

Managing Lawns and Turfgrass

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It takes some time and effort to develop a lawn with the right mixture of turfgrass species and varieties for your landscape and situation, but it is worth the investment to achieve results that are attractive, durable and easy to maintain. Important questions to ask are: How will the area be used, and what level of maintenance will it receive? What are your expectations for your yard? What are the different levels of shade in your landscape? What are your climate and soils?

Managing a lawn involves decisions about frequency of mowing, fertilization and watering, and whether you plan to use crabgrass preventers or products to control turfgrass diseases and insects. You will also want to evaluate any historical information you have about disease and insect occurrences. Taking time to consider these factors in advance will help you select the best species or mixture of species for your situation.

Species and cultivar selection

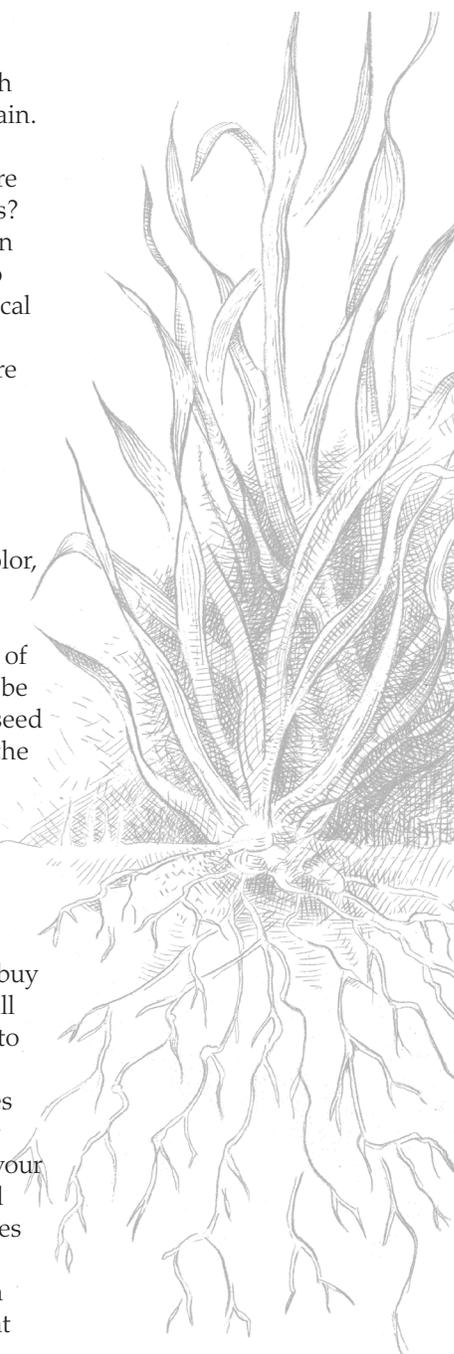
The key to a quality lawn is to select turfgrass species and varieties that will grow best in your region. Finding those varieties that will offer good quality, color, density and disease resistance will make lawn care easier.

The following information on available turfgrass species and varieties will help you select species well adapted for specific situations. There are hundreds of commercially available varieties for most turfgrass species, but not all will ever be available for sale by any single seed company, garden center or nursery. Local seed companies align themselves with specific national seed growers, which limits the number of varieties they sell.

In addition to providing many of the premium seed varieties, seed suppliers can provide useful information for selecting species and varieties that perform best in particular situations. Many of the major seed companies have their own websites that offer information and list contacts and retail sources where you can buy their products. Websites will often sell small quantities, which they will deliver directly to your door, a convenience to consider.

The difficulty can be finding the varieties you read about. One approach to selecting varieties is to list those recommended for your area or with the desired characteristics and then cross-reference your list to the varieties you find available.

Before you buy, read the information on the seed label to make sure you know what you are buying (Figure 1).



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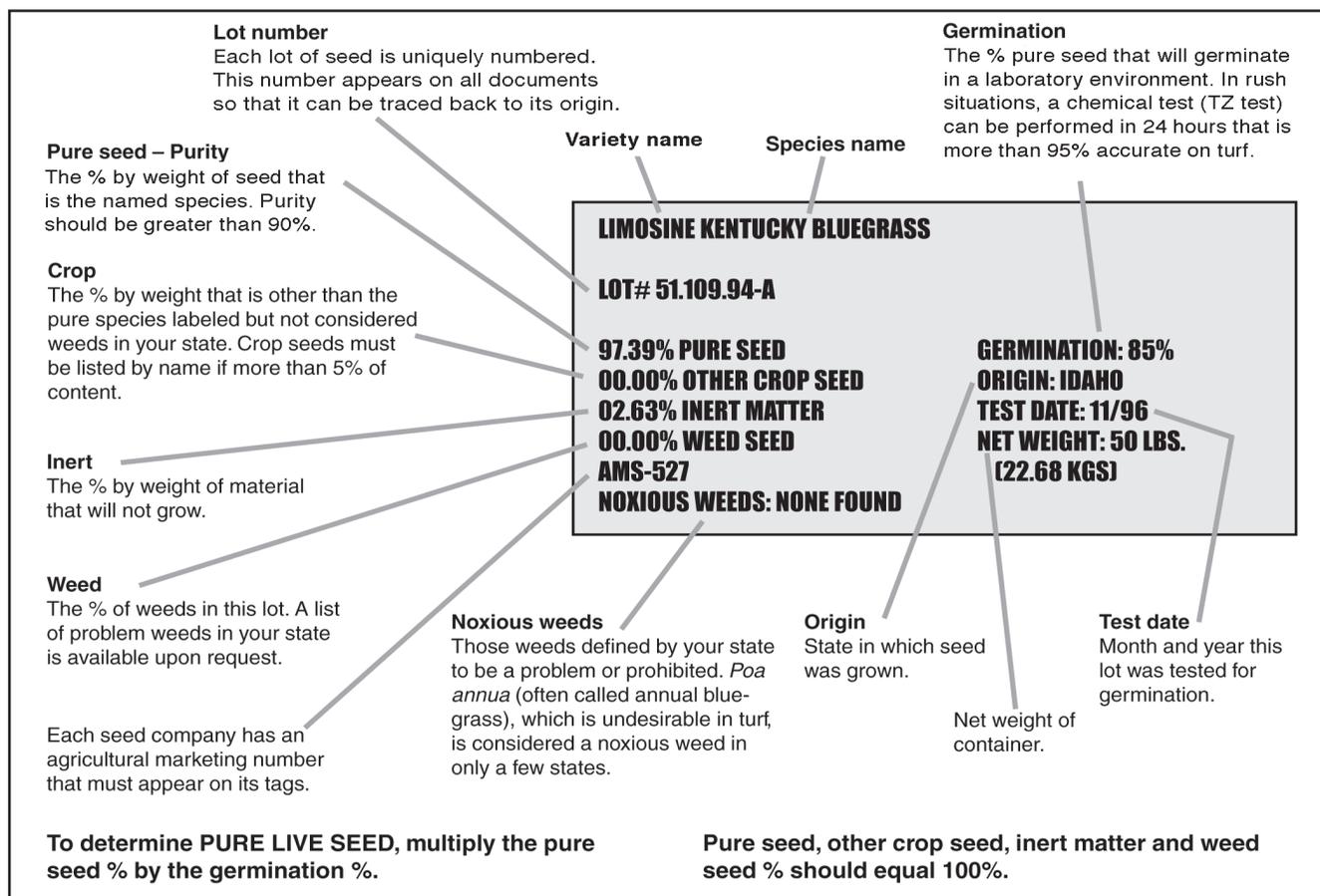


Figure 1. Seed labels.

Seed bags carry a printed tag with important information, including species, variety name, purity, germination, weed seed and noxious weed seed content, and testing date. The species and variety names can be cross-referenced to local recommendations of those that grow best in your area. As long as purity and germination are acceptable, the next vital information is the weed list. The best products will have 0 percent listed for weeds and noxious weeds. Avoid products with large amounts (greater than 0.2 percent) of annual bluegrass (*Poa annua*) and rough bluegrass (*Poa trivialis*); patches of these weeds will decline during the summer, creating unsightly spots in your lawn.

Species and cultivar identification

Turfgrass species can be identified by various plant parts. The primary plant parts used in identification are the leaf blade, leaf tips, collars, ligules, auricles and roots (Figure 2). Knowing the various shapes and sizes of different species and the characteristic presence or absence of key plant parts will help you to identify turfgrass species.

First it is necessary to distinguish between cool-season and warm-season grasses. Plants that have rhizomes (below-soil surface runners) or stolons (surface runners) are warm-season plants. Some cool-season plants (many bluegrasses, a few turf-type fescues) have small rhizomes, but none have stolons. Once a plant is known as a cool-season or warm-season species, further identification can be made.

Cool-season turfgrasses

Cool-season species are characterized as C₃ plants, which means the first product of the photosynthesis process is a compound containing three carbon atoms. Cool-season grasses grow best in the spring and fall when air temperatures range between 60 and 75 degrees F. The best root growth occurs

Cultivated variety

“Cultivar” is a term now used in place of variety. It means “cultivated variety” and differentiates a plant from a botanical, or natural, variety.

