gophers.

Moles vs. Pocket Gophers

Knowing how the mounds of moles and gophers are constructed helps distinguish one from the other. From the main tunnel of the mole run, a short shaft extends straight up to the surface. Soil expelled from the vertical shaft wells up like water. Successive loads form a nearly circular mound on which there may be ripple marks in the form of complete circles. In contrast, a short inclined tunnel to the surface of the main tunnel is characteristic of the pocket gopher. Successive loads of soil are pushed through the tunnel in one direction. Each heap lands partly on top of the one before, forming a mound on which half circles are visible.

Moles normally do not eat garden seeds and bulbs although they are often blamed for doing so. When moles make runways in the garden it is because more moisture, insect larvae, and earthworms exist within the rows than between the rows. Moles are looking for insects and earthworms to consume. The real culprits responsible for eating the seeds are mice and other seed and plant-eating animals that use mole tunnels.

Poisons for Killing Moles

Poisons are not normally used to control moles because their diet consists of insects and earthworms. In cases where poison seems to be effective, the user has probably frightened the mole out of the runway with the scent or other quality of the poison or killed the mole's food.

Indirect Control

Moles deprived of food will be forced to move. Several insecticides can be used to reduce earthworms and insect populations so soil longer provides enough food to fulfill daily requirements. Results may take several weeks, and moles may cause even more damage as they search for food.

Trapping Moles

Trapping is the most common method of mole control, but it is successful only when mole habits and instincts are carefully considered. Two good traps for catching moles in Kansas are the scissor type and the harpoon type.

Selecting a trap site. The selection of a frequently used runway for a trap set is of prime importance. The traps will have to be placed where ridge tunnels run in a straight line for a few feet. These tunnels are often used as travel ways.

Pocket Gophers

Pocket gophers eat the roots of some plants, bringing soil to the surface and killing plants. Dirt mounds can interfere with mowing.

Pocket gophers create a series of deep runways leading to nests and food storage areas. These generally are about 4 to 5 feet below ground. These tunnels are not connected directly to the surface but lead to the runways closer to the ground, about 10 inches under the surface.

The amount of soil brought up in a year will vary from one gopher

to another and depends on how far they travel in search of food. It is estimated that in a year the average gopher transports 2¼ tons of soil to the surface. At this rate, seven gophers per acre could cover the ground with a layer of loose soil 1 inch deep in 10 years.

Control Methods

Control operations can best be conducted during the seasons when the pocket gophers are most active near the surface. This usually is indicated by the presence of fresh mounds of dirt. At other times labor and material may be wasted on unoccupied systems of runways.

Trapping

The best time to trap is when gophers are pushing soil to the ground surface and can be easily located. Set traps at freshly dug soil.

Success depends on the proper use of traps. The following steps are suggested:

1. Locate the newest mound in the area.
2. Probe to locate the main runway. To locate the main runway find the plug where the gopher has filled up the lateral tunnel and left a horseshoe-shaped depression in a fresh mound. The main runway will be about 15 to 18 inches away from the mound on the same side as the horseshoe-shaped depression. To build a probe, use a piece of ¾-inch pipe about 35 inches long. The end section which is forced into the soil, should be solid and pointed. A foot pedal on the probe may make the task easier. The release of ground friction will be felt when the probe drops into the runway.
3. Dig down until you locate the runway and remove soil from the burrows so that traps can be placed far back into the tunnels.
4. Connect the trap to a metal stake with a piece of wire. The stake serves as an anchor and helps locate the set for tending. The gopher cannot pull the stake into the burrow.
5. Set and place two traps, one in each direction. The trigger (flat metal plate) is placed away from the excavation.
6. The open burrows attract the gopher and he will be caught while trying to plug them. However, if you let in too much light, he may push a large amount of soil ahead of him. This may spring the trap and let the gopher escape. Therefore, push traps into the open tunnel as far back as possible, or partially cover the entrances.

Use of Poisons

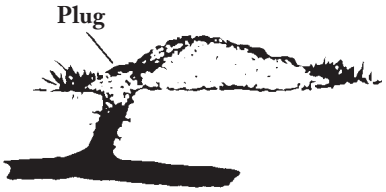
When using poison grain it is best to use a burrow builder or a hand applicator in applying the bait. The burrow builder is a machine that consists of a corn planter-type feed mechanism with packer wheels, power for feeding mechanism, coulter wheel, and steel pipe used to make the burrow.

