



Turf Pest Control



K-STATE
Research and Extension

Kansas State University Agricultural Experiment Station
and Cooperative Extension Service

Category 3B



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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. By each question in parenthesis is the page number on which the answer to that question can be found. This will help you in checking your answers.

These study questions represent the type that are on the certification examination. By reading this manual and answering the study questions, you should gain sufficient knowledge to pass the Kansas Commercial Pesticide Applicators' Certification examination.

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 general utility purposes. In general, people appreciate and take pride in maintaining attractive and quality turf.

Turf must have proper care and management and timely pest control to be attractive, have good color and density and be free of weeds, insects and disease. Turfgrass management includes selecting the right grass, mowing, watering, fertilizing and thatch control. These cultural practices are the most important factors in maintaining good turf and preventing problems.

Pesticides can be used as an aid in turf management but not as a substitute for good cultural practices.

Pesticides will not offset the effects from improper watering, fertilizing practices, mowing height and frequency, thatch accumulation, poor soil or improper turfgrass species.

The following factors affect turfgrass growth: climate, soil, management, pest control and selecting adapted species and cultivars.

The climate of Kansas is often harsh for growing consistent quality turfgrass. Temperature ranges from summer to winter are extreme and limit the kinds of grasses that will grow. Rainfall and soil pH vary considerably from eastern to western Kansas. The extreme, variable and

unpredictable combinations of temperature, rainfall, humidity, sun intensity, day length and wind often put considerable stress on turfgrasses growing in Kansas. Only a few months of each year offer ideal growing conditions.

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 here as farther north or south.

Because Kansas grows both cool-season grasses (bluegrass, tall fescue and ryegrass) and warm-season grasses (bermudagrass, zoysiagrass and buffalograss) the turfgrass manager must be able to accurately identify the various kinds of grasses and be familiar with their management requirements. The management practices for cool-season and warm-season grasses are distinctly different with distinct problems. Many chemicals are for use on warm-season turf or cool-season turf only.

Some problems arise from improper selection of a turfgrass species or cultivar. The wrong grass for the wrong situation will result in continual problems that are difficult to combat, even with good management and pesticide application. Problems develop when turfgrasses are unable to withstand environmental stress or when good management cannot offset the effects of environmental stress. Then pesticides can be a valuable aid to management.

This manual will provide detailed information on diagnosis and management of diseases, insect pests, and weeds.

Turfgrasses are susceptible to numerous diseases and environmental stresses. Most turfgrass diseases are caused by fungi. Like other plants, turfgrasses are more susceptible to diseases when they are stressed by other environmental and other non-living site factors such as temperature, moisture, soil fertility, soil structure, or shade. Furthermore, damage from environmental stresses can sometimes be misdiagnosed as a disease. So, it is important to be familiar with both diseases and environmentally-related problems.

There are numerous species of fungi that cause turf diseases. The most common turfgrass diseases in Kansas are described later in this book. Many fungi produce spores for reproduction and spread. Most fungi thrive in wet conditions. Therefore, water management (both foliar and soil) is key to managing fungal diseases. In general, watering deeply and infrequently is better than watering lightly and frequently. Each different fungus thrives in certain temperature ranges. Therefore, some turfgrass diseases are common in cool weather whereas others are most common in hot weather.

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 will damage turfgrass roots and overall plant health.

Provide appropriate fertility. Different species of turfgrass and different types of sites have varying fertility requirements. Determine what is appropriate for the specific

site. Consider submitting soil to a testing laboratory. Some diseases thrive when fertility is too low, and some thrive when fertility is too high, so it is essential to find a balance. In addition, be sure 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 and can cause symptoms that are confused with diseases. More details about thatch are provided below in the section on environmental stresses.

Use appropriate mowing heights. Each species has a range of mowing heights that is most appropriate. 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 mowing problem is mowing too low. Mowing too low reduces green tissue, therefore 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.

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

Diagnosing turfgrass diseases and environmental stresses

Turfgrasses are susceptible to a wide array of diseases as well as environmental stress problems. The first step in the control of any turfgrass problem is accurate diagnosis because the various problems may require different types of management. An incorrect diagnosis and inappropriate management may only compound the problem.

Diagnosis requires knowledge of what normal or healthy turfgrass looks like, including roots, and the symptoms of abnormal or diseased plants. Some turfgrass diseases such as powdery mildew and rust are relatively easy to identify. Others, including most of the 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 problems, not diseases.

The following steps will help to diagnose turfgrass problems.

- 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 turfgrass diseases

The following section lists some common turfgrass diseases in Kansas, when they occur, symptoms, and management. There are other diseases that can occur and a turfgrass extension educator or plant disease diagnostic laboratory can provide further references and information.

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 deficiency of nitrogen.

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.

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Dollar spot lesion



Dollar spot on tall fescue



Dollar spot on creeping bentgrass



Rhizoctonia brown patch on tall fescue

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Fairy ring



Fairy ring



Fairy ring

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.

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 the turfgrass health, 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

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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.

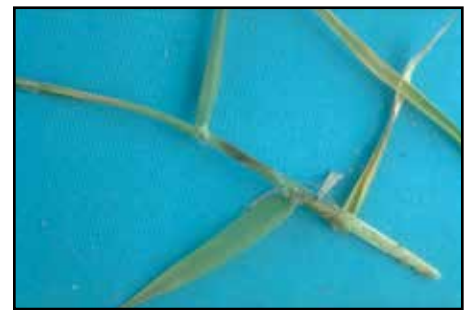
Symptoms of necrotic ringspot usually appear in late spring or early fall, but they may continue into the summer months. The disease is worse when wet weather is followed by hot, dry conditions.

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



Rhizoctonia large patch of zoysiagrass



Lesion on Zoysia leaf sheath



Necrotic ring spot on Kentucky bluegrass

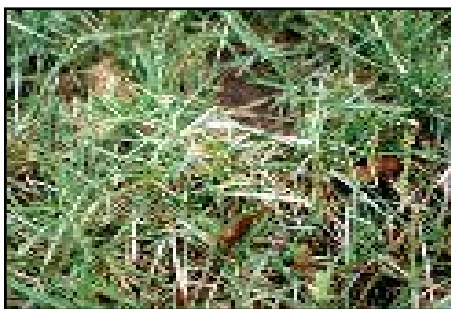


Drechslera on tall fescue

Turf Diseases



Pink snow mold on creeping bentgrass



Powdery mildew on Kentucky bluegrass



Powdery mildew



Pythium blight mycelium

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 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

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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 herpoticum*, *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,



Pythium blight on perennial ryegrass



Pythium blight



Rust pustules



Spring dead spot of bermudagrass

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Smut on Kentucky Bluegrass.



Slime mold.



Summer patch on Kentucky Bluegrass.



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

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 promote good rooting. The appropriate time to cultivate bermudagrass (a warm-season turf) is summer. Avoid excessive nitrogen fertilization (>4 lb of active nitrogen/1000 sq. ft/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 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. In order to see the discoloration, plants should be gently pulled and washed in water to remove the soil. Small fungal strands, called runner hyphae, can sometimes be seen on the roots with a 10× hand lens. These runner hyphae are not necessarily diagnostic for summer patch, since certain other fungi also produce similar strands on roots. In the final stages of the disease, blighted areas of turf 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 “frog-eye” pattern. Symptoms of summer patch can easily be confused with insect damage (grubs, billbug), herbicide injury, or drought stress. These possible causes should be eliminated before a diagnosis of summer patch is made.

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 over stimulated, growing condition. A balanced fertilization program is

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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 in late April through mid-May in Kansas, with several additional applications. Applications after symptoms have developed are not very 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, concrete, etc., 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 in which decreased 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, shrub rows, etc.

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



Iron chlorosis.



Nematode damage on zoysiagrass.



Soil sterilant (herbicide) injury to tall fescue.



Dry algae crust.

Turf Diseases



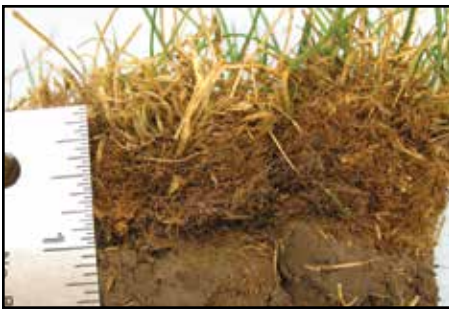
Dog urine injury.

watering to flush the salts helps spots to recover.

Thatch

Thatch is a tightly intermingled layer of decomposing stems and roots of grasses which develops between the layer of 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 and

therefore are less likely to accumulate excessive thatch than Kentucky bluegrass, zoysiagrass, or bermudagrass. Control thatch by cultivating when $\frac{1}{2}$ 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. There are pros and cons to the various methods, so do some research ahead of time to determine which method is best for your site and the turf species.



Excessive thatch.

Introduction and Turf Diseases

Study Questions

- What is included in turfgrass management?*
 - proper grass selection
 - mowing
 - thatch control
 - all of the above
- An example of a cool season grass is:*
 - bluegrass
 - Bermuda grass
 - zoysia
 - buffalo grass
- What causes most turfgrass diseases in the Midwest?*
 - insects
 - bacteria
 - fungi
 - viruses
- The following practices can help prevent the development of disease:*
 - improve airflow and light availability
 - select appropriate turf species
 - provide appropriate fertility
 - all of the above
- The first step in the control of any turfgrass disease is:*
 - accurate diagnosis
 - apply a fungicide
 - apply a bactericide
 - apply an inch of water
- To diagnose turfgrass diseases, the following is important:*
 - review cultural and chemical practices
 - determining the overall distribution of the disease
 - observe symptoms on individual plants
 - all the above
- Leaf spot and melting-out disease is caused by a:*
 - bacteria
 - virus
 - fungus
 - rodent
- From a distance, rust-infected turf appears:*
 - dark green
 - dull yellow
 - dark brown
 - brick red
- Powdery mildew can be reduced by:*
 - frequent nitrogen applications
 - pruning trees and shrubs to increase sunlight
 - spraying a bactericide weekly
 - spraying a herbicide
- In order to manage large patch fungus, it is important to:*
 - allow thatch buildup
 - core aerate when patch symptoms are active
 - fertilize when the symptoms are active
 - avoid overwatering in fall and early spring
- Spring dead spot is the most common and destructive disease of:*
 - bermudagrass
 - tall fescue
 - zoysiagrass
 - Kentucky bluegrass