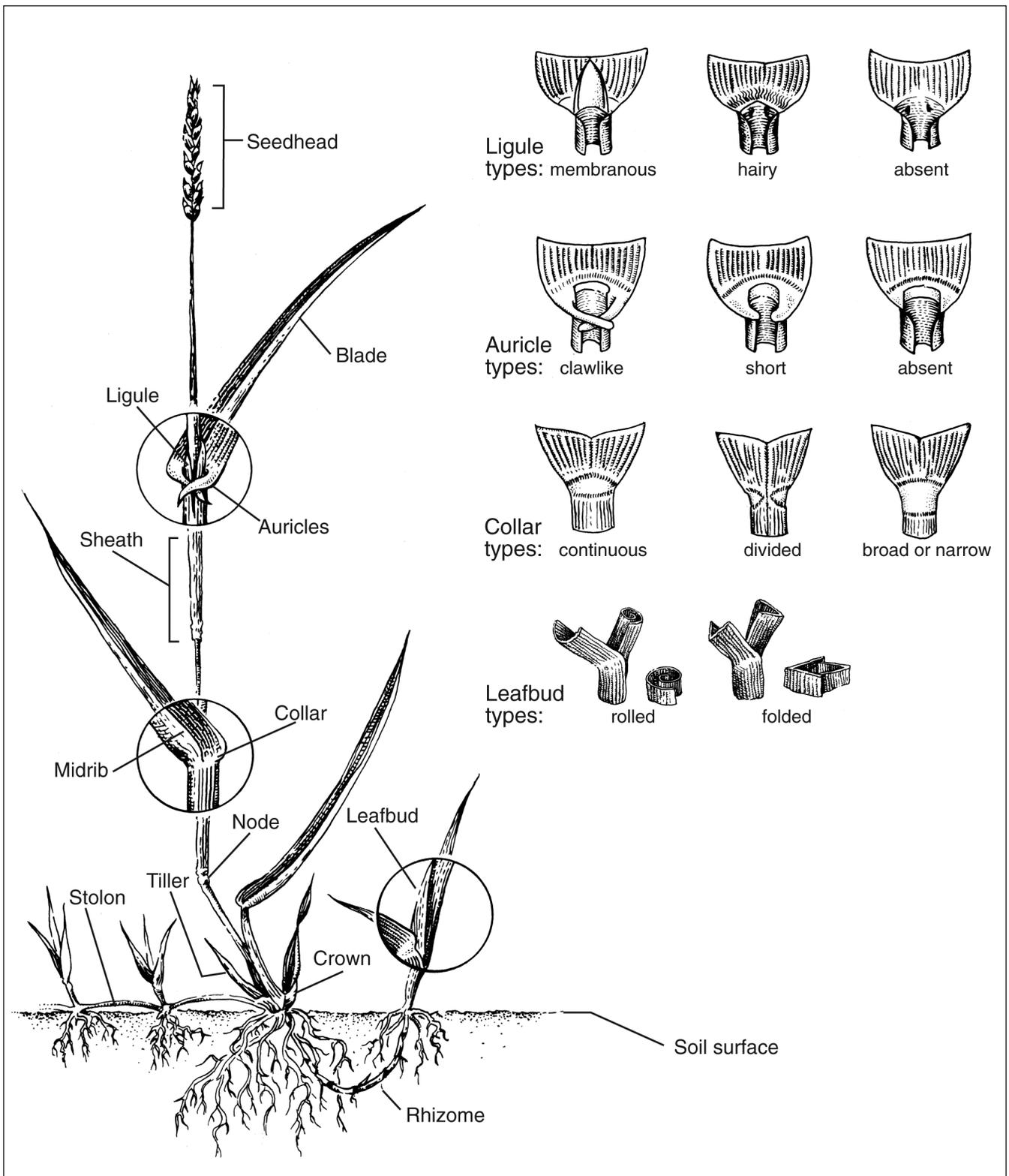


Figure 2. Turfgrass identification.

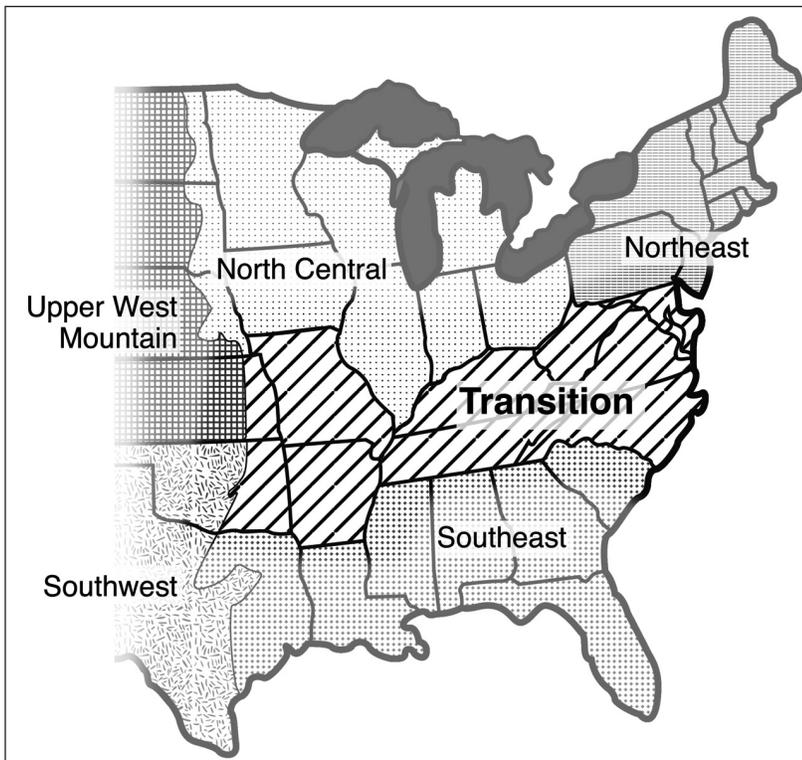


Figure 3. The Transition Zone.

Within this turf management region, neither warm- nor cool-season grass species are completely adapted (from *Turf Management in the Transition Zone* by John Dunn and Kenneth Diesburg).

when soil temperatures range between 50 and 65 degrees F. The growing season for cool-season grasses ranges between the months of March and November; however, these grasses do not grow well in the hot summer months. The cool-season grasses include turf-type tall fescue, Kentucky bluegrass, perennial ryegrass, fine fescue and bentgrass. Bentgrasses are used in high-maintenance golf courses and will not be discussed here.

Turf-type tall fescue (*Festuca arundinacea* Shreb.)

Suggested seeding rate: 7 to 9 lbs. per 1,000 sq. ft.

Mowing height: 3 to 4 inches

1 to 2 mowings per week

Tall fescue has been a favorite for nonirrigated turfgrass in the Transition Zone (Figure 3) since the release of Kentucky 31 in 1943. Tall fescue forms a deep root system in sandy soil or clay and tolerates a wide range of soil pH. It grows well in moderate shade and in open, sunny locations. The species tolerates summer heat and drought better than any other cool-season grass.

Some turf managers prefer to mix tall fescue with Kentucky bluegrass. Such mixtures of two or more compatible species often produce a better-quality turf than a single species because one of the species will

be more resistant to prevailing diseases or other stresses that come over time. For example, research has shown that in some years, diseases such as Rhizoctonia brown patch infects tall fescue without affecting Kentucky bluegrass. At other times, dollar spot severely affects Kentucky bluegrass while tall fescue is resistant.

To mix species, a blend of two or three improved tall fescues combined with a blend of two or three Kentucky bluegrasses is suggested. Use a ratio of 9-to-1 fescue to bluegrass blend by seed volume. Avoid using the more aggressive Kentucky bluegrass cultivars, which may be too competitive with tall fescue.

Seed distributors often sell turf-type tall fescue blends that combine several different tall fescue cultivars. These blends are ideal for home lawn use and are generally less expensive than buying single varieties.

Use of the forage-type tall fescues is not recommended, as this type of tall fescue, although persistent, results in lower lawn quality than turf-type cultivars. Its use should be restricted to roadsides and other low-profile turf sites. If used, the seeding rate should be increased to 10 pounds of seed per 1,000 square feet.

A milestone in the development of tall fescue occurred with the release of Rebel tall fescue in 1979. Rebel's leaf texture was finer, about two-thirds the width of a Kentucky 31 tall fescue leaf. Rebel also spreads more aggressively when producing tillers, which means that only one-third to one-half as much seed is needed to establish turf.

In recent years, numerous turf-type tall fescues have appeared on the commercial seed market. Some are so-called dwarf varieties, with a slower vertical growth rate than other turf-type tall fescue cultivars. Dwarfs often require fewer mowings than some of the other tall fescue cultivars, but they may also be slower to recover from disease and injury.