The burrow builder makes an artificial burrow for the pocket gopher and at the same time places poison bait in this burrow. The machine is attached to a tractor and pulled back and forth across a field making a series of parallel burrows about 25 feet apart.

Soil condition, particularly soil moisture, should be considered before using the burrow builder. Generally, if soil is damp enough that a handful can be compressed and hold its shape, it is suitable for using the machine.

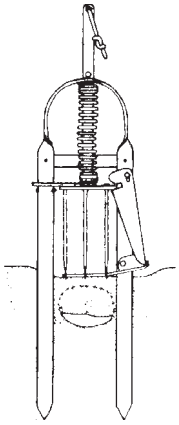
In general, a burrow depth of 10 inches is desirable. Burrow builder effectiveness depends on gophers finding the artificially constructed runway and using it long enough to find the poisoned bait. To make this possible, artificial burrows should be constructed at a depth and spaced out so as to cut through the greatest number of natural gopher tunnels. The burrow builder will give good control if used properly.

Fumigation effectiveness is limited. Gopher burrow systems are extensive. Portions are blocked by earth plugs with the gopher occupying various sections at a time.



Gopher tunnel and mound

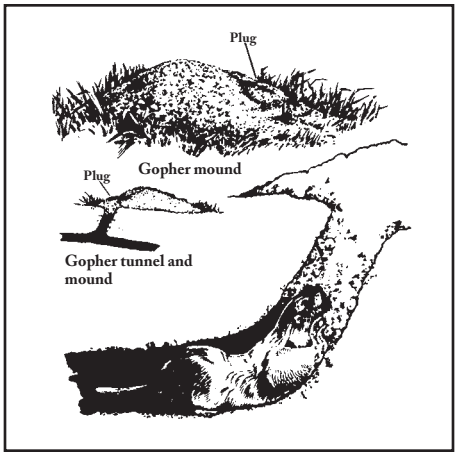
Mole tunnel and hill



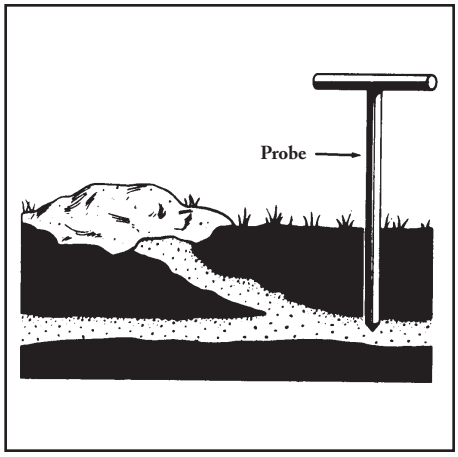
Setting a harpoon trap

Pack down the runway ridge and push the set trap into the ground with trigger snugly on depressed ridge.

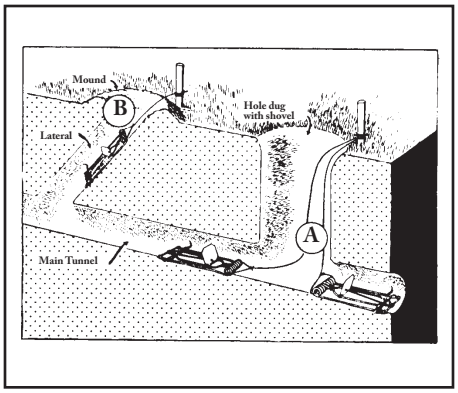
Vertebrate Pests



Pocket gopher using nose and front feet to tamp earthen plug to tunnel



Gopher-trapping hole



Gopher trap

Study Questions

1. *Which species of skunk is protected by Kansas regulations?*
   a. tree skunk
   b. striped skunk
   c. spotted skunk
   d. long-tailed skunk

2. *The best method for controlling skunks is:*
   a. trapping and euthanasia
   b. exclusion
   c. toxicants
   d. they cannot be controlled

3. *A permanent mole tunnel can be identified by:*
   a. a half circular mound of dirt
   b. change in turf color
   c. a large, flat-topped mound of hard packed dirt
   d. a circular mound of dirt

4. *The best method of mole control is:*
   a. poisoning
   b. shooting
   c. trapping
   d. excluding them from the premises

5. *When is the best time to control pocket gophers?*
   a. winter
   b. spring
   c. summer
   d. any season when gophers are most active near the surface