Introduction and Turf Diseases



**Check answers for this section.
The question numbers
were out of order.**

Study Questions

12. *Fairy ring is caused by:*
- insects
 - bacteria
 - viruses
 - fungi
13. *Necrotic ring spot symptoms may be confused with summer patch and _____.*
- Rhizoctonia large patch
 - rust
 - fairy ring
 - powdery mildew
14. In lawn height turf, dollar spot causes these symptoms:
- rotted roots
 - tan or bleached patches 2-6 inches in diameter
 - tan or bleached patches less than one inch in diameter
 - orange pustules on foliage
15. (13) Rhizoctonia brown patch is the most common and important disease on _____.
- tall fescue
 - bermuda grass
 - Kentucky bluegrass
 - zoysiagrass
16. (14) In the control of brown patch _____ is important.
- proper fertilization
 - proper irrigation
 - proper air circulation
 - all the above
17. (14) Summer patch is:
- controlled by high nitrogen application
 - extremely difficult to control
 - easily controlled by one application of fungicide
 - easily controlled by proper aeration
18. (15) Slime molds are _____ parasitic on plants.
- seldom
 - not
 - always
 - usually
19. (16) Chlorosis is when the turf becomes _____ in color.
- purplish
 - brownish
 - yellowish
 - reddish
20. (16) Moss occurs in lawns with:
- low fertility
 - poor drainage, compaction
 - thinned turf
 - combinations of the above
21. Which statement about thatch is NOT true:
- thatch interferes with water flow into the soil
 - thatch inhibits root growth
 - thatch is caused by returning clippings to the turf stand
 - thatch is less likely to build up in bunchgrasses such as tall fescue

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.

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 are:

Broadleaf Weeds	Grass Weeds
common chickweed	downy brome
shephardspurse	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

Weed Control

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 post-emergence 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.

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.

Turf Weeds

Management in Weed Control

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 Kansas Turfgrass Weeds

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 absent.

Bermudagrass

(Cynodon dactylon)

Warm season perennial producing both rhizomes and stolons which lay flat and creep across an area rooting at the nodes. Flowering culms flattened erect or ascending 4 to 15 inches tall, ligule 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 $\frac{3}{16}$ inch. May die suddenly during summer months.

Other names: Poa annua.



Barnyardgrass



Spreading Bermudagrass



Field Bindweed



Field Bindweed

Turf Weeds

Carpetweed

(*Mollugo verticillata*)

A late-starting, rapidly growing summer annual. The green, smooth stems branch along the ground in all directions from the root 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 and 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 white, sometimes with a tinge of pink. Seeds will live for 20 or more years 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 (1) large crabgrass (*Digitaria sanguinalis* L.) sometimes known as hairy crabgrass and (2) smooth crabgrass (*Digitaria ischaemum* Schreb.). Smooth crabgrass tends to be smaller, less hairy, and has purplish color on the 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.)

Dock seldom flowers when growing in lawns. The plant forms a large rosette. Curly dock (*Rumex crispus* L.) is most common. The leaves have crinkled edges. They are often tinted with red or purple color. Pale dock, also known as tall dock (*Rumex altissimus* Wood.), has leaves that tend to be more flat and broad. Both species have flowering stalks that may reach a height of 2 to 3 feet.

Fescue, tall

(*Festuca arundinacea*)

A very coarse cool-season perennial bunch grass. Scattered clumps are objectionable in fine textured turf grasses. Leaf veins are strongly 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 above 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* L.) also is a frequent weed in bluegrass lawns.

Foxtail (*Setaria* spp.)

Foxtails are warm-season annuals. Yellow foxtail (*Setaria glauca* L.) has flattened stems that are often reddish colored on the lower portion. The stems of green foxtail (*Setaria viridis* L.) 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



Carpetweed



White Clover



Foxtail Crabgrass



Dandelion

Turf Weeds

bulbs and bulblets are produced underground. Green to purple flowers are often replaced with bulblets. There is a characteristic onion-garlic odor.

Wild onion is similar to wild garlic but does not produce under ground bulblets and the leaves are not hollow.

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 near the base are whitish in color. Flower heads are thicker and more robust than on common crabgrass. The extensive fibrous root system makes it difficult to pull.



Curly Dock



Wild Garlic



Goosegrass



Henbit

Henbit

(*Lamium amplexicaule*)

A winter annual that starts growth in September. Stems are squarish; plants usually upright. Flowers are lavender to blue. Leaves are opposite. A few plants may bloom in the fall but the majority blossom in early spring.

Knotweed, prostrate (*Polygonum aviculare*)

An annual that thrives from early spring to late fall. Germination occurs in very early spring. Grows flat from a long white taproot. Individual plants may have a spread of 2 feet or more. Stems wiry, very leafy; at each leaf node there is a thin papery sheath. Leaves often have a bluish cast. Seeds are three-cornered, light-brown early and shiny black at maturity.

Mallow, Purple Poppy

(*Callirhoa involucrata*)

Perennial spreading by seed and underground root. Reddish-purple flowers borne in clusters have five petals. Leaves alternate, two to three inches long, lobed with large oval-shaped stipules at the base of each leaf. Lawns started with pasture sod or soil may be infested.

Nimblewill (*Muhlenbergia schreberi* J.F.)

A warm-season perennial grass. The wiry fine stems root at the nodes; root system is shallow and fibrous; 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* L.)

Warm-season perennial. Triangular stems of sedges produce three-ranked leaves from near the ground. Leaves are light yellow-green. Lower portion of plant is fibrous and brown. Roots often terminate with small nutlets, about the size of a kernel of popcorn. Seed heads appear burlike. Plants grow rapidly in spring and early summer. Several species of sedge are common to our 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* Denc.) are oval shaped and 2 to 3 inches across with purplish stalks. Broadleaf plantain (*Plantago major* L.) has smaller leaves without purplish coloration. Both species have rat-tail like seed heads that are several inches long.

Plantain, buckhorn

(*Plantago lanceolata*)

Perennial. Has slender, narrow leaves that are about one inch across with three to five prominent veins. The seed head is a short cylindrical spike.

Poison Ivy (*Rhus radicans*)

Woody perennial reproducing by seed and root. Found principally in woods and shady places. Leaves divided into three ovate leaflets. Seeds borne in white berries. All plant parts contain a toxic substance which may be irritating to people. Usually not a problem in turf except as it occurs in natural areas.

Turf Weeds

Puncturevine

(Tribulus terrestris)

A prostrate freely branching warm-season annual. Plants slightly hairy. Some stems may be 4 or 5 feet long. Taproot. Leaflets bright green. Flowers yellow. Seeds angled, each with two stout spines that give a Texas longhorn appearance.

Purslane, common

(Portulaca oleracea)

A warm-season annual. Leaves and stems fleshy or succulent, reddish in color. Grows prostrate. Root system tends to be fibrous; stems root wherever they touch the ground, particularly if the main root has been destroyed. Flowers small, yellow. Seeds very small, black.

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.

Shepherdspurse

(Capsella bursa-pastoris)

A winter annual. The deeply lobed leaves form rosettes in the fall that may be confused with dandelions; however, the leaves lack the milky sap. Blooms in very early spring. White flowers develop into triangular seed pods filled with numerous tiny reddish brown seeds. Individual seed pods held by their small stems resemble the purse once carried by shepherds.

Speedwell (*Veronica spp.*)

Several weedy species exist, most being winter or early-spring annuals. Plants very low growing; leaf shapes vary with species but generally are small and numerous; flowers are light blue with white throats. Seed pods are divided and almost heart-shaped.

Spurge, prostrate

(Euphorbia supina, Raf.)

A prostrate growing warm-season annual. Most prominent in July, August and September. Milky sap; leaves with or without reddish brown spots. Seeds are borne in three's in a capsule.

Other common names: Milk spurge.

Thistle (various genera and species)

Biennial or perennial; reproducing by seed or fleshy root system. Leaves vary from 2 to 6 inches long, dark green or white in color with a spiny margin. May occur in turf as a rosette.

Violets (*Viola spp.*)

Cool-season perennials that are among the first plants 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 common to our region.

Windmill Grass

(Chloris verticillata Nutt.)

Perennial. Leaf sheath flattened and keeled, leaf blade grayish-green, ¼ to ½ inch wide. Panicles of two or three whorls, stiff, wide spreading spikes. Primarily occurring 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 giving a cloverlike appearance. Funnel-form flowers are



Henbit



Prostrate Knotweed



Yellow Nutsedge



Broadleaf Plantain

Turf Weeds

yellow (in some species violet). The seedpod is cylindrical, five-sided and pointed. The plants contain soluble oxalates that give it a rather pleasing sour taste.

Yarrow, common (*Achillea millefolium*)

Perennial. May grow 1 or 2 feet tall. Leaves are soft, finely divided, 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* Nutt.) also is common in the region.



Buckhorn Plantain



Poison Ivy



Puncturevine



Common Purslane

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 applications are made 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.

Read Carefully

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 certain it is registered for your needs. Most farm and ranch herbicides are not labeled for use on turf. Such products applied to turf would be inconsistent with the labelling and a violation of the Federal Environmental Pesticide Control Act.

Some products are sold under several trade names, thus 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 broad-leaf species. Products have varying residuals and seeding must be delayed for several months after applying. Check the label.

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.

Turf Weeds

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.

Demension (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.

Some 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.



Field Sandbur



Shepardspurse



Veronica



Prostrate Spurge

Turf Weeds

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

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

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.

Some 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. However, 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.

Non-selective 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



Thistle



Windmillgrass



Oxalis



Common Yarrowgrass

Turf Weeds

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



Oxalis



Chickweed



Chickweed

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.

The application of herbicides with hose-end units is difficult to control. Wrestling with the water hose and lack of precision placement with hose-end applicators makes for misapplication. Save hose-end units for the applicator of insecticides, fungicides and liquid fertilizers.

Using Herbicides

Weed control using a given herbicide may vary in effectiveness from year to year or area to area. Factors influencing weed control with soil-applied herbicides include:

- Kinds of weeds
- Application rates
- Uniformity of application
- Solubility of herbicide
- Volatility of herbicide
- Rainfall
- Soil type
- Organic matter

Factors influencing weed control using foliage-applied herbicide include:

- Kinds of weeds
- Application rates
- Uniformity of application
- 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 helps select herbicides for different weeds.