The availability of many new tall fescue cultivars provides fresh options for cool-season turf in the Transition Zone. Several of these varieties offer resistance to some of the common turf diseases, especially brown patch. Therefore, selecting the more resistant varieties will improve turf quality. The new varieties generally will still require fungicides for the control of brown patch.

Turf-type tall fescues can appear a deep emerald green with a slightly coarser texture than bluegrasses. The sheath of the plant at the crown appears pinkish. Tall fescues can appear clumpy and have severe thinning. The leaves have a rolled vernation with expanded leaves showing prominent evenly spaced veins and rough leaf edges. The sheath is round, smooth and split. Ligules are blunt or absent and may have hairs on the margins. Auricles are indistinct and blunt.

Kentucky bluegrass (*Poa pratensis* L.)

Suggested seeding rate: 2 to 3 lbs. per 1,000 sq. ft.

Mowing height: 2.5 to 3.5 inches

1 to 2 mowings per week

Kentucky bluegrass is well adapted to a moderate climate with average daily summer temperatures below 90 degrees F, soil pH of 6.0 to 7.0, and adequate moisture. Bluegrasses are less drought tolerant than tall fescue. They become increasingly difficult to maintain as summer temperatures approach and exceed 90 degrees F. Careful irrigation is required to maintain quality Kentucky bluegrass turf in hot, dry summers. For these reasons, as recommended in the previous section, mixtures of bluegrass with other grasses such as turf-type tall fescues (10 percent bluegrass, 90 percent fescue) combine the advantages of each species to mask their respective weaknesses.

As a group, the Kentucky bluegrasses adapt best to open, sunny areas in fall and spring. During hot summers, bluegrass often does best in areas that receive afternoon shade. Turfgrass breeders have managed to incorporate a moderate degree of shade tolerance in several newer cultivars, partly because these have improved resistance to powdery mildew.

Unfortunately, most common Kentucky bluegrass types are weakened at some point by unfavorable environmental conditions or diseases such as leaf spot. However, turfgrass breeding programs have developed improved cultivars, such as Merion, named for the Philadelphia golf course where it was discovered. Merion was a big improvement over common Kentucky bluegrass, but in spite of its resistance to leaf spot disease, it is still highly susceptible to other diseases, such as stripe smut and summer patch.

Other bluegrass cultivars, such as Flyking and Pennstar offered further improvements, but vulnerability to summer diseases still discouraged their use in the Transition Zone, especially for high-traffic areas

Turf-type tall fescue

Advantages

- + establishes faster than bluegrass
- + deeply rooted for drought tolerance
- + better wear tolerance
- + few insect problems
- + turf types possess nice texture and color
- + does moderately well in shade
- + may contain endophytes

Disadvantages

- brown patch is generally a problem
- can appear clumpy
- tougher leaf tissue to mow
- may require more frequent mowing

Vernation

Vernation refers to how new leaves are arranged in the shoot. Grass leaves with a folded vernation are V-shaped in the shoot, and those with a rolled vernation are circular.

Kentucky bluegrass

Advantages

- + good sod-forming grass
- + high recovery potential and rate
- + soft, easily mowed leaves
- + high quality (color and density)
- + excellent cold tolerance
- + good drought resistance (can go dormant to survive long period without water)

Disadvantages

- aggressive varieties form thatch
- disease prone (leaf spot, dollar spot, summer patch)
- poor to fair shade tolerance
- more frequent insect problems (grubs and cutworms)
- fair heat tolerance
- higher nitrogen requirement
- may require more frequent irrigation

Endophytes

Endophytes are fungal organisms that live symbiotically within the cells of the grass plant. They create a bitter-tasting toxin that repels most insects and kills many of those that continue to feed. Many cultivars of cool-season grasses contain endophytic fungi, especially tall fescues and perennial ryegrasses. Natural cultivars of bluegrass that contain endophytic fungi have not been found. Endophytes remain in the foliage portion of the plant and do not normally provide protection from root-feeding insects such as white grubs. Endophytes reproduce with the plant and remain active for as long as the plant lives.

and closely mowed golf course fairways, tees and sports fields. Newer cultivars have good resistance to brown patch disease, but they are still susceptible to dollar spot, leaf spot and summer patch, so selecting bluegrass varieties that offer some resistance to these diseases is a practical first step in lawn establishment.

Blends of Kentucky bluegrasses look rich with dark, blue-green colors that make them visually pleasing. Bluegrasses do develop tillers and small rhizomes, which allow bluegrasses to recover better than tall fescues from thinning or other problems. The leaves have a folded vernation, which is smooth on top with a translucent midvein. The leaf tips are boat-shaped and look much like the end of a canoe. The collars are considered medium in height, and the auricles are absent. The ligule is short and blunt. The sheath is round, smooth and split.

Perennial ryegrass (*Lolium perenne* L.)

Suggested seeding rate: 6 to 8 lbs. per 1,000 sq. ft.

Should not be seeded alone

Mowing height: 2.5 to 3.5 inches

1 to 2 mowings per week

Unfortunately, many seed mixtures and blends available to homeowners at local garden centers contain large amounts of ryegrass (both annual and perennial). Though ryegrasses tend to germinate quickly, which can help them establish quickly, they are also susceptible to disease and generally have not been tolerant of high summer temperatures. Current breeding work, using germplasm from southern states, should lead to new cultivars with better summer qualities than those currently available, but until this happens, the best use of perennial ryegrass in the Transition Zone is for sports fields where rapid establishment is needed and funds are available for periodic fungicide use.

Perennial ryegrasses have not been popular in the Transition Zone, where extreme summer temperatures and humidity create an ideal environment for Rhizoctonia brown patch, dollar spot and other warm-weather diseases. Manhattan, Pennfine and several succeeding ryegrass cultivars showed better disease resistance than common types, which usually decline after one or two summers until little remains of the original turf. New generations of perennial ryegrass also offer improved heat tolerance. Most of these ryegrasses are deep-rooted and will recover rapidly from drought stress when soil moisture is replenished and temperatures are moderate.

Manhattan and Pennfine and other ryegrasses have been widely used in seed mixtures with Kentucky bluegrass and other cool-season grasses because of their quick germination and other qualities mentioned earlier. Athletic field managers depend on them for rapid germination (five to 10 days) to fill worn areas in turf cover after games. In lawns, they persist better than most Kentucky bluegrasses on wet, lower pH, infertile soils.

Manhattan-type perennial ryegrasses are characterized by tough leaf tissue consisting of thick-walled cells that helps the ryegrass tolerate traffic but also

makes it tougher to mow. A sharp mower is needed for perennial ryegrass turf to prevent fraying of leaf tips that produces an unsightly brown cast. Pennfine-type perennial ryegrasses have somewhat softer leaves that are easier to mow.

Perennial ryegrasses have deep emerald colors that are attractive, particularly in the spring and fall. Leaf blades have a folded vernation that appears

Perennial ryegrass

Advantages	Disadvantages
+ quick germination and establishment	- poor recuperative ability
+ good wear tolerance	- tougher leaf blade dulls mowers
+ good color and density (spring and fall)	- disease prone
+ does not form thatch	- poor shade tolerance
+ compatible with bluegrass	- poor freezing tolerance
+ may contain endophytes	- high fertility needed
	- poor drought tolerance
	- fair heat tolerance

fine in texture and tapers to a sharp point. The backsides of the leaf blades are glossy, which can lead to a distinct striping effect as sometimes noticed on athletic fields. Collars are distinct and divided. Auricles are small and clawlike. Ligules are small membranous, blunted to pointed structures. The sheath is usually compressed and smooth and appears reddish at the base of plants. Perennial ryegrasses do not produce rhizomes.

Fine leaf fescue (*Festuca* spp.)

Suggested seeding rate: 5 lbs. per 1,000 sq. ft.

Should not be seeded alone

Mowing height: 3 to 4 inches

1 mowing per week

Fine leaf fescues are often used in lawn seed mixtures with Kentucky bluegrass or ryegrasses. Rapid germination allows them to provide early cover that prevents soil erosion and retards weed competition, while Kentucky bluegrass develops at a slower pace. Fine fescues grow best in dry, shady lawn areas that have slightly acid soils, conditions that discourage growth of Kentucky bluegrass. Proper management of fine leaf fescues in a shady environment includes high mowing with little fertilizer and water.

When irrigated, fine leaf fescues will adapt to open, sunny areas in mild coastal climates and to dry southwestern climates. They will not persist in areas where warm, humid summers provide optimal conditions for diseases such as leaf spot, dollar spot, brown patch and summer patch.

Fine leaf fescues have pointed and bristle-like leaf blades that are dark green. Collars are usually narrow, but are broad in Chewings. Auricles are absent. Ligules are membranous and short. The sheaths are usually round, but are flattened in Chewings.

The primary species of fine leaf fescues used for turf are briefly described below.

Chewings fescue is one of the quickest of the fine fescues to establish turf. Its aggressiveness makes it a better companion grass for perennial ryegrass than for Kentucky bluegrass. It adapts to closer mowing than other fine fescues. This grass is moderately susceptible to dollar spot but has better resistance to red thread than other fine leaf fescues.