6. *When using poison grain to control pocket gophers what is the best method of application?*
   a. dropping pellets by hand around the burrow opening
   b. using a burrow builder
   c. aerial application
   d. poison grain will not kill pocket gophers

7. *Fumigation for pocket gophers is of limited use because:*
   a. gophers are resistant to fumigants
   b. there is no method for getting the fumigants into the burrows
   c. there are many burrows and earth blockages that isolate the gophers
   d. contamination of the groundwater will always result after the gophers are poisoned

Environmental Considerations

Phytotoxicity

Phytotoxicity is the measure of the degree to which a chemical or compound is toxic to plants. This usually results in undesirable injury to plants, causing abnormal growth, discolored leaves, foliar burn, leaf drop, stem distortion and even plant death. Sensitive plants can be impacted by spray droplets, soil residues, or vapors from herbicides. A pesticide used to control a pest on one plant may leave residues in the soil that will damage or kill another type of plant. Phytotoxicity symptoms are similar to those caused by insect damage, plant disease, and response to adverse growing conditions such as insufficient moisture and improper fertilization. For this reason, the exact cause of phytotoxicity may not be easy to determine.

The active ingredient in a pesticide does not always contribute to the phytotoxic effects. Formulation solvents, impurities in the water, using more pesticide than the labeled rate, and poorly mixing spray solutions can also damage plants. Other factors which may contribute to pesticide phytotoxicity include:

- high air temperature during and immediately after pesticide application.
- environmental conditions such as temperature, humidity, and light.
- excessive rates of pesticide application.
- too little water.
- uneven distribution of pesticide.
- mixing liquids or emulsifiable concentrates with wettable powders.
- mixing fertilizers with pesticides.
- the condition of the plants.
- soil properties such as texture, moisture, pH and microbial activity.
- variety and species differences.

The phytotoxic effects can be minimized by reading and following label directions. A pesticide label may list plants or varieties that are sensitive to the product and is the best guide to whether the pesticide should be used on a specific turf species. Avoid spraying pesticides when drift is likely to occur as well as using the correct planting times. A field assay can be conducted by treating a few plants with the product to see how the cultivar or species will react.

Drift

The proximity of different plants with varying degrees of susceptibility to pesticide damage requires that commercial applicators in the turf category be aware of the problems associated with drift.

Two forms of drift are associated with pesticides. The most common form is drift of the spray droplets or dust particles. This type is directly affected by spray pressure, nozzle opening size, wind velocity as well as the pesticide formulation. Lower spray pressures will result in larger droplet size and less drift potential. Vapor drift is the drift of a chemical with low vapor pressure (or high volatility). Vapors or gasses can drift in harmful concentrations – even in the absence of wind. Some pesticide products are volatile and thus capable of vaporizing from soil or leaf surfaces in potentially harmful concentrations. Plants can be severely damaged or even killed by herbicide vapors.

Drift can be prevented or minimized by taking certain precautions. The applicator should consider the hazard and toxicity of the active ingredient when several pesticides are available. Select the least hazardous pesticide that will be effective. Use formulations and methods of application that will minimize drift. Use products with low volatility. If possible, select pesticides that are safe for both target and non-target plants. Apply pesticides when wind speeds are low (< 5 mph) and are blowing away from sensitive areas (e.g. waterways, crops, etc). Use the lowest operating pressure and largest nozzle opening. Keep the nozzles as close to target or the surface as possible. Don't use airblast sprayers and dusters when

working near sensitive areas inhabited by animals or wildlife. It may be necessary to plan a barrier around the target plant or remove susceptible plants from the area (such as removing susceptible potted plants from a greenhouse).

Pesticide movement can be mitigated by using special precautions when applying pesticides on slopes. Use the lowest labeled rate of a given pesticide. If possible, establish a buffer zone between the treated area and any sensitive areas. Don't apply pesticides if rainfall is predicted. Avoid irrigating areas following pesticide applications. If possible, avoid applications and pesticides that may lead to ground water contamination.