Get additional information from the label, the dealer or your county 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+MCP+ Dicamba
Bindweed, field	No	Drive	2,4-D + MCP + Dicamba
Bluegrass, annual	Yes, but difficult especially on golf courses	Prograss	
Carpetweed	Some	2,4-D	Dicamba
Chickweed, common	Some	Dicamba	MCP
Chickweed, mouseear	Gallery	Dicamba	MCP
Clover, white	No	Drive, Escalade II, Confront	MCP, Dicamba
Crabgrass	Yes	Drive	Acclaim
Dandelion	Gallery	2,4-D, MCP, Dicamba, Confront	
Deadnettle	Some	2,4-D + MCP + Dicamba, Escalade II	
Dock	No	Manor	Dicamba
Fescue, tall	No	Roundup, Finale (spot treat)	
Foxtail	Yes	Acclaim	
Garlic, wild	No	Q4, Surge	2,4-D + MCP + Dicamba
Goosegrass	Yes	Acclaim	
Henbit	Some	2,4-D + MCP + Dicamba, 2,4-D + MCP + Dicamba + Carfentrazone	MCP
Ivy, ground	No	2,4-D, Escalade II	Turflon Ester
Knotweed, prostrate	Yes	2,4-D + MCP + Dicamba	2,4-DP
Kochia	No	2,4-D, Dicamba, Escort,	Confront
Mallow	No	4-D + MCP + Dicamba, Speed Zone, Surge	Turflon Ester
Medic, black	No	Dicamba	Confront
Moss	No	Quicksilver	
Nimblewill	No	Tenacity	Roundup or Finale
Nutsedge, yellow	No	Manage	Basagran, MSMA
Pigweed, prostrate	Some	2,4-D, MCP, Dicamba	
Plantain	Gallery	2,4-D + MCP + Dicamba	
Puncturevine	No	Dicamba (early)	2,4-D (early)
Purslane, common	Yes	Dicamba	2,4-D
Quackgrass	No	Roundup, Finale (spot treat)	
Sandbur	Yes	Acclaim	MSMA, DSMA
Shepherdspurse	Some	2,4-D + MCP + Dicamba	2,4-D
Sorrel, red	Gallery	Confront	2,4-D + MCP + Dicamba
Speedwell	Gallery	2,4-D + MCP + Dicamba, Surge, Speed Zone	Dicamba
Spurge, prostrate	Gallery	T-Zone, Momentum, Manor	2,4-D + MCP + Dicamba, Q4, Speed Zone
Thistle, Canada	No	2,4-D + MCP + 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

Weed	SPRING			SUMMER			FALL			WINTER		
	Early	Mid	Late	Early	Mid	Late	Early	Mid	Late	Early	Mid	Late
Barnyardgrass		-----	=====	=====	=====					
Bellflower, creeping	=====	=====	=====	=====			=====	=====	=====			
Bindweed, field		=====	=====	=====			=====	=====	=====			
Bluegrass, annual	-----					-----			=====	=====		-----
Carpetweed		=====	=====	=====	=====	=====	=====					
Chickweed, common	=====	=====	=====	=====	=====		=====	=====	=====	=====		
Chickweed, mouse-ear	=====	=====	=====	=====	=====		=====	=====	=====	=====		
Clover, white	=====	=====	=====	=====			=====	=====	=====			
Crabgrass		-----	=====	=====	=====	=====	=====					
Dandelion	=====	=====	=====	=====	=====		=====	=====	=====			
Deadnettle	=====	=====	=====	=====			=====	=====	=====			
Dock	=====	=====	=====	=====			=====	=====	=====			
Fescue, tall	=====	=====	=====	=====	=====		=====	=====	=====			
Foxtail		-----	=====	=====	=====	=====	=====					
Garlic, wild	=====	=====	=====	=====	=====							
Goosegrass		-----	=====	=====	=====	=====	=====					
Henbit	=====	=====	=====	=====			=====	=====	=====			
Ivy, ground	=====	=====	=====	=====			=====	=====	=====			
Knotweed, prostrate	-----	=====	=====	=====	=====	=====	=====					-----
Kochia		=====	=====	=====	=====	=====	=====					
Mallow	=====	=====	=====	=====	=====	=====	=====					
Medic, black	=====	=====	=====	=====	=====	=====	=====					
Moss	=====	=====	=====	=====	=====	=====	=====	=====	=====			
Nimblewill			=====	=====	=====	=====	=====					
Nutsedge, yellow			=====	=====	=====	=====	=====					
Pigweed, prostrate		=====	=====	=====	=====	=====	=====					
Plantain	=====	=====	=====	=====	=====	=====	=====	=====	=====			
Puncturevine			=====	=====	=====	=====	=====					
Purslane, common		-----	=====	=====	=====	=====	=====					
Quackgrass	=====	=====	=====	=====	=====	=====	=====	=====	=====			
Sandbur			=====	=====	=====	=====	=====					
Shepherdspurse	=====	=====	=====	=====			=====	=====	=====	=====		
Sorrel, red	=====	=====	=====	=====	=====		=====	=====	=====			
Speedwell	=====	=====	=====	=====			=====	=====	=====			
Spurge, prostrate	-----	=====	=====	=====	=====	=====	=====					
Thistle, Canada	=====	=====	=====	=====	=====		=====	=====	=====			
Thistle, musk	=====	=====	=====	=====	=====	=====	=====	=====	=====			
Violets	=====	=====	=====	=====	=====		=====	=====	=====			
Woodsorrel, yellow		=====	=====	=====	=====	=====	=====	=====	=====			
Yarrow		=====	=====	=====	=====	=====	=====					

===== = 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.

Herbicide Applicators Low-Pressure Sprayers

Low-pressure sprayers are the most commonly used equipment for pesticide applications to turf. They are used to apply pesticides 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, primarily used to spray trees for disease and insect control, are capable of developing pressure up to 800 psi, which drives the spray through heavy foliage or to the tops of tall trees. When equipped with a boom and proper pressure regulators, high-pressure sprayers can do any work usually done by low-pressure sprayers. When equipped with handguns, they can also be used for spot treatments, for spraying fence rows, roadsides, ornamentals, turf and washing equipment.

High- and low-pressure sprayers are similar in design, but high-pressure sprayers have piston or diaphragm pumps. The pumps typically deliver up to 50 gallons per minute at pressure up to 800 psi. All components must be designed for high pressure. Consequently, they are heavier and more expensive than low-pressure units.

Handguns that can handle pressures up to 1,000 psi are available for high-pressure sprayers. These guns have a range from a low rate with a wide cone spray pattern to a high flow rate with a straight stream pattern.

Handguns are not normally recommended for spraying turf areas such as lawn or golf greens. It is very difficult to constantly obtain uniform coverage from a handgun on turf areas. A hand or walking boom with conventional nozzles should be used if it is not possible to use a conventional sprayer with a boom. If a handgun must be used because of rough or very irregularly shaped areas, you must be aware of the difficulty in obtaining a uniform spray in the correct amount over the area.

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 the leaves often tinted reddish colored with 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 which are whitish near the base and a very fibrous root system that is hard 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 since 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

Study Questions

11. *The common yarrow is:*
 - 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 herbicides
 - b. selective postemergence herbicide
 - c. herbicides which control grassy weeds
 - d. 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-applied herbicides 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

Study Questions

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
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 result in injury, their damage may cost considerable repair and replacement.

Proper management is the first line of defense against turfgrass-insect pests. Healthy turfgrasses have a greater capability than weak turfgrasses in reducing problems with insect pests.

To effectively manage insect pests, commercial pesticide applicators must have a working knowledge of pests' life cycles and habits. It is also important to realize that it is not possible, or practical, to eliminate all turf insects. However good management practices—including applying insecticide when needed—and will reduce damage to turfgrass.

Steps in Managing Pests

Successfully managing pests requires recognizing problems, taking appropriate actions, and making a follow-up assessment. To reduce insect pest problems, the following five steps should be taken:

1. Inspect turfgrass regularly.
2. Learn how 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. Periodic inspections are needed to detect insect infestations and accurately assess the potential for damage. The inspection should be systematic. Look at the above the ground plant parts such as blades and stems for feeding injury. A simple check for aboveground insects can be made by sprinkling a mixture of 1 quart water and 1 tablespoon of laundry detergent over a 4-foot square area. (One teaspoon of pyrethrum also may be used instead of 1 tablespoon of detergent.) This mixture should bring aboveground insects to the surface of the turfgrass within

10 minutes. They can be collected and counted. This technique can be used in several places to determine the average number of insects present.

To inspect for possible root damage, take a handful of grass and pull up. If the plants can easily be pulled back, the roots are damaged. If the grass stays in place or blades of grass are easily pulled-up, then above ground portions may be damaged.

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

Identification. The first step is to determine whether or not the damage symptoms are insect related. This is not always easy because other factors may resemble insect damage—such as fertilizer burn, diseases, improper mowing, the characteristic of the particular grass variety, dry weather, spots from dog or cat urine, and damage caused by improperly using insecticide, fungicide or herbicide.

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

Correct identification is also important to separate the nondestructive insects from the destructive ones. For example, some insects may benefit the turf because they feed or prey 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 turf, but usually do not cause damage.

Develop a sound management strategy. Once the problem has been diagnosed as an insect, a management decision must be made. Determine actual and potential damage, and then decide whether to treat with insecticides and how

Turf Insects

to to maximize the effectiveness of the application. Depending on the nature of the problem and the time of year, insecticide applications may or may not be helpful.

Chemical control. Insecticides should never 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, the next step is to apply the insecticide at the proper 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 of pests are present such as nymphs and adults. 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 their original containers and locked in a cool, dry, clearly-marked location.

Evaluation. A thorough follow-up evaluation should be conducted to determine the success of the program. 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, try to determine the cause.

Thatch Reduces Effectiveness of Insecticides

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

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

The effects of thatch may be reduced by using granular insecticides or by wetting the thatch before applying

liquids and watering heavily (½ inch or more) immediately afterward. Results are best when thatch is reduced by power raking, top dressing or using light applications of lime.

Insecticide-Fertilizer Mixtures

Insecticide-fertilizer combinations are designed to fertilize the turfgrass and control the insect.

Fertilizer and insecticides are not always needed at the same time. Applying insecticide or fertilizer when it is not needed wastes money and is not an environmentally sound practice.