Slender creeping red fescue spreads by short, fine rhizomes. This fescue establishes rapidly to produce a dense turf but is highly susceptible to red thread disease.

Strong spreading, creeping red fescue produces rhizomes that are coarser than those of the other fine spreading fescues, which may aid in drought tolerance. Leaf texture is somewhat coarser than that of other fine fescues. Spreading fescue is similar in color and compatible in seed mixtures with Kentucky bluegrass. Disadvantages of spreading fescue include intolerance of close mowing and a high susceptibility to disease in warm, humid summers.

Hard fescue adapts to shaded areas but is also adapted to sunny, hot, dry locations with infertile soils. Hard fescues have slower establishment and leaf growth and better tolerance to summer stress than other fine fescues, with Chewings fescue being the second most tolerant. Hard fescue's tolerance of dollar spot and red thread disease is generally best among the fine fescues.

Fine leaf fescue	
Advantages	Disadvantages
+ quick establishment	- poor to moderate wear tolerance
+ very fine leaf texture	- poor to moderate recuperative ability
+ high density	- can develop thatch
+ tolerates low fertility	- difficult to mow
+ tolerates poor soil conditions	- NOT heat tolerant
+ drought resistant	- susceptible to diseases
+ good shade tolerance	
+ good cold tolerance	

Turfgrass information

Many resources are available to help you select turfgrass species and varieties suited for your region and for your own lawn with its unique growing conditions.

Good sources of information include turfgrass specialists, MU Extension publications (a list is provided at the end of this publication), garden centers and websites.

The National Turfgrass Evaluation Program (NTEP) is also a source of good information on selecting varieties. NTEP provides data tables for all turfgrass species based on several characteristics – including quality, density, color, disease resistance and wear resistance – ranked from best to worst, and averaged nationally and by location. See NTEP's website, <http://ntep.org>.

Sheep fescue has a lower rate of vertical growth than either Chewings or hard fescue. Sheep fescue has good tolerance of cold and drought. Some new cultivars have good resistance to red thread and dollar spot.

Warm-season turfgrasses

Warm-season species are characterized as C₄ plants, with the first product of the photosynthesis process being a compound that contains four carbon atoms. Warm-season grasses grow best in the summer, from May through September, when air temperatures range from 80 to 95 degrees F. Best root growth occurs when soil root temperatures are from 75 to 85 degrees F.

Zoysiagrass (*Zoysia japonica* L.)

Suggested seeding rate: 1 to 2 lbs. per 1,000 sq. ft. in late May to late June

Suggested sprigging rate: 8 to 10 bushels per 1,000 sq. ft. in late May to late June

Suggested plugging rate: 2-inch plugs planted on 1-foot centers in late May to late June

Mowing height: 1.5 to 2 inches, best at 1 inch

Taller height, 1 mowing per week; short height, 2 mowings per week

Zoysia japonica originated in the western Pacific area. It is the species to which Meyer zoysiagrass belongs. Meyer has good heat and drought tolerance and is more winter hardy than bermudagrass, the other principal warm-season grass grown in the Midwest. Excellent summer qualities made Meyer a logical choice, in the 1960s, of golf course superintendents, who considered it a good alternative to Kentucky bluegrass for Transition Zone summers.

In addition to its good summer qualities, Meyer's tough leaf tissue is an added advantage for use on high-traffic areas such as golf course fairways and tees. Its mature turf is dense and tends to exclude most weeds. A high-quality lawn can be maintained with 1 to 2 pounds of nitrogen per 1,000 square feet per year. Research plots have been maintained with as little as 1 pound of nitrogen in eight years. Higher annual rates of nitrogen are sometimes used to speed recovery of the slow-growing zoysia from damage. Meyer zoysia is dormant about six months from fall to spring in the Transition Zone. However, many homeowners find the gold-brown color to be compatible with late fall and winter landscapes.

Meyer zoysia lawns and golf course fairways are susceptible to occasional winter injury. Damage is usually confined to poorly drained areas, and corrective measures should be taken to improve soil drainage in those locations. Damage may also occur where close-mowed zoysiagrass turf grows on heavy-clay ridges with exposure to heat and drying winds in summer and severe wind chills in winter.

Another problem, large patch disease of zoysia, appears most often during cooler spring and fall weather. Patches range from a few inches to several feet in diameter and continue to expand in the same location over successive years. An orange band may form on the active border of the patch. *Rhizoctonia* species have been implicated in this disease, which is difficult to control with fungicides.

Fortunately, this disease does not kill the plant's growing points (stems and roots), and zoysia will usually recover and fill-in during active summer growth.

Two important species, *Zoysia tenuifolia* Willd. ex Trin. and *Zoysia matrella* (L.) Merr., with few exceptions, are best adapted south of the Transition Zone. Several improved

seeded-type and vegetative-type zoysias are currently being tested. Presently, Zenith and Companion are two seeded-type zoysias with good winter tolerance

Zoysiagrass

Advantages	Disadvantages
+ excellent heat tolerance	- straw-colored, winter dormancy
+ excellent drought tolerance	- first green-up in late April
+ excellent weed competition	- poor shade tolerance (needs 6–8 hours sun)
+ excellent sod formation	- slow wear recovery
+ low fertility required	- potential winter damage
+ tough leaves, dense growth	- can develop thatch

for establishment in Missouri. They are usually seeded at 1 to 2 pounds per 1,000 square feet

The terminal buds of zoysiagrass are rolled and pointed like a pencil point. The leaf blades are short and pointed with scattered hairs. Leaves extend off the shoot at a 90-degree angle. The collars are indistinct to broad and have hairs at the margins. The auricles are absent, and the ligules have short fringes of hairs. The sheath is round and smooth and has hairs at the top of the split. Zoysia has both rhizomes and stolons.

Bermudagrass (*Cynodon* spp.)

Suggested seeding rate: 1 to 2 lbs. per 1,000 sq. ft. in late May to mid-July

Suggested sprigging rate: 8 to 12 bushels per 1,000 sq. ft. in late May to mid-July

Mowing height: 1.5 to 2 inches, best at 1 inch

Taller height, 1 mowing per week; short height, 2 or 3 mowings per week

Bermudagrass is not recommended for *lawn* turf in the Transition Zone. It is an invasive, aggressive spreader that does not recognize borders. Once established, it is difficult to eradicate. In southern areas of the Transition Zone, many lawns are contaminated with common bermudagrass to the point that eradication is impossible. In such cases, it is easier to fertilize and mow than to attempt control.

Bermudagrass is superior to zoysiagrass in heat and drought tolerance. It requires just a little more fertilizer for optimal growth than zoysiagrass. The big question for its use in the Midwest is winter hardiness. In that respect, it is inferior to zoysiagrass. Turf managers should expect moderate to severe bermudagrass winter injury at least one or two times every 10 years in the Transition Zone. However, because of its aggressiveness, bermudagrass will recover from injury more rapidly than zoysiagrass. Natural enemies of the southern bermudagrasses include nematodes, mites and mole crickets. Unfortunately, there is not much to slow its growth in the Transition Zone.

Despite its drawbacks, bermudagrass has long been popular, especially in the southern United States. Homeowners discovered that bermudagrass would make a good southern lawn grass even if it was coarse and its cold hardiness unpredictable. Early golf course superintendents appreciated its heat and drought tolerance, which meant bermudagrass required little or no irrigation during the summer. Density of the established hybrid bermudagrasses helps to exclude weeds. However, the finest quality turf requires generous fertilization (at least 1 pound of nitrogen per 1,000 square feet per actively growing month), ample water and close, frequent mowing.

Westwood bermudagrass, discovered on a fairway in St. Louis in the 1960s, probably originated as a mutation of an earlier U-3 plant, but with superior cold hardiness. Spring dead spot disease does not seem to be an extensive, recurring problem in Westwood. Westwood has been used on golf courses and athletic fields from southern Indiana and Illinois through the southern half of Missouri.

The bermudagrass cultivars Midway, Midiron, Midlawn and Midfield are all intermediate in cold hardiness and texture, between coarse, cold-hardy Midwestern strains and the finer, less hardy African bermudagrass, *C. transvaalensis*. These early cultivars are not seen much these days. Recently, several cultivars — Yukon, Riviera, Patriot, Northbridge and Latitude 36 — have been released and have gained much ground in the athletic field market.

Bermudagrass	
Advantages	Disadvantages
+ good cold-hardy cultivars	- prone to spring dead spot disease
+ quick growth and recovery	- invasive to flower beds and cool-season turf
+ seeded and vegetative cultivars	- difficult to eradicate
+ excellent fine textures and density	- straw-colored during winter dormancy
+ good dark green color	- can develop thatch
+ excellent sod formation	- poor shade tolerance
+ excellent heat tolerance	- requires high fertility for good quality
+ excellent drought tolerance	

The terminal bud of bermudagrass is mostly folded and flat. The leaf blade is flat and sharply pointed and may have some hairs. Leaves extend off the shoot at a 45-degree angle. The collar is narrow and has hairs on the edge. Auricles are absent, and the ligule contains fringes of hair, like zoysia. The sheath is slightly flat and sometimes hairy. Bermudagrass has both rhizomes and stolons.