Persistence

Persistence is an important part of pest control because successful pest control requires a knowledge of the persistence period to make subsequent applications. For example, herbicides commonly used for preemergence weed control in turf persist for 60 to 90 days, and post-emergence herbicides last from one to two days to three or four weeks, depending on the specific herbicide. A persistent pesticide has an advantage for long-term pest control because fewer applications are needed, but issues can develop when applications are made too frequently, causing potential phytotoxicity for other plants.
The period of pesticide residual activity varies greatly from one class of pesticides to another. Persistence is directly related to application rate, soil type or texture, temperature, moisture conditions, rainfall amounts, and other factors. Commercial applicators must be familiar with the persistence of each pesticide that can be applied to turf, especially where adjacent areas may be affected or where soil is used to grow other plants. Information on the persistence of a particular pesticide can be found on the product label.

Pesticide Hazards

Preventing Groundwater Contamination

The potential for groundwater contamination is an important consideration when choosing pesticides. Several products have groundwater advisory statements on their label. These statements advise not to apply these products where the water table (groundwater) is close to the surface and where soils are very permeable (loamy sands). Observe all precautions on the label when using these products.

Protecting Humans, Pets, and Domestic Animals

Turf pesticides often must be applied in areas frequently used by humans, as well as pets and other domestic animals. The pesticide applicator should be aware of hazards associated with this situation. The applicator must prevent humans, pets, and other domestic animals from contacting hazardous amounts of pesticides within the treated area.

Follow safety precautions in these situations to limit exposure. The applicator should make sure the correct location is being treated. Animals and humans should be kept from the area during the pesticide application. (They should also be kept from the area of potential drift or run-off until the spray residues have dried or the dust has settled).

Check neighbor's yards for children or pets that may come into contact with spray drift. Remove toys, pet food dishes, bird feeders, or other items from the application site. Also avoid spraying fish ponds, bird baths, and lawn furniture as pesticide residues on these articles can be a hazard. Remove all clothing from the area. Make sure all house windows are closed.

Observe pesticide label restrictions concerning tolerance for fruits and vegetables. Sweep or rinse away any puddles. Secure all pesticide containers or spray equipment before moving sites. Do not use pesticides when people or pets cannot be

Environmental Considerations

excluded during the reentry period specified on the label.

Earthworm Preservation

Earthworms are important, beneficial invertebrates in turfgrass. Their burrowing and feeding activity enhances soil structure and fertility and incorporates thatch and plant residues into the soil. Certain pesticides can significantly reduce earthworm populations. To ensure long-term stability of the turfgrasss ecosystem, it is important to preserve earthworms and other beneficial soil invertebrates.

Study Questions

1. *Phytotoxicity is:*
   a. undesirable injury to plants
   b. poisoning to humans by pesticides
   c. when pesticide degradation occurs too rapidly and pests are not controlled
   d. insect damage

2. *Which factor may contribute to pesticide phytotoxicity?*
   a. plant condition
   b. environmental conditions
   c. soil properties
   d. all of the above

3. *What are two forms of spray drift associated with pesticides?*
   a. vapor and gas drift
   b. target and non-target drift
   c. spray droplet and vapor drift
   d. none of the above

4. *Drift can be prevented by:*
   a. using higher spray pressures
   b. selecting an appropriate formulation
   c. spraying on a windy day
   d. all of the above

5. *Herbicide persistence is affected by:*
   a. soil factors
   b. climatic conditions
   c. both a and b
   d. none of the above

6. *How can commercial applicators prevent pesticide hazards to humans when spraying turfgrasses?*
   a. make sure you have the correct location
   b. remove all toys, pet food dishes, and bird feeders from the area
   c. sweep or rinse away spray puddles
   d. all of the above

Answers to Study Questions

Pages 7–16

1. d 2. a 3. c 4. d 5.a
6. d 7. c 8. b 9. b 10. d
11. a 12. d 13. c 14. b 15. a
16. d 17. b 18. b 19. c 20. d
21. c

Pages 19–32

1. b 2. d 3. a 4. b 5. b
6. c 7. a 8. a 9. c 10. d
11. d 12. d 13. b 14. b 15. d
16. b 17. b 18. c 19. b 20. c
21. b 22. c 23. b

Pages 36–44

1. d 2. d 3. a 4. b 5. b
6. a 7. d 8. d 9. a 10. d
11. d 12. a 13. b 14. c 15. a
16. b 17. b 18. c 19. d 20. a

Pages 48–53

1. a 2. d 3. a 4. d 5. d
6. b 7. c 8. c 9. d 10. d

Pages 55–58

1. c 2. a 3. d 4. c 5. d
6. b 7. d

Pages 60–62

1. a 2. d 3. c 4. b 5. c
6. d

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