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

Common Turf-Damaging Insects

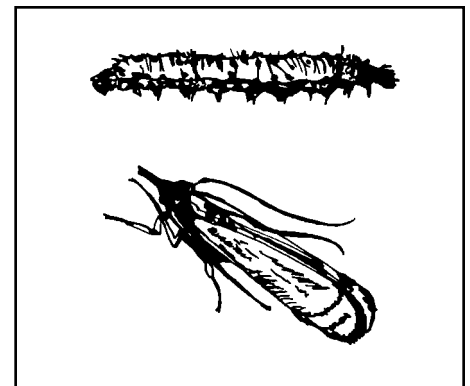
Insects that damage turfgrass may be grouped into two categories: aboveground and underground pests. The two categories usually feed on different parts of the turfgrass and require different control techniques.

Aboveground pests feed on the blades and stems of turfgrass. Included in this group are sod webworms, armyworms, cutworms and chinch bugs. Insecticides are applied to, and should remain on, the blades and stems to kill the insects as they crawl around or feed on the turfgrass.

Underground pests feed primarily on the roots. This group includes white grubs and billbugs. Insecticides are applied to the turfgrass and then watered into the soil about a ½ inch where the insects live.

Aboveground Pests Bluegrass sod webworm (lawn moth)

The bluegrass sod webworm is one of the most destructive pests of turfgrass in Kansas. Infestations often damage bluegrass or mixtures of bluegrass and tall fescue. This webworm attacks bentgrass greens on golf courses, can



Bluegrass sod webworm (lawn moth)

Turf Insects

sometimes damage plantings of pure tall fescue, and has been reported occasionally on bermudagrass. In most instances bermudagrass develops vigorously enough to minimize serious problems.

Description and Life Cycle. Sod webworms are the caterpillars of lawn moths. The moths (adults) are small ($\frac{1}{2}$ inch long) and whitish-gray. They roll their wings close to their bodies when resting with mouth parts projecting forward from the head like a snout. The moths are usually 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, they may be seen flying a few feet above the turfgrass and dropping their eggs. In a few days, these eggs laid on the lower parts of the turfgrass stems hatch into small caterpillars. It is the caterpillar that damages the 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 with pieces of turfgrass, essentially webbing the thatch into a mat. The larvae clip off grass blades close to the ground and pull them back into their silken runways, thus most of the actual feeding is done while they are protected. After several weeks of feeding, they reach maturity (now about $\frac{3}{4}$ inch long), change into pupae, then emerge as moths. Two generations occur each year. The first-generation adults appear in June and the second-generation adults in late July and August. The second generation larvae tend to cause the greatest amount of turfgrass damage in Kansas.

Damage and Detection. The close clipping of grass blades by the sod webworm larva does not kill the turfgrass directly but exposes the crown to excessive sun; thus, 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. Be careful not to confuse

other causes of spots with webworm feeding, for example, fertilizer burn, diseases, improper mowing, the characteristics of the particular grass variety, dry weather, cat and dog urine spots, damage caused by improper use of pesticides (insecticides, fungicides or herbicides) or damage caused by underground feeding of insects such as white grubs or billbugs.

If lawn moths are abundant, watch for signs of caterpillars feeding during the next seven to 14 days. However, an abundance of moths does not mean that damaging larval populations will develop. Other evidence of a sod-webworm infestation is the presence of large numbers of birds, particularly starlings, pecking holes in the turfgrass looking for caterpillars.

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

Apply a detergent or pyrethroid mixture as outlined under "Periodic inspection" and count the number of larvae present. If fewer than eight caterpillars are found per square foot, chemical treatment is probably not necessary unless the turfgrass is highly stressed. A healthy turfgrass may tolerate more webworms because the grass has a much better chance of recovering from feeding activity.

Chemical Control. Insecticide applications should be considered when two to four webworms per square foot of sod are detected. Mowing the turf before applying the insecticide will minimize the amount of post-spray contact. Using a grass catcher to catch the clipping will also reduce the amount of insecticide that is intercepted.

Contact your regional, state-wide, or university-based extension entomologist for recommendations regarding insecticides for sod webworm.

One method of timing spray applications is to apply the insecticide seven to 10 days after moth numbers peak. Treatments may be warranted to control the first generation (sometime

in June). Although this may not be necessary for first generation larvae. High moth numbers do not necessarily translate into a serious larval problem. More lawns are treated (especially for first-generation suppression) than necessary. This is especially true of pure fescue turfgrass. The way to avoid excess application of insecticides is to initiate a routine inspection program with the objective of detecting damage. Insecticides may be applied once infestations are confirmed. Be sure to use enough water to thoroughly moisten turfgrass and thatch, but not to the point of runoff. After applying an insecticide be sure to irrigate lightly afterward, in order to move the material to the crown area of the turfgrass. Also do not irrigate heavily for two days.

When using a granular insecticide apply $\frac{1}{2}$ to 1 inch of water within 24 hours of treatment. Do not mow afterwards. Check the label to determine the minimum interval between applications. This will vary depending on the rate applied.

Even if treatments were made for the first generation, another application may be necessary to control the second generation. A late July or August application may be needed because many of the chemicals applied for the first generation will only work from one to four weeks. Also, moths from untreated lawns in the area may reinfest the turfgrass by laying eggs for the second generation. A post-treatment evaluation should always be conducted to determine whether the insecticide was effective.

Children and pets must be prevented from entering treated areas, at least until sprays have dried (see label for other cautions). Clean out 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, and the life

cycle and biology differ from the bluegrass sod webworm.

Description and Life Cycle. Adults are about $\frac{3}{4}$ inch long and light to dark brown. They are active at dusk and hide in the turfgrass during the day. Mature caterpillars are about $1\frac{1}{4}$ inches long. They have a light-brown head and light-brown spots arranged in rings around otherwise grayish bodies.

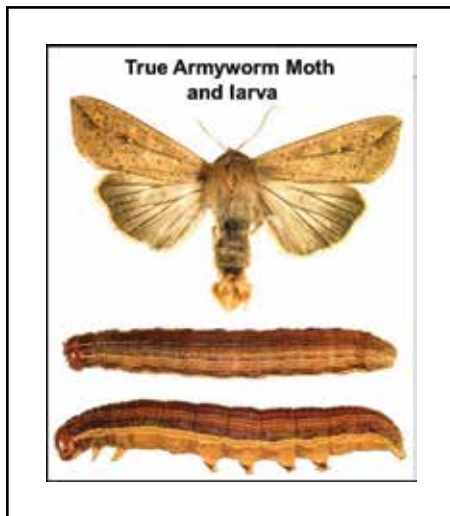
In the spring, the caterpillars that overwintered begin feeding on buffalograss. During the day, caterpillars live in an extensive silk-lined runway near or just below the soil surface. They rarely leave this protective habitat and extend the system laterally so that new grass blades are within easy reach. Grass blades are severed from the plant then pulled within the silk network 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 the presence of 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 to sunlight, possibly the crown. Damage is much more severe during hot, dry weather and on berms or elevated locations.

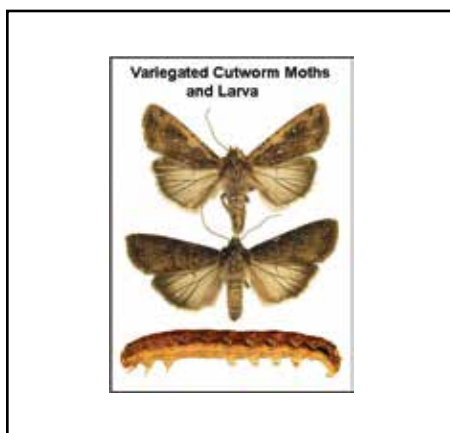
Chemical Control. Control measures should be implemented when there is one defoliated spot per square yard of buffalograss. Buffalograss sod webworm caterpillars cannot be detected using the water-detergent mixture because they are hidden in tunnels near the soil surface.

Buffalograss sod webworm caterpillars are difficult to control using insecticides labeled for sod webworms.

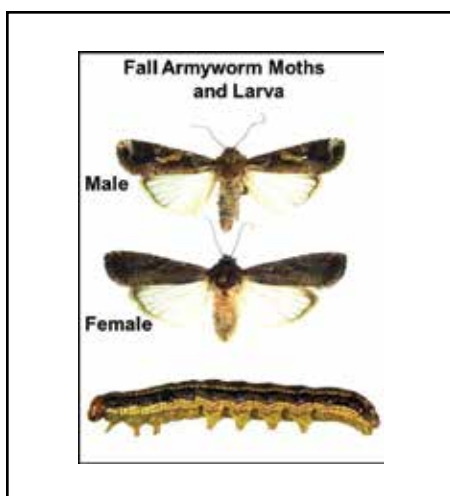
Turf Insects



True Armyworm



Variegated Cutworm



Fall Armyworm

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, get down on your hands and knees when the turf 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 healthy larvae are present and doing damage one week after treatment, check the label determine if the proper application rate was used and sufficient water volume was applied. If nothing was wrong 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 your county 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, the 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 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 can not 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 any of these larvae. Damage is more likely to occur if the lawn borders cropland of large untended fields. Armyworms, in particular, seem to be attracted to areas of lush vegetation. Inspect turfgrass more frequently when vegetation in these nearby areas is removed, forcing the caterpillars to seek out new food. If cutworms are suspected, check the damaged areas a couple of hours after dark. Depending on the species involved, larvae may feed on plant foliage near the crown of the plant. Damage near the crown should be considered 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 critically assessing the damaged area and determine larval density. Make insecticide applications near dusk. Both liquid or granular formulations can be applied. Be sure to read the label to obtain information on post-application procedures.

Chinch Bugs

Chinch bugs are common in zoysia turfgrass but seldom cause 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 noticed. Adults overwinter in bunch grasses and feed on various other grasses in the spring. Females

Turf Insects

lay about 200 eggs over three to five weeks. Nymphs begin feeding after hatching. A second generation occurs produced in the summer. As nymphs mature, a white waistband becomes obvious. 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 a county extension agent.

Damage and Detection. Most damage is caused by the red nymphs which remove plant juices 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 the dying patches of turfgrass. Chinch bugs thrive under hot and dry conditions. However, wet weather may result in many being killed by a fungus.