Buffalograss (*Buchloe dactyloides* [Nutt.] Engelm.)

Suggested seeding rate: 1 to 3 lbs. per 1,000 sq. ft.

Suggested plugging rate: 2-inch plugs on 1-foot centers

Mowing height: 2.5 to 4 inches

1 mowing every 1 to 2 weeks, depending on use (can be left unmowed)

Buffalograss is known for its endurance in the dry western plains. It is a fine-textured grass that spreads by stolons. It is best used in low-maintenance areas such as golf course roughs, roadsides, parks and low-maintenance lawns. Buffalograss can survive on as little as 1 inch of water during an entire summer. For this reason, it has been a logical choice in the Plains states by turf managers faced with the challenge of maintaining rough areas without irrigation.

Buffalograss grows best in sunny locations where rainfall ranges from about 12 to 24 inches annually, but it will become dormant during extended periods of dry weather. A soil pH of 6.5 to 7.0 is close to optimum, but buffalograss will adapt to alkaline soils where the pH exceeds 8.0.

An unusual characteristic of this species is the occurrence of male and female flowers on separate reproductive stems. Seed heads of male plants grow on stems 6 to 8 inches tall. Seed of female plants are found in burs low in the turfgrass canopy, which makes harvesting seed difficult and raises its cost.

Buffalograss should be seeded (with burs), plugged or sodded in late May to

late June after soils have warmed. Rake burs (each contains three to five seeds) into soil, and then roll to ensure good bur-to-soil contact. Sod and sod pieces should be lightly top-dressed with nitrogen until they are well established. Irrigate seed and sod during establishment to prevent drought stress. Buffalograss is not competitive during establishment, but careful use of herbicides will decrease weed competition and improve the establishment rate. Irrigate only enough to retain green color during droughts. Excessive moisture will encourage weed and disease pressure.

The terminal bud of buffalograss is rolled and has short, pointed and noticeably hairy leaf blades. The collar is broad, the auricles are absent, and the ligule is a fringe of hairs. The sheath is round, smooth and split. The plant is grayish-green and has stolons only.

Lawn and turfgrass fertilization

Soil testing is the starting point of any lawn fertilization program and is recommended each time you establish new seed. A soil test checks the pH level and the availability of macronutrients such as phosphorus (P), potassium (K), calcium (Ca) and magnesium (Mg). After seed establishment, soils should be tested every two or three years to monitor soil pH and nutrient availability.

Buffalograss	
Advantages	Disadvantages
+ excellent heat tolerance	- straw-colored during winter dormancy
+ excellent drought tolerance	- poor to fair shade tolerance
+ excellent cold tolerance	- poor wear tolerance
+ can form sod (requires longer growth and netting)	- slower growing
+ a native species	- poor density, more weeds
+ can be established from seed, plugs or sod	- can have winter annual broadleaf weeds
+ excellent for rough, low-maintenance areas	- off-green color
+ unmowed, 6-8 inch maximum height	

The optimal pH range for growing turfgrasses is 6.0 to 7.0. Most Missouri soils are slightly acidic and in the range of 5.0 to 7.0. A balanced availability of plant nutrients is found in the pH range of 6.0 to 7.0. An even better range for your soil pH is 6.5 to 6.8. You will notice how important pH can be when soils are on the acid side of the scale. Many nutrients are tied up and unavailable to the plant as pH dips to around 5.0 to 5.5. When this happens, turfgrasses look stunted and chlorotic (yellow) and do not respond to additional fertilizer applications. The same holds true for a soil pH greater than 7.5 — nutrient availability declines.

Liming soil with a pH of less than 6.0 will easily and effectively raise soil pH to the desired level. Calcium carbonate (CaCO_3) is the best liming material; it neutralizes hydrogen (H^+) ions in the soil solution and can replace H^+ on the cation exchange sites of the soil. Through this process, the pH of acidic soils is increased into a range more suitable for plant growth. However, liming materials can burn turfgrasses, especially during higher summer temperatures. Lime should be applied during the cooler days of spring and fall. Because it is difficult to get lime into the root zone of a mature turf, the ideal time to add lime is at the time of establishment, when it can be tilled into the soil before the grass is seeded.

Many testing labs will make a recommendation on their soil test report for the proper amount of lime to add, but there is a simple way that you can calculate the amount of lime needed. Take the neutralizable acidity (N.A.) number and multiply it by 25 to equal the number of pounds of lime to add per 1,000 square feet. As a rule, lime should not be applied to actively growing grass in amounts that exceed 50 pounds per 1,000 square feet per application. For a new lawn, it is acceptable to till in the entire amount required.

Use a soil probe or small trowel to sample your soil at a 4-inch depth. Pull 10 to 15 samples randomly from each lawn area. Remove any plant tissue or thatch. Mix these samples in a *plastic* bucket, and then pull a representative 1-pint sample from this to send to the lab. Sample problem areas separately. The University of Missouri Soil and Plant Testing Laboratory will do these tests and give liming and fertilizer recommendations for a small fee. Contact your local extension center to submit a soil sample.

Complete fertilizers

Most fertilizers bought by homeowners contain, in addition to nitrogen (N), varying amount of phosphorus (P, shown on the analysis label as P_2O_5), varying amounts of potassium (K, shown on the analysis label as K_2O) and perhaps iron (Fe) or sulfur (S). The fertilizer composition of these products is usually in a quick-release form, meaning that they release all their nutrients at once, which creates a huge flush of growth followed by a tapering growth decline over two to three weeks. Generally, annual use of these products will not create any problems, but if soil tests are showing high levels of P and K, it is not necessary to add more P and K. In this situation, a good nitrogen fertilizer alone would be sufficient. Using a fertilizer with some amount of controlled-release nitrogen provides slower feeding over six to eight weeks for sustained growth with little stress.

Nitrogen

The goal of nitrogen (N) fertilization is to apply the right amount at the right time to promote consistent growth. Maintaining a darker, longer-lasting color and allowing the turfgrass to recuperate from damage are key to a healthy lawn. Nitrogen fertilizer does make grass grow and is directly related to how often a lawn should be mowed — another factor in the fertilizer equation.

Feed turfgrasses when they are actively growing (Table 1). Cool-season grasses should be fed primarily in the fall, with some fertilizer applications made in spring. Many spring applications are applied with a form of fertilizer that also contains preemergent herbicides (crabgrass preventers) to control annual grassy weeds. Warm-season grasses should be fed after initial green-up in the spring.

Cation exchange capacity

Cation exchange capacity (CEC) is the total capacity of the soil to hold positive cations, such as H^+ , to soil particles that are negatively charged. This soil property affects soil pH and nutrient availability, among other characteristics.

They can be given N fertilizer during each month of active growth (May through August for nitrogen only, with potassium applications in September).

Late-season nitrogen fertilization of cool-season grasses, sometimes referred to as late-fall fertilization, has been used by turf managers for years. This type of fertility program involves applying much of the season's nitrogen during the late-season months of August through October or November (depending on location). Late-season fertilization should not be confused with dormant or winter fertilization. With winter fertilization, fertilizer is applied after the turf has lost most of its color during late fall or winter and is not actively growing. This differs notably from the late-season method, which requires that nitrogen be applied before the turf loses its green color in the fall. Late-season fertilization has become popular because of agronomic and aesthetic advantages that include better fall and winter color; earlier spring green-up; increased shoot density; improved root growth in the fall, winter and spring; and enhanced storage of energy reserves (carbohydrates) within the plant.

The nitrogen source used for fall application should be a type that does not depend heavily on microbial activity to cause the nitrogen to release. This means that fertilizers containing urea, sulfur-coated urea (SCU), IBDU, shorter-chain methylene ureas and ammonium sulfate are ideal N sources for late-season applications. Although SCU and IBDU are referred to as controlled-release fertilizers, the rate at which nitrogen is released from these fertilizers mainly depends on soil moisture, not on the degree of microbial activity. The use of microbe-dependent N sources for late-season applications may not elicit the desired fall/winter color response because they do not provide enough available nitrogen for plant uptake in low temperatures. However, these slow-release N sources would be ideal for spring and summer use. Examples of these would be natural organic nitrogen sources and fertilizers consisting mostly of longer-chain methylene-ureas (low in cold-water-soluble N). Research has shown that natural organic fertilizers — such as Bradfield, Milorganite, Sustane, Ringer, Nature's and Luscious Lawn — perform well in home lawn fertilization programs. A product such as Luscious Lawn, a corn gluten-based fertilizer, can also provide some preemergent activity for control of annual grass and broadleaf weeds.

Calculating how much fertilizer to apply

The first of the three numbers on a fertilizer bag is the percentage of nitrogen (by weight), the second is the percentage of P_2O_5 (not actual P), and the third is the percentage of K_2O (not actual K).

The percentage of nitrogen refers to the concentration of nitrogen in the fertilizer source. Natural organic sources are typically low in nitrogen concentration, while synthetic nitrogen sources are higher. Knowledge of this number allows you to calculate how much fertilizer to apply based on specific rates of nitrogen being applied per 1,000 square feet. For example, if you want to apply 1 pound of nitrogen per 1,000 square feet of lawn area, you must apply Ringers organic fertilizer (9 percent N) at a rate of 11 pounds of fertilizer per 1,000 square feet (the result of $1 \div 0.09$). Knowing the basis for this simple calculation allows you to apply the proper amount of nitrogen per 1,000 square feet regardless of the type of fertilizer or the nitrogen type.

Example

- Apply 1 pound of nitrogen (N) per 1,000 square feet with a 24-4-12 fertilizer.
- Take 1 pound of N divided by the percentage of N in the product, which will equal the pounds of fertilizer to apply per 1,000 square feet.

$$\frac{1 \text{ lb. of nitrogen needed}}{0.24 (\%)} = 4.16 \text{ lbs. of fertilizer per 1,000 sq. ft.}$$

In the same way, fertilizer applications can be calculated based on the amount of phosphorus (P) or potassium (K) needed per 1,000 square feet. Divide the number of pounds you need per 1,000 square feet by the percentage of P or K (decimal form) to equal pounds of fertilizer required per 1,000 square feet.

Table 1. Nitrogen application scheduling¹.

	September	October	November	March to April ²
Standard cool-season	1.0	1.0	1.0	0.5–1.0
Low-maintenance cool-season	1.0		1.0	0.5–1.0
	May	June	July	August
Standard warm-season	0.50	0.50	0.50	0.50
Low-maintenance warm-season	0.50		0.50	

Notes:

1. All rates are in pounds of nitrogen (N) per 1,000 square feet.
2. The spring application may be made with a combination crabgrass preventer.

Phosphorus

Phosphorus (P) is a major component for energy transfer in plants. It is also required for good seedling growth and development, which makes it vitally important during establishment of new seed. Phosphorus also promotes good root development. Adequate levels of P on a soil test report would be around 25 to 35 pounds per acre. Soil test recommendations for phosphorus are based on P_2O_5 (the form in a fertilizer product).

Do not apply more than 2.5 pounds of P per 1,000 square feet to established lawns at one time. To calculate the actual amount of phosphorus in P_2O_5 , multiply the amount of fertilizer

needed by 0.44. There are several good sources of P fertilizers, including super phosphate (0-18-0), triple superphosphate (0-45-0), monoammonium phosphate (11-48-0) and diammonium phosphate (18-46-0).

Potassium

Potassium (K) is another major component for plant growth. It enhances root growth, enhances disease resistance, improves heat tolerance, improves drought tolerance and increases cold tolerance. Adequate levels of K would be between 200 and 400 pounds per acre. Soil test recommendations for potassium are based on its form as K_2O .

Do not apply more than 1.5 pounds of K per 1,000 square feet to established lawns at one time. To calculate the actual amount of potassium in K_2O , multiply the amount of fertilizer needed by 0.83. Potassium sulfate (0-0-50), often referred to as SOP, is an excellent source.

Winterizer fertilizers

Fertilizers with higher percentages of potassium or phosphorus, in addition to nitrogen, are often called “winterizer” fertilizers. Equal percentages of nitrogen

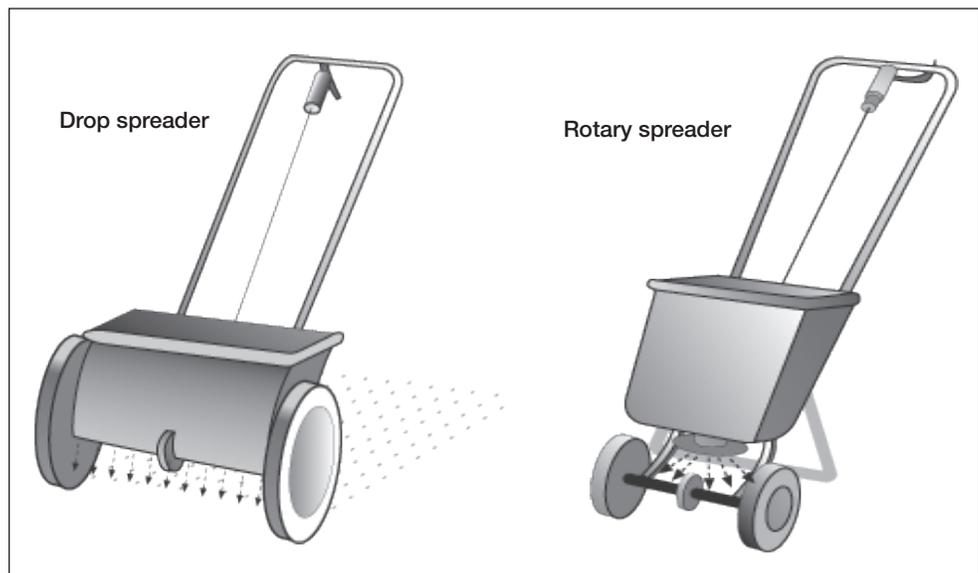


Figure 4. Fertilizer spreaders.

Drop spreaders and rotary spreaders are two common types of fertilizer spreaders that are practical for home lawn use.

and potassium equal are preferred, but are often hard to find unless you buy a commercial-grade fertilizer.

Potassium enhances cold hardiness in turfgrasses by helping plants to “harden off,” that is, to release excess water from their cells in preparation for winter. Water expands when frozen, causing plant cells to burst under high water content or succulent growth. Hardening off is not as important with cool-season grasses, but it is vital with warm-season grasses, such as zoysiagrass and bermudagrass.

Warm-season grasses should not receive nitrogen applications into the fall. Final applications of nitrogen for warm-season grasses should be made in late August. While zoysiagrass and bermudagrass are still growing in September, applications of potassium during the month will help these grasses harden off for the coming winter months and increase winter survival. One or two applications of 1 pound of potassium per 1,000 square feet can be applied during the month of September on a 14- to 21-day interval. If soil test reports indicate high to very high potassium levels, additional potassium from a winterizer is not needed.

Lawn establishment and renovation

Establishment of turfgrass brings beauty to any landscape. When preparing an area for turf, do not hurry the process. Mistakes made at this time will be evident later and will cost extra in time and labor. A beautiful turf depends on many factors, including initial soil preparation.

Fall seeding of cool-season turfgrasses

Summer heat and humidity through July and August causes many people to wonder why to even try to maintain cool-season grasses, such as Kentucky bluegrass and turf-type tall fescue, in home lawns. Yet even in a difficult year, the beauty of cool-season grasses can inspire the annual rituals of renovation and overseeding. Turfgrass brings beauty and value to any landscape, and the success of a beautiful turf depends on many factors.

Late summer or early fall is the optimal time to establish cool-season turfgrasses. Labor Day weekend is usually an excellent time to start seeding preparations. Successful turfgrass establishment takes several steps.

First, perform a soil fertility test to get fertilizer recommendations. Knowing which nutrients are sufficient in the soil and which ones are needed will determine optimal fertilizer needs. The pH of the soil is also important to know. A pH range of 6.5 to 6.8 is excellent for turf establishment. A pH range of 6 to 7 is acceptable. Any lime requirements to raise pH will be specified on the soil test results. Having this information before seeding can save you time and money when trying to establish turfgrasses. Starter fertilizers (for example, 10-24-18, 6-24-24, 13-13-13) are usually recommended at a rate of 0.5 pound of nitrogen per 1,000 square feet at time of seeding, but again this depends on soil test results.

Preparation of the site includes the removal of any debris, such as rocks, and a visual inspection to make sure the grade or slope of the landscape will provide adequate surface drainage. Holes from rock removal and low water-holding pockets need to be filled in to ensure proper drainage. Poorly drained areas are detrimental to maintaining healthy turf. Site preparation should also include broadleaf weed control if infestations are high. Perennial broadleaf weeds, such as dandelion and plantain, should be controlled at this time of year. Trimec, Weed-B-Gon or Weed-B-Gone MAX are excellent over-the-counter products available to homeowners. Labels for these products usually recommend a three-week interval between spraying and seeding; therefore, start early if you first need to control broadleaf weeds.

If you choose to renovate your lawn to a different turf species (such as bluegrass to fescue, or vice versa) or you just wish to start over, an application of a nonselective herbicide (Roundup, Finale or an equivalent product) is needed to kill the old turf and any weeds. Start earlier in August when taking out an old

lawn to give more time for the products to work. Always try to time your actual seeding for Labor Day weekend or the first week of September. Nonselective herbicides can be bought at any home-and-garden center; be sure to follow the application instructions on the label. In seven to 10 days, a second application may be necessary to control any areas missed in the first application. If your old lawn is totally brown, then soil preparation and reseeding can take place seven days after the final herbicide application.