During hot, dry weather as few as five to 10 chinch bugs per square foot may weaken zoysiagrass and reduce its resistance to diseases. Inspect turfgrass for chinch bugs in the morning on warm days because they may enter cracks in the soil at the edges of sidewalks, driveways and curbs in the afternoon. A coffee can opened at both ends can be used to monitor for chinch bugs. Push the sides down firmly into the turfgrass at the margin of a damaged area and fill with water. Chinch bugs will float to the surface. The detergent method previously discussed can also be used. Close inspections should be conducted when initial signs of damage are observed.

Insecticides can be used against chinch bugs. However, timing of application, coverage, and frequency of application are important. Contact your county extension agent or a university-based extension entomologist for recommendations.

Prewatering may enhance the movement of a spray application to the target site. After applying the insecticide, water enough ($\frac{1}{2}$ inch) to move the insecticide into the thatch layer where most of the chinch bugs are located. However, do not over water,

in order to prevent leaching of the insecticide down below the zone where chinch bugs reside. Follow label directions to determine application rates. Do not re-enter a treated area until turfgrass has dried.

Ants

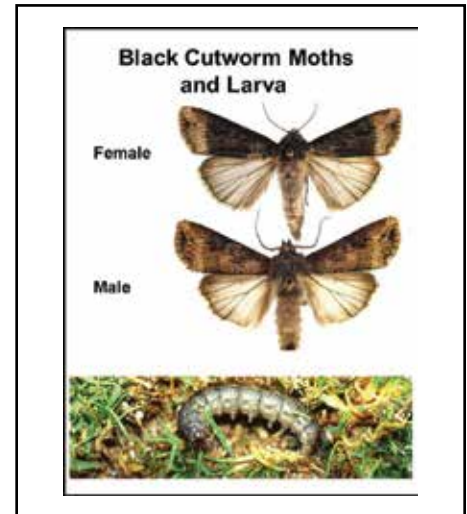
Description and Habits. Ants may be red, yellow, brown or black. They have a narrow (constricted) waist-line, may be winged or wingless, and have elbowed or bent antennae. Ants may be $\frac{1}{32}$ to $\frac{1}{2}$ inch in length, depending on the species. Ants live in colonies or nests usually located 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 the 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.

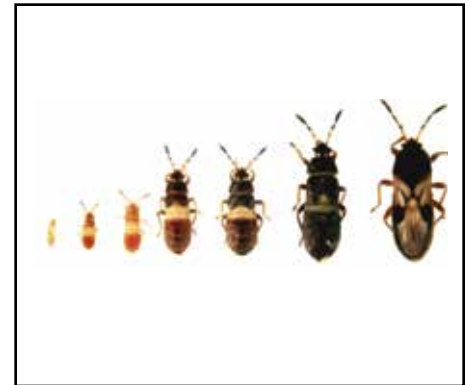
Damage and Detection. Ants build nests in the ground and form mounds around the nest openings. The unsightly mounds make it difficult to mow turfgrass and sometimes smother a portion of the surrounding turfgrass. In addition, turfgrass stands may be weakened by ants that feed on the seeds and roots of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

Chemical Control. There are insecticides commercially-available for control of ants; however bait formulations are the most effective when placed in homes. These formulations are also less harmful to children and pets. For more information, contact a regional or state-wide extension agent or university-based extension entomologist. Always follow the label of any insecticide.

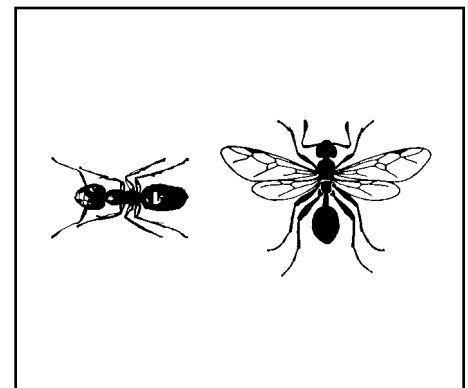
Mowing the turf before applying an insecticide exposes more of the



Black Cutworm



Chinch Bugs



Ants

Turf Insects

mounds and minimizes the need to enter the treated area any sooner than necessary. Apply sprays or granules to ant mounds. Then water the area thoroughly. Keep pets and people away from the area until the turfgrass has dried.

Underground Pests

White grubs

White grubs refers to the larval stage of any number of very destructive insect species in three major groups present in Kansas. These are: May beetles or June bugs (also known as Phyllophaga); Southern masked chafers (or Cyclocephala) and Black turfgrass ataenius.

Description and Life Cycle. Adults vary in color from light brown to nearly black. Foliage feeding occurs at night, from April through June. Many trees and shrubs are also attacked at night, but damage is usually 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 in color. They have a brown head, six legs located behind the head, and a dark area on the abdomen or hind end. Mature white grubs are up to 1 inch long, whereas billbug grubs are similar in shape but are white, legless, and smaller.

May Beetles or June bugs require three years to complete their life cycle (Figure 1). Grubs feed on roots, then burrow below the frost line to overwinter. In the spring of the second year, the grubs migrate upward to the root zone and resume feeding; during this time turfgrass may be severely damaged. 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 these pupae in July and August, but do not appear above the ground until April or May of the following year.

The southern masked chafer has become a common pest of Kansas turfgrass, especially those with a heavy accumulation of thatch.

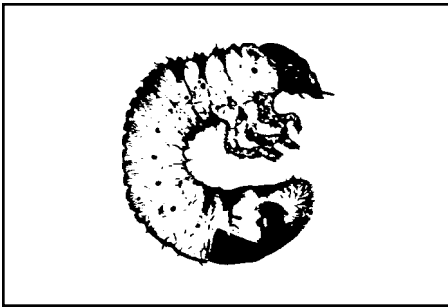
This insect has a one-year life cycle (Figure 1). Eggs are laid in July and hatch to grubs in early August. These grubs do most damage to turfgrass during peak feeding periods of August and September feeding periods. By mid-October, the grubs have moved down into the soil to form cells for overwintering. In April the grubs migrate upward again to feed on roots. However, unless numbers are excessive, there may be minimal damage done to the turfgrass. Pupation occurs in May and adults emerge in late June or early July.

Damage and Detection. Damaged turfgrass may wilt, turn brown, and die even under conditions of minimal water stress. Plants can be pulled up with very minimal resistance, and a section of sod can be rolled back like a carpet because the grubs have consumed the roots.

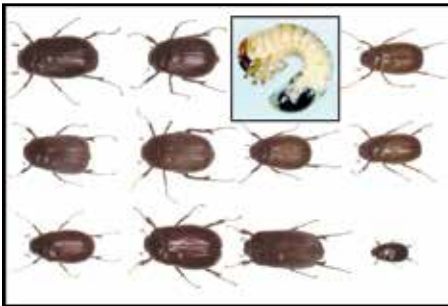
C-shaped grubs may be present in the area if grubs are causing the damage. Although damage may be somewhat difficult to detect, stem of infested turfgrass may have tunneling present caused by small billbug grubs.

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. The root zone should always be inspected for grubs if dead areas appear in August or September. Be careful not to confuse other causes of damage with grubs, including fertilizer burn, diseases, improper mowing, dry weather, urination spots from dogs and cats, damage caused by improper pesticide (insecticide, fungicide, or herbicide) use, or damage from aboveground insect feeding, including sod webworms or cutworms.

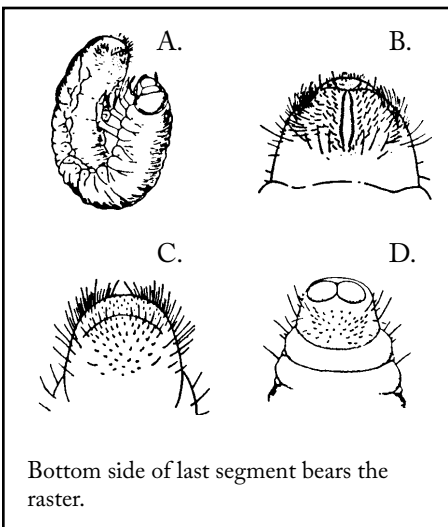
Chemical Control. Insecticides are commercially-available for control of white grubs; however applications should be made before eggs hatch as the young grubs are more susceptible to insecticide residues than mature or older grubs. For more information, contact a county extension



White Grubs



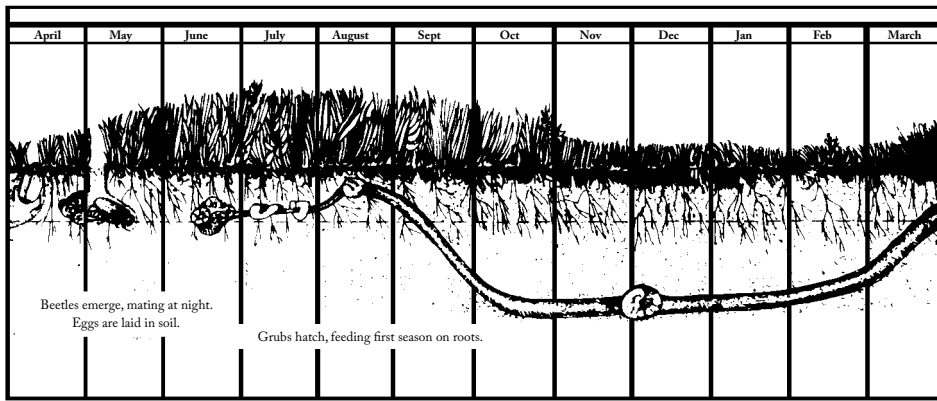
May or June Beetles



A. Typical grub; B. May or June beetle; C. Masked chafer; D. Black turfgrass ataenius

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

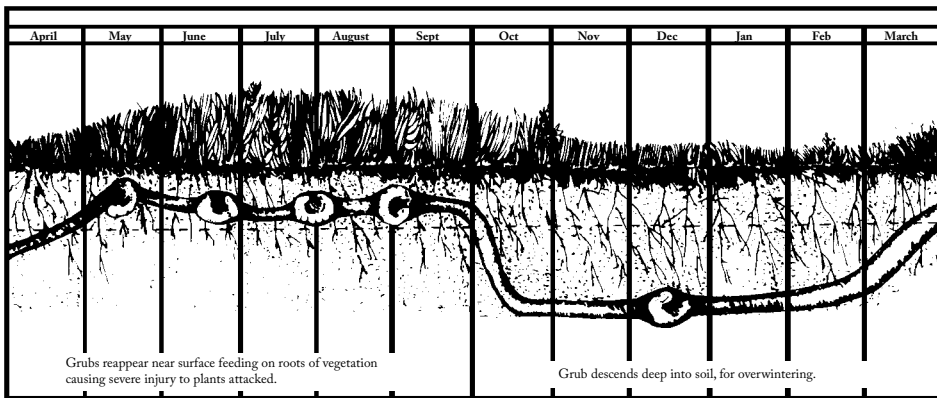
Turf Insects



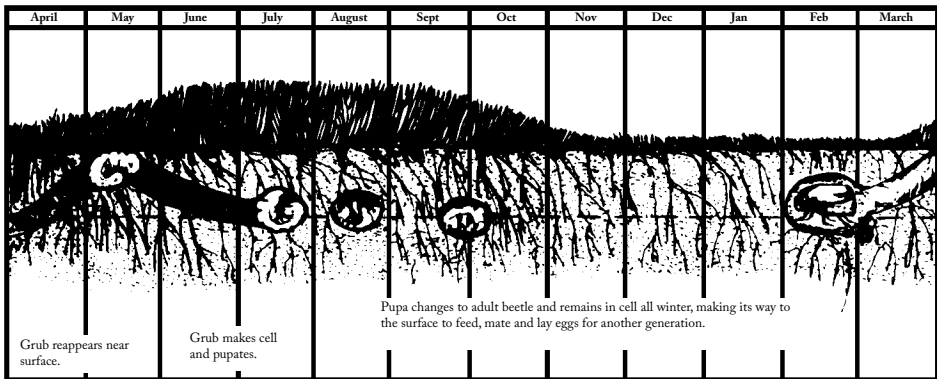
May beetle or June bug first year.