If your lawn only requires overseeding to fill in thinned areas or small spots from summer disease or drought, then a nonselective herbicide is not required, and seeding can proceed.

When seeding, good seed-to-soil contact improves germination. If you choose to renovate with a nonselective herbicide, you have the option to till the soil and create a fine seedbed. After seeding, cover the tilled soil with straw at a rate of one bale per 1,000 square feet to prevent erosion. The best method of planting seed is with a slit-seeder, a piece of equipment that plants the seed about ¼ inch deep. This method allows for better seed germination and reduces the chance that seed will wash away in a heavy rain. Other methods to ensure good seed-soil contact include using a power rake or vertical slicer. Either of these will work up the top half-inch of soil and can be used for complete or partial renovations. Such equipment can usually be rented at a local rental or hardware store for a small fee.

Seeding rates for Kentucky bluegrass should be about 2 to 3 pounds per 1,000 square feet. Turf-type tall fescues can be seeded at about 7 to 9 pounds per 1,000 square feet. Seed applications following tillage, power raking or vertical slicing should be raked in lightly to help cover the seed with soil at a shallow depth (about ¼ inch). To improve seed distribution and stand density, seed half rates of seed in two directions.

The final step to a successful lawn renovation is proper watering. The first two weeks following seeding are the most crucial. Until seeds germinate and start to put down roots, they can easily wash away. You should keep the soil surface moist, not wet. Do not let the seed dry out once it starts to germinate. On warm, windy days with lower humidity, keeping the surface moist may require several light waterings a day. Always avoid puddles and runoff.

In a successful renovation, seedling turfgrass should be up and growing in 10 to 14 days. If you renovate in the first half of September, you will be mowing your new lawn once or twice in late fall. One month after you notice new seedlings, apply additional fertilizer; use a good complete fertilizer, such as 24-4-12, at a rate of 1 pound of nitrogen per 1,000 square feet. Recommended fall seeding programs for cool-season grasses can start Labor Day weekend, with seeding still possible until Oct. 15.

Early spring seeding of turfgrasses

Spring seeding techniques vary depending on which month your spring seeding occurs. The old remedy of seeding before a snowfall does have some credibility if done at the right time of late winter or early spring. This procedure will work from late January through February if there is an excellent chance of getting the seed down to the soil surface. Melting snow will mud-in the seed just enough to achieve germination. Although this is not usually the best procedure, germination rates should be high enough to improve a thinned stand of turfgrass.

A second option is to broadcast seed (at a half rate in two directions) on mostly bare soil that may have been tilled or loosened the previous fall. This broadcasting can be done through February when weather conditions are still likely to include a series of freezing and thawing periods. Freezing and thawing of bare soil develops small ice-forming peaks and ridges in the soil surface that create cracks and crevices into which the seed can fall and eventually be covered with soil. This type of seeding has good germination rates. It also allows seed to establish early, which offers some competition against summer annual grasses and broadleaves.

General steps to establish turfgrass

1. Obtain a soil fertility test and fertilizer recommendations.
2. Rough grade.
3. Apply lime if needed.
4. Apply fertilizer as recommended by soil test.
5. Apply organic amendments if needed.
6. Till materials listed above into top 4 to 6 inches of soil.
7. Perform finish grading.
8. Apply starter fertilizer and work into top inch of soil.
9. Apply seed.
10. Rake or drag to lightly cover seed.
11. Roll lightly.
12. Mulch.
13. Water.
14. Mow.
15. Control weeds.

Normal spring seeding practices after the final thaw can involve two procedures. The first includes complete tillage of the area being seeded. This requires drier conditions to work the soil. Overseeding on freshly tilled, graded soil offers a perfect seedbed and only requires minor raking or dragging to work the seed into the soil. With this procedure, germination rates should be as high as the seed label specifies. Straw will be needed to help hold the soil and serve as a little mulch until germination begins. One bale of straw per 1,000 square feet is recommended on freshly tilled soil.

If you want to avoid the need for complete tillage in spring, another spring seeding option is to use a power seeder or slit-seeder. These seeders can be used for complete renovation jobs or for partial renovations on thinned out areas of your lawn. They plant seed into a powdery seedbed or into shallow furrows on 3-inch centers. They should achieve good seed-to-soil contact, which is the most effective way to get complete seed germination. These procedures generally do not require the use of straw.

Keep in mind that spring seeding will not allow the use of many preemergent herbicides (crabgrass preventers) for annual grass control; however, two are available. Tupersan (siduron) can be applied at any time seed is planted, but it is best with applications during the last week of March through the first two weeks of April. It is the only preemergent herbicide to control annual grassy weeds that can be applied the same day as seeding.

Dimension (dithiopyr) can be used for annual grass control (crabgrass, foxtails, etc.) after a new stand of grass has had two mowings. Grass seed planted early (March 1) could possibly receive two mowings by mid-April, thus allowing for an application of Dimension at that time. Many other preemergent products require the grass to be well established before their use. Both Tupersan and Dimension need to be watered in with $\frac{1}{4}$ to $\frac{1}{2}$ inch of water.

For grass seed germination, water conservatively if periodic spring rains keep the soil moist. The first two weeks are the most crucial. Always prevent puddles and runoff. Watering can be reduced once the seed begins to germinate and root.

Sodding cool-season turfgrasses

The soil should be prepared as indicated above: rocks and debris removed, desirable grade, and powdery on the surface. Before laying the sod, apply a good starter fertilizer, such as 10-24-18, at a rate of 1 pound of nitrogen per 1,000 square feet. Soil should be slightly moist when sod is laid. Irrigate the newly sodded lawn heavily on the first watering to soak through the sod and wet the top 1 to 2 inches of the soil. You can easily check the depth by pulling back a piece of sod and observing. Water often enough to keep the sod moist — do not keep the sod and soil saturated. You should be able to walk on the sod without sinking in or making footprints. Sod transplanted to a well-prepared soil should begin to knit horizontally with adjacent pieces and root down within one to two weeks. The timing depends on the thickness of the sod and weather conditions. Overwatering and underwatering are usually the primary reasons for sod failure.

Establishing warm-season turfgrasses

Many improved varieties of zoysia, bermuda and buffalograss are now available as seed. Seeding rates should range from 1 to 2 pounds per 1,000 square feet for zoysia and bermuda, and 1 to 3 pounds per 1,000 square feet for buffalograss.

Warm-season grasses can be established from sprigs, which are pieces of torn sod that usually contain stolons with up to four nodes. Sprigs can be planted by broadcasting them over loose soil and then lightly disking or tilling to partially cover them with soil. A portion of each sprig should remain exposed after planting. Mechanical spriggers are available, by contract, from sod installers. The sprigger slits the soil open, plants the sprig and covers the sprig with a small amount of soil. In either case, the sprig should produce roots and creeping stolons from each planted node. Sprigs can be bought as sod and then shredded, or often

can be bought by the bushel. One square yard of sod makes one bushel of sprigs. Plant eight to 10 bushels of sprigs evenly distributed per 1,000 square feet.

You can also use plugs to establish warm-season grasses. Plugs are usually 1 to 2 inches in diameter with 1 to 2 inches of soil attached. They should be fitted tightly into prepared holes and tamped firmly into place. Plugs are generally placed 6 to 12 inches apart. This spacing will usually allow fill-in within one growing season if planted by June 1.

Managing thatch and compaction

Thatch is a tight, brown, spongy organic layer of both living and dead grass, roots and stems that accumulate above the soil surface. Interactions between environmental and soil conditions and management practices (turf species, fertilization, mowing and irrigation), influence the rate and extent of thatch accumulation. Thatch tends to be a problem in Kentucky bluegrass, fine fescues and zoysiagrass lawns. Thatch is rarely a problem in tall fescue. Grass clippings do not contribute to thatch accumulation and should be returned to the lawn during mowing to recycle the nutrients contained in them.

Take steps to slow thatch accumulation when the thatch layer (easily measured by removing a small plug of turf that includes a portion of the underlying soil) is thicker than ½ inch. The thickness of the thatch layer can increase quickly beyond this point, which makes it more difficult to control later. As the thatch layer thickens, it becomes the main rooting-medium for the grass. Rooting in thatch predisposes turf to drought stress and winter injury and increases the possibility of weed, disease and insect problems. Also, fertilizers and other lawn-care products applied to a thatch layer work less efficiently.

Power raking and dethatching

Power raking is a method of thatch removal that has been used for years. Light, or shallow, power raking can be beneficial if done often enough. However, deep power raking of a very thatchy lawn can be damaging, and the practice often removes a substantial portion of living tissue. Used properly, power raking of wet, matted turf can help to speed spring green-up of turf by encouraging air movement into the root zone and enhancing turf warming. Dethatching in the spring should be completed before applying preemergence herbicides for annual grass control in cool-season grasses. September is a better time to dethatch cool-season grasses. Warm-season grasses should be dethatched when grasses are actively growing in late May to early June. Before using it as mulch or soil amendment, compost the thatch and organic material gathered after power raking to kill any living plants or weed seed that might be present in it.