Masked chafer

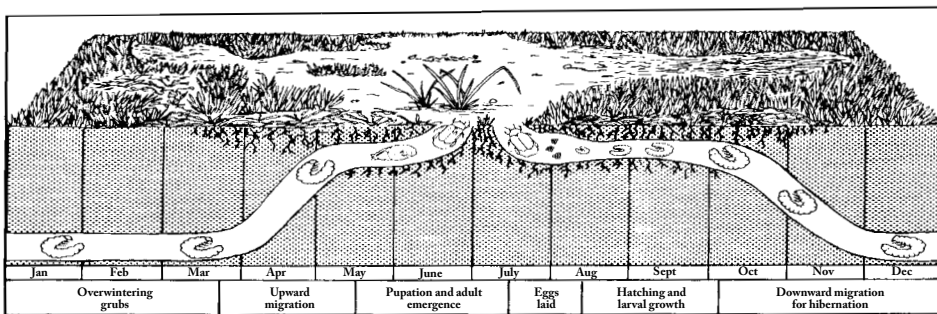


May beetle or June Bug second year.



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

agent or university-based extension entomologist.

Three or more grubs per square foot of turfgrass may be enough to justify applying an insecticide. Eight to 10 grubs per square foot will usually result in severe turfgrass damage and warrant application of an insecticide. Treatment thresholds mentioned above may be helpful in determining when to apply an insecticide; however if the turfgrass is regularly monitored, then these thresholds should never be reached. If these thresholds are, in fact, present then the only option is multiple applications of an insecticide.



Billbugs

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

However, infestation levels may vary depending on environmental conditions (temperature, moisture, and soil conditions (dry vs. wet)). Damage to turfgrass is more pronounced during late summer (August-September) as grubs increase in size and populations.

Successful control is possible if insecticides are applied early August. In some situations, applying insecticides preventatively by mid-to-late July may increase effectiveness. Before applying an insecticide be sure to de-thatch turfgrass so that the treatment will penetrate into the root zone where grubs are located, and not be bound by the thatch layer. Treatment for annual white grubs should not occur during early-to-mid summer because only the adults are present at this time.

If the problem is caused by the *Phyllophaga* grubs (three-year grubs — May beetle or June bug) the treatment period is less well defined as grub age may be an important factor. Active feeding may be expected throughout the season if *Phyllophaga* spp. grubs are less than one inch in length because they are only in the second calendar year of their life

cycle. Insecticide applications may be effective almost any time from mid-May through September. If most of the three-year grubs are an inch or more in length they are probably in the third year of larval development, which means that damage should be less by mid-June. Insecticide application must be applied before substantial damage is noticeable.

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

Billbugs

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

Description and Life Cycle. Damage is caused by the grubs, or larvae, which are $\frac{1}{4}$ to $\frac{1}{2}$ inch long, white and legless. They have a dark brown or yellow head. Billbug grubs can be distinguished from white grubs because white grubs have six legs and billbugs have none. Billbug grubs feed on the stems, stolons and roots of primarily zoysiagrass.

Adults are $\frac{1}{4}$ to $\frac{3}{8}$ inch long with a long snout or mouthpart. Adults are usually located near the grass 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 resemble those of white grubs—small patches of brown or damaged turfgrass. Stems may have tunnels where the small grubs have bored downward although this may be difficult to detect. In zoysiagrass, stolons (underground stems) will show signs of feeding and tunneling damage. Grubs and adults may or may not be present when damage is evident. However most damage occurs when the grubs initiate root feeding.

Chemical Control. There are insecticides commercially-available for controlling or regulating populations of billbugs. For more information, contact a regional or state-wide extension agent or university-based extension entomologist.

Billbugs are best controlled with insecticides when they are applied when the adults and newly hatched grubs are present. Once the young grubs begin tunneling in the stems, they are very difficult to kill with contact insecticides. In situations, where billbugs are a common problem on zoysiagrass, insecticide applications should be conducted from late May to early June, which may kill adults and young grubs before they become established. Insecticides may also be applied in July to control grubs feeding on the roots. It is important to de-thatch turfgrass, especially those with a thick-thatch layer, so that the treatment will penetrate into the zone where the grubs and adults are located. This will enhance the effectiveness of the application.

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 grub or larva looks similar to a white grub. Grubs are about $\frac{1}{4}$ inch long when mature; the adult beetles are black and $\frac{3}{16}$ 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 from 4 to 6 p.m. on warm afternoons. Females begin laying eggs in late April and continue through May. Clusters of about ten eggs may be laid in thatch or soil immediately beneath the thatch. In June, grubs burrow 1 to 3 inches into the soil while feeding 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 feet have been found in bentgrass. Second generation grubs pupate in September. Adults emerge in October and leave golf greens to locate places to overwinter.

Insecticides are commercially available for controlling or regulating populations of Black Turfgrass Ataenius. For more information, contact your local K-State Research and Extension agent or entomologist.

Turf Insects

Study Questions

- The following is true concerning turfgrass pest management:*
 - most of the insects in turfgrass cause damage
 - healthy turfgrass has no advantage over weak turfgrass when attacked by insects
 - insecticides are the only means to control insects
 - a working knowledge of common pests is important to control them
- What other problems can resemble insect damage to turfgrass:*
 - improper mowing
 - fertilizer burn
 - improper pesticide use
 - all of the above
- To determine if the treatment insecticide application was successful or not is known as:*
 - evaluation
 - prescription
 - application
 - postscription
- The following is true concerning thatch in turfgrass:*
 - it augments the effectiveness of insecticides
 - it is conducive to turfgrass diseases
 - it develops directly beneath the soil surface
 - it can be avoided by using large amounts of fertilizer
- The most destructive turfgrass pest in Kansas is the:*
 - German cockroach
 - bluegrass sod webworm
 - chinch bug
 - fescue rootworm
- How do sod webworms damage turfgrass?*
 - they chew off blades near the soil and expose the crown to sunlight
 - they create sticky webs which kill the turfgrass
 - they burrow in the soil and damage the root systems
 - they vector the deadly dutch turfgrass disease
- When should insecticide applications for sod webworm larvae be considered?*
 - when 2–4 webworms per 10 square feet are detected
 - when 2–4 webworms per 6 square feet are detected
 - when 2–4 webworms per 4 square feet are detected
 - when 2–4 webworms per 1 square foot are detected
- The buffalo grass sod webworm is a pest in:*
 - northern Kansas
 - southern Kansas
 - eastern Kansas
 - western Kansas
- When is damage from the buffalo grass sod webworm more severe?*
 - hot, dry weather
 - cool, dry weather
 - cool, moist weather
 - hot, moist weather

Study Questions

10. *Why is it hard to detect buffalo 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 bug
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 turfgrass 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 insecticides 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 grubs are black and white grubs are white
 - b. billbug grubs have spotted bodies and white grubs are all white
 - c. billbug grubs have no legs and white grubs have 6
 - d. billbug grubs are twice as long as white grubs

Turf Insects

Study Questions

19. *Symptoms of billbug grub 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 grub (*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

For the most effective control, the pesticide selected must be applied uniformly at the recommended, labeled rate. Pests will not be adequately controlled if the pesticide is applied sparsely or if areas are missed. Turfgrass may be injured or excessive residues may remain if pesticides are applied above the label rate.

Some herbicides have a narrow margin of safety between turfgrass injury and weed control. Use properly functioning and accurately calibrated equipment whether it be large power equipment or a small hand applicator.

Calibration means determining the amount of spray volume to apply to a given area under specified conditions. The conditions associated with power sprayers: (1) speed (engine and ground), (2) nozzle type and size, (3) pressure uniformity and (4) equipment maintenance.

Calibrating Field Sprayers

Failure to calibrate a sprayer can injure the plants, create a hazardous situation and is expensive in terms of wasted pesticide. In addition to calibrating sprayers at the start of the season, it is essential to recalibrate routinely. Tests have shown that wettable powders can wear nozzle tips resulting in an increase in the discharge rate after spraying for 10 hours. Also, some new nozzles show a tendency to wear and increase discharge 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 with a soft-bristle brush or toothpick. Don't use a nail or pocket knife to clean sprayers as 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 time how long it takes to fill the jar. Take the mean of the results. Replace any nozzles that vary more than 20 percent from the mean. Nozzles that discharge 20 percent more than the new specifications (provided by the nozzle manufacturer) are likely worn and should

be replaced. Inspect all hoses for leaks and cracks.

When the sprayer is operating properly, it is time to calibrate. Many techniques are used for calibrating a sprayer, but they are all based on determining 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 chemical 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:

$$\text{GPM} = \frac{15}{S}$$

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:

$$\text{MPH} = \frac{120}{T}$$

Where:

MPH = speed in miles per hour

T = number of seconds required to travel 176 feet

Calibration

- Now, determine the application rate using the formula:

Where:

GPA = application rate in gallons

$$\text{MPH} = \frac{\text{GPM} \times 5940}{\text{MPH} \times W}$$

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.

- Divide tank capacity by the gallons per acre determined in step 5. This is the number of acres covered by one spray tank.
- 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:

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

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

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

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

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' X 10" 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.

Calibration of Liquid Sprayers

Calibration of liquid sprayers is relatively easy. When spraying trees or shrubs 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 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/1000 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 1000 sq. ft, so the following conversions may be useful:

dry products—oz/1000 sq. ft =
recommended lb/A × 0.37

liquid products—oz/1000 sq. ft =
recommended qt/A × 0.73

4. Determine the proper amount of pesticide and add it to the water in the spray tank by:

See No. 1, next section

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:

$$\begin{aligned} \text{oz./1000 sq. ft} &= \text{lb/A} \times 0.37 = \\ 4 \times 0.37 &= 1.5 \text{ oz/1000 sq ft} \end{aligned}$$

Then:

See No. 2, next section

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.

$$1. \quad \text{oz pesticide/tank} = \frac{\text{gal/tank} \times \text{oz pesticide/1000 sq. ft}}{\text{gal applied/1000 sq. ft}}$$

$$2. \quad \text{oz pesticide/tank} = \frac{\text{gal/tank} \times \text{oz pesticide/1000 sq. ft}}{\text{gal applied/1000 sq. ft}}$$

$$= \frac{3 \text{ gal} \times 1.5 \text{ oz/1000 sq. ft}}{1.5 \text{ gal/1000 sq. ft}}$$

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

Calibration

Calibration of 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:

$$\text{swath area} = 5 \text{ ft. wide} \times 100 \text{ ft. long} = 500 \text{ sq. ft}$$

$$\text{amount applied} = 1 \text{ lb.}$$

$$\text{application rate} = 1 \text{ lb./}500 \text{ sq. ft}$$

$$\text{or } 2 \text{ lbs./}1000 \text{ sq. ft}$$

or if the recommendation is given in pounds per acre:

Example:

$$\text{swath area} = 5 \text{ ft. wide} \times 100 \text{ ft. long} = 500 \text{ sq. ft.}$$

$$\text{amount applied} = 1 \text{ lb.}$$

$$1 \text{ acre} = 43,560 \text{ sq. ft.}$$

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.

$$\begin{aligned} \text{Acres covered} &= \frac{\text{distance traveled (ft)} \times \text{swath width (ft)}}{43,560 \text{ sq. ft/A}} \\ &= \frac{5 \text{ ft} \times 100 \text{ ft}}{43,560} = 0.011 \text{ A} \end{aligned}$$

Then:

$$\begin{aligned} \text{Application rate} &= \frac{\text{amount used (pounds)}}{\text{Acres covered}} \\ &= \frac{1 \text{ lb.}}{0.011 \text{ A}} = 87 \text{ lbs/A} \end{aligned}$$

Application

Methods of application 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.

Area Measurements

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.

$$\text{Area} = \text{Length} \times \text{Width.}$$

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

$$\text{Area} = 3.14 \times \text{the radius} \times \text{the radius.}$$

Triangle: The area of a triangle is the base (b) multiplied by the height (h), divided by 2 .

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

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:

$$\text{Area A} + \text{B} + \text{C} = \text{Total Area}$$

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.

$$\text{Area} = \text{Length} \times \text{Width.}$$

Example:

$$\text{Length} = \text{line AB}$$

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

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

Example:

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

Weights and Measures

Weights

$$1 \text{ ounce} = 28.35 \text{ grams}$$

$$16 \text{ ounces} = 1 \text{ pound} = 453.59 \text{ grams}$$

$$1 \text{ gallon water} = 8.34 \text{ pounds} = 3.785 \text{ liters} = 3.78 \text{ kilograms}$$

Liquid Measures

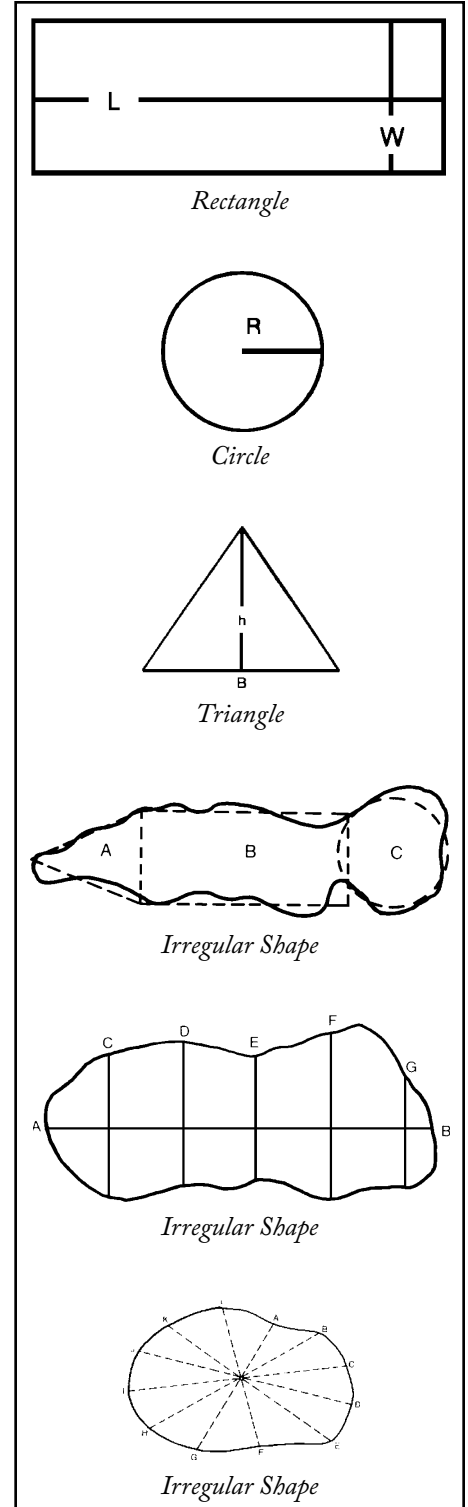
$$1 \text{ fluid ounce} = 2 \text{ tablespoons} = 29.573 \text{ milliliters}$$

$$16 \text{ fluid ounces} = 1 \text{ pint} = 0.473 \text{ liter}$$

$$2 \text{ pints} = 1 \text{ quart} = 0.946 \text{ liter}$$

$$8 \text{ pints} = 4 \text{ quarts} = 1 \text{ gallon} = 3.785 \text{ liters}$$

Calibration



Calibration

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 for personal protective equipment. At a minimum, wear closely woven fabric clothing consisting of a hat, long-sleeved shirt, long legged 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 all of the label on the pesticide container and follow its recommendations and safety precautions.

Check the mechanical condition of the application equipment for tight connections and cleanliness.

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



Striped Skunk



Spotted Skunk

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

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

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

Skunks

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

Skunks may be the least popular of all our wild animals because of the disagreeable musk which they discharge when provoked. Yet, they are very beneficial, more than 1,600 stomach analyses indicated. Nearly half of their natural diet is insects, one-fifth fruit and one-fifth mice. They are particularly destructive of potato beetles, grasshoppers and white grubs.

When a skunk raises its tail, it is a warning. Ordinarily, there is no discharge, but if it believes it is in danger, one discharge will not empty

the reservoir. An effective method to neutralize the odor is to wash everything with ammonia water. Neutroleum alpha mixed 2 ounces to a gallon of water can also be sprayed and is effective in masking skunk odor.

A high nuisance value attributed to skunks is their habit of burrowing in lawns and on golf courses in search of beetle larvae and other insects which constitute a significant portion of their diet. In many instances these skunk activities are charged to moles or gophers and the resulting misdirected control efforts are, of course, fruitless.

Control

Control is best achieved by exclusion, trapping and relocation, or by de or removing the food supply. Because skunks can carry rabies or other serious diseases, they should not be live-trapped and relocated. Animals that appear sick or that are acting abnormally should be avoided. The following symptoms may indicate the presence of rabies or other neurological diseases of mammals: unprovoked aggression, impaired movement, paralysis or lack of coordination, unusually friendly behavior and disorientation. If you see this behavior, avoid the animal and notify your local animal control officer.

To a very limited extent, skunks are considered of value to the fur market when skins are prime. In Kansas, skunks are the primary wildlife carrier of rabies. They may also carry other diseases of importance to humans. Because of the 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. This procedure with individuals or families of skunks is best accomplished with cage traps or solid sided special skunk traps. Other traps that kill or maim may result in serious odor problems.

Vertebrate Pests

Box or cage traps should be baited with a chicken head, dead mouse, or a portion of 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 and, providing the trap is handled with a minimum of jarring or shaking, can be transported to a remote area and released with little concern for possible musk discharge or being bitten by the skunk.

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 soils.

The mole's habits and food are different from pocket gophers as are the methods for their control. Both animals live in the soil, make underground tunnels, and put up earth mounds on the surface.

Moles dig two kinds of tunnels. One is made only an inch or two below the surface of the ground by the mole swimming through the loose topsoil. This kind of runway leaves a ridge of earth on the surface of the ground. More permanent tunnels are made 6 to 10 inches below the surface of the ground and no telltale ridge of earth is left on the surface, but instead mounds of earth are thrown up at intervals. These are likely to be confused with those made by pocket gophers.

Moles vs. Pocket Gophers

Knowledge of how the mounds of moles and gophers are constructed permits a person to distinguish one from the other. From the main tunnel of the mole run, a short shaft extends straight up to the surface. The soil that is expelled from this vertical shaft wells up like water and successive loads form a nearly circular mound on which there may be ripple marks in the form of complete circles. In

contrast, there is a short inclined tunnel to the surface of the main tunnel of the pocket gopher. Through this tunnel, successive loads of soil are pushed out in one direction, each partly on top of the one before, thus 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. If moles make their runways in the rows of plants in the garden, it is because of more moisture, more insect larvae, and earthworms in the rows than between the rows. The moles are looking for insects and earthworms to eat. The real culprits responsible for eating the seeds are mice and other seed-and-plant-eating animals using mole tunnels.

Poisons for Killing Moles

Moles normally cannot be controlled by the use of poisons. The principal diet of the mole consists of insects and earthworms.

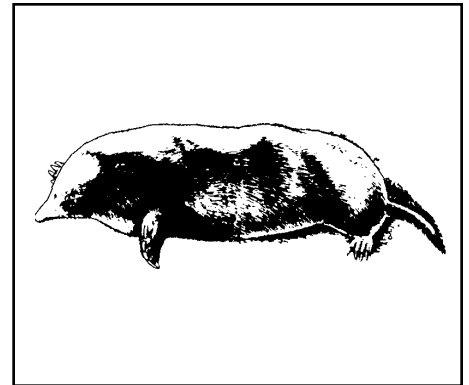
When the use of poisons seems to be effective, the user has probably (1) frightened the mole out of his present runway by the scent or other quality of the poison used or (2) killed the food upon which the mole feeds.

Indirect Control

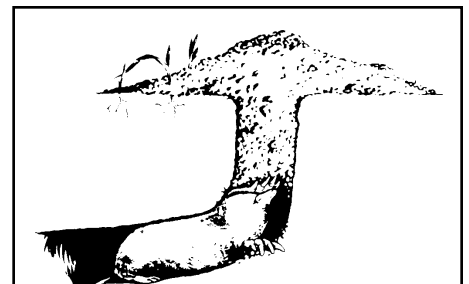
If moles are deprived of their food supply, they will be forced to seek another area. Several insecticides are capable of reducing the population of earthworms and soil insects to a point where the soil no longer provides sufficient food to fulfill the mole's daily requirements. The effect on the moles cannot be expected for several weeks and moles may cause increasing damage as they search in a decreasing food supply.

Trapping Moles

Trapping is the most universally applicable and satisfactory method of mole control, but it is successful only if the habits and instincts of the mole are carefully considered. Two good traps for catching moles in Kansas



Mole



Mole pushing dirt through tunnel onto surface.



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

Vertebrate Pests

are (1) the scissor type and (2) 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 at the roots of some plants and bring soil to the surface killing some plants. In addition, the dirt mounds are a nuisance to mowing.

Pocket gophers have 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 the period of a year will vary from one gopher to another and distances traveled in the search for food. It is estimated that in one year the average gopher transports $2\frac{1}{4}$ tons of soil to the surface! At this rate, seven gophers to an acre could cover the surface to the ground with a layer of loose soil 1 inch deep in 10 years.

Control Methods

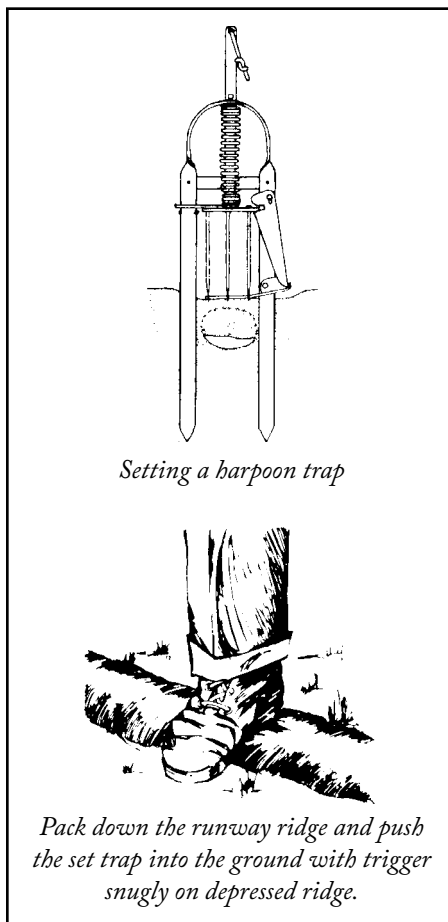
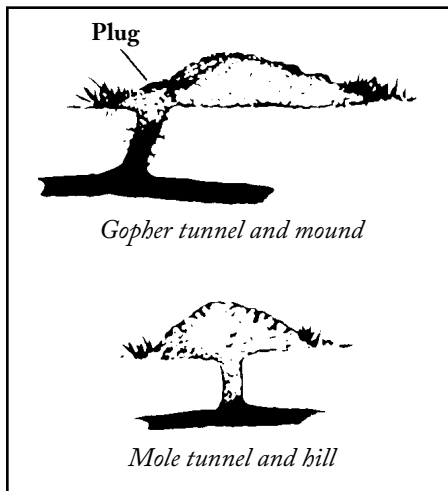
Control operations can best be conducted during the seasons when the pocket gophers are most active near the surface. This usually is indicated by the presence of fresh mounds of dirt. At other times labor and material may be wasted on unoccupied systems of runways.

Trapping

When fresh mounds are found, that is the best time to trap because gophers then are most active in bringing soil up onto the surface of the ground and most easily located. Traps should be set at fresh workings.

Success depends upon 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 $\frac{3}{4}$ -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.



Vertebrate Pests

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.

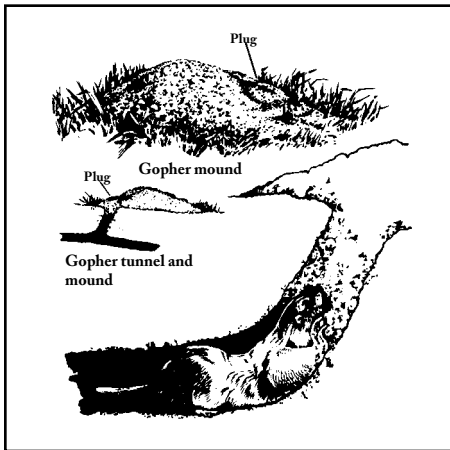
The condition of the soil, principally soil moisture, must be considered before using the burrow builder. Generally, if the soil is damp enough so that a handful can be compressed

and hold its shape, it is suitable for using the machine.

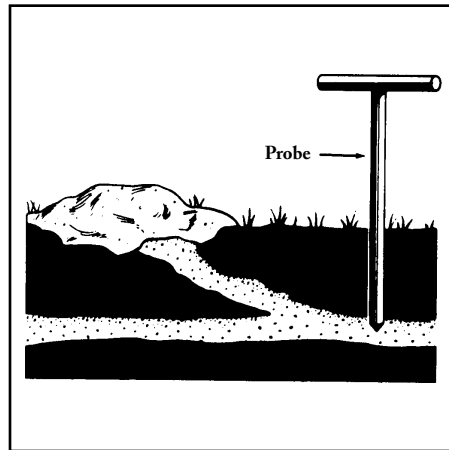
In general, a burrow depth of 10 inches is desirable. The effectiveness of the burrow builder depends upon the gophers finding the artificially constructed runway and using it long enough to find the poisoned bait. To make this possible, the artificial burrows should be constructed at a depth and spaced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

The burrow builder will give good control if it is used properly.

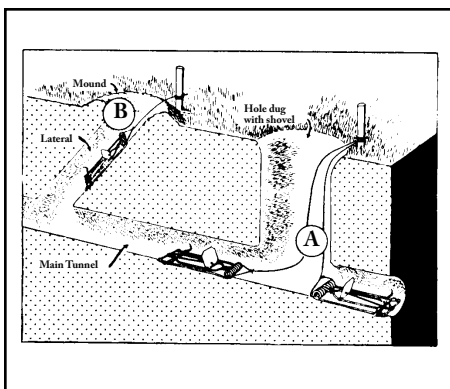
Fumigation is of limited effectiveness. Gopher burrow systems are extensive and portions of them are blocked off by earth plugs, as the gopher occupies various portions at a time.



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



Gopher trapping hole



Gopher trap

Vertebrate Pests

Study Questions

- Which species of skunk is protected by Kansas regulations?*
 - tree skunk
 - striped skunk
 - spotted skunk
 - long-tailed skunk
- The best method for controlling skunks is:*
 - trapping and euthanasia
 - exclusion
 - toxicants
 - they cannot be controlled
- A permanent mole tunnel can be identified by:*
 - a half circular mound of dirt
 - change in turf color
 - a large, flat-topped mound of hard packed dirt
 - a circular mound of dirt
- The best method of mole control is:*
 - poisoning
 - shooting
 - trapping
 - excluding them from the premises
- When is the best time to control pocket gophers?*
 - winter
 - spring
 - summer
 - any season when gophers are most active near the surface
- When using poison grain to control pocket gophers what is the best method of application?*
 - dropping pellets by hand around the burrow opening
 - using a burrow builder
 - aerial application
 - poison grain will not kill pocket gophers
- Fumigation for pocket gophers is of limited use because:*
 - gophers are resistant to fumigants
 - there is no method for getting the fumigants into the burrows
 - there are many burrows and earth blockages that isolate the gophers
 - contamination of the groundwater will always result after the gophers are poisoned

Phytotoxicity

Phytotoxicity is the measure of 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 Issues

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

Environmental Considerations

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 Beyond Period of Control

Persistence is an important part of pest control, since successful pest control requires a knowledge of the persistence period to make subsequent applications. For example, herbicides commonly used for pre-emergence 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 rate of application, soil type or texture, temperature, moisture conditions, rainfall amounts, and other factors. Commercial applicators must be familiar with the persistence of each pesticide which may 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.

Minimize Pesticide Hazards to the Environment

Protecting Groundwater

The potential for contamination of groundwater 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 must often be applied in areas frequently used by humans, as well as pets and other domestic animals. The pesticide applicator must be aware of the 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.

It is important to follow safety precautions in these situations, in order to limit exposure. The applicator should double check to make sure the application is being made to the correct location. 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). Be sure to check neighbor's yards for the presence of children or pets who may come into contact with spray drift. Remove toys, pet food dishes, bird feeders and other items from the application site. Also avoid spraying fish ponds, bird baths, lawn furniture, as pesticide residues on any of these articles can be a hazard. Be sure all clothing is removed 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 excluded during the re-entry period specified on the label.

Earthworms

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. In order to have long-term stability of the turfgrass ecosystem, it is important to preserve earthworms and other beneficial soil invertebrates.

Environmental Considerations

Environmental Considerations

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

Notes

Notes

Answers to Study Questions

Pages 7–16

1. d 2. a 3. c 4. a 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 36–45

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 49–54

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

Pages 56–59

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

Pages 61–63

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

Frannie L. Miller
Extension Pesticide Coordinator

Authors: Appreciation is expressed to the following for preparation of the material in this manual:

Bob Bauernfeind, Entomologist, Horticulture
Raymond Cloyd, Entomologist, Ornamentals
Steve Keeley, Extension Specialist, Turfgrass
Megan Kennelly, Plant Pathologist, Horticulture and Turf
Charles Lee, Extension Specialist, Wildlife Damage Control
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