Core cultivation

Core cultivation, or aerating, is the recommended technique to manage thatch. It is more beneficial than power raking because it helps improve the root zone by relieving soil compaction while also helping to control thatch accumulation. Soil compaction, in fact, is one of the contributing factors to thatch accumulation. Core aeration also allows air, water and nutrients to more efficiently enter the root zone. Plugs of thatch and soil 2 to 3 inches long (longer is better) are removed by the aerating machine and deposited on the lawn surface. A single aeration using a machine equipped with half-inch tines on 2-inch centers will remove about 10 percent of the thatch from a lawn in one pass.

Methods to deal with the cores left on the lawn vary. The best method is to break up the plugs and work the soil back into the canopy or thatch layer of the sod. However, rainfall and time will disintegrate the plugs. Depending on the soil type, core disintegration may take only a few days or several weeks. The mingling of soil and thatch that results hastens the decomposition of the remaining thatch due to microbial activity. The little tufts of thatch and turf can also be collected and composted. Irrigation helps to wash the soil from the cores, and dragging

Preparation to establish warm-season turfgrass

1. Control any existing weeds (broadleaves and grasses) early in the spring, especially if a broadleaf herbicide is needed for perennial broadleaf weeds. Three to four weeks is required between applying a broadleaf herbicide and planting warm-season grasses. Nonselective herbicides can be used closer to planting (at least seven days). If desirable grasses exist, use of a nonselective herbicide is not recommended. Newly emerging crabgrass can be controlled with MSMA, 14 days before planting.
2. Time warm-season grass planting for early June to optimize air and soil temperatures. Warm-season grasses can be seeded, sprigged or plugged until July 15. Sod can be laid until Aug. 1.
3. Remove all rocks and debris, fill in holes and set grade to desired elevations.
4. Add lime, if needed, and fertilize with 1 pound of nitrogen per 1,000 square feet using a good starter fertilizer (for example, 10-24-18). Apply before any tillage.
5. Loosen hard soils and prepare a seedbed by intensively coring, spiking or slicing the surface. Light rototilling may be desirable if establishing a new lawn.
6. Plant seed, sprigs, plugs or sod of desired warm-season grass. Zoysiagrass seed requires light to germinate, so **do not cover** with soil. Press the seed into the soil surface with a light roller.
7. Water frequently to encourage germination and rapid coverage. Keep moist, but prevent puddles and runoff.
8. Begin mowing as soon as possible (usually around 1.5 inches) to force horizontal growth.

Note: Ronstar (oxadiazon) is the **ONLY** preemergent herbicide that can be applied to bermudagrass **sprigs** for crabgrass control.

with pieces of chain-link fencing or an old metal doormat can speed the process. Running over the cores with a power rake or dethatcher also does a good job of breaking cores. Running over the cores with a rotary mower can be effective but will quickly dull the blades.

Core aeration can be done in spring and fall for cool-season grasses. It is usually done in June for warm-season grasses.

Proper mowing key to healthy lawns

Turfgrass plants mowed shorter than their optimal height of cut are generally under more stress and are more susceptible to weeds, diseases and insects. Optimal cutting heights for cool-season grasses, such as blends of turf-type tall fescues, should range from 3 to 4 inches. For warm-season grasses, such as zoysia, they should range from 2 to 3 inches.

The current recommendation is to select the tallest acceptable mowing height for your species of grass and maintain that height during the entire season. This provides benefits throughout the season — competition against weeds as well as reduced summer stress. However, seasonal variation in mowing height was once thought to be highly beneficial, and some people still hold this view. Mowing cool-season grasses a little taller in summer months can provide the benefits of deeper roots and better cooling effect through summer stress periods. Taller grasses will conserve moisture, which reduces irrigation requirements. Cool-season grasses mowed a little taller in the spring and fall also compete more successfully against weeds, providing up to 80 percent control of annual weeds.

Mowing creates wounds through which fungi can enter and infect plants. Leaf cuts made by a sharp mower blade are cleaner and heal faster than the tearing and shredding caused by a dull mower blade. A dull mower blade inflicts more and bigger wounds that increase potential for infection from diseases. Observe leaf tips in the lawn or grass clippings collected on your mower deck immediately after a mowing to see the quality of cut. Use this as an indicator of when to sharpen mower blades. Having a spare, sharp mower blade allows you to switch blades when needed and prevents delays in mowing when a mower blade needs to be sharpened.

During hot summer months, it is best to mow later in the day to minimize additional stresses on your grass. It is also best to change direction of mowing each time you mow.

To determine how often to mow, use the one-third rule of mowing: Remove no more than one-third of the leaf growth during a single mowing. During the spring and fall, cool-season grasses can be mowed every five to six days when properly fertilized.

A word of caution about using weed trimmers. Rotary line trimmers typically scalp turfgrasses when edging along sidewalks, curbs and driveways. This scalping actually *promotes* weeds. Best edging practices include using a power edger or line trimmer (rotated) with a vertical steel blade to prevent scalping turfgrasses.

When to bag clippings

- When rain delays mowing.
- When you want to make compost (avoid using chemically treated grass clippings in compost).
- When preparing for aeration and overseeding in late summer to early fall.

Handling clippings

Clippings should be uniformly distributed rather than deposited in clumps. Mowing the lawn when the grass is dry and using a properly sharpened mower blade will spread clippings evenly. If some areas produce excess clippings, simply mulch those in with a second pass of the mower.

Many homeowners believe grass clippings need to be removed for a healthy, vigorous lawn, but removal is not usually recommended. By following the steps in the “Don’t Bag It” lawn care program (see box on this page), you can have a beautiful lawn without collecting the grass clippings. Returning them to the soil can greatly enhance fertility (providing as much as 30 percent of the nitrogen and 50 percent of the potassium needed annually). Grass clippings also contribute

to the organic matter levels of your soil, which improves the soil's water- and nutrient-holding capacity.

Irrigation

As much as 80 percent of the water used around a home during the summer is for outside uses. Watering the lawn is usually the main outside water use. During dry summers, local water authorities may cut off water for outside use or only allow watering on certain days; such measures may be necessary and effective to reduce water consumption and relieve the strain on water supplies. To avoid severe loss of turf and to be prepared to conserve water if necessary, manage your lawn each year in anticipation of water restrictions.

This section describes cultural practices that will reduce the need to irrigate your lawn, while still improving its appearance and its competitiveness.

Read your lawn to know when to water

Purple-blue wilting leaves or leaves that are folded or rolled lengthwise along the blade are signs that a lawn should be thoroughly watered if grasses are to remain green and actively growing. Another sign of insufficient water is when footprints remain in a lawn several hours after it has been walked on. Leaves with plenty of water quickly return to their rigid upright shape, whereas leaves that lack water will remain trampled for a while.

If high temperatures and dry conditions continue without rain or irrigation, the aboveground portion of grasses will turn entirely brown and die. Grasses are said to be dormant during this browned-out stage because the lower portion of the plant usually remains alive but not growing. Summer dormancy of grasses is a mechanism that helps a lawn survive, but it does not guarantee that a lawn will fully recover from dormancy. Thorough watering will bring the lawn out of dormancy, and new growth will resume from the belowground base — the crown — of grass plants.

Dormant lawns should receive at least 1 inch of water every two to three weeks during summer to prevent complete turf loss. Grasses may not show a noticeable greening, but that amount of irrigation should be sufficient to hydrate the lower plant portions and increase recovery when adequate moisture is available.

Wet wilt is another type of wilt to look for. Wet wilt occurs when the soil is saturated from spring rains but the root system is not able to keep pace with water demands from sudden increases in air temperatures. The curling of leaves from wet wilt looks much like wilt caused by lack of soil moisture. Waterlogged lawns that have a shallow root system are susceptible to wet wilt. Do not add more water when lawns are wilting but soil moisture appears adequate. Additional water will only aggravate the problem by starving the root zone of oxygen.

Select a watering system

Soils in the Transition Zone often have low water-infiltration rates. Automatic controllers can be set to supply several short cycles so that the total amount of water desired is supplied without runoff.

The most common type of watering occurs with hose-end sprinklers. Some studies have shown that the average homeowner applies more than twice the amount of water that is required for turf growth when using hose-end sprinklers.

There are several types of hose-end sprinklers. Select one that best fits your size and shape of lawn and then operate it efficiently. All hose-end sprinklers can be attached to inexpensive timers that can be used to shut off unattended sprinklers and avoid overirrigation.

Watering by hand may be needed in some problem areas to postpone the need to irrigate the entire lawn. Some areas of a lawn usually wilt before others. These "hot spots" may be caused by hard soils that take up water slowly. They often occur on slopes, southern exposures and warmer areas next to drives and walks.

Quick facts about watering

- Lawns in the Transition Zone may require as much as 1 to 1.5 inches of water per week from irrigation or rainfall during summer to remain green and actively growing.
- When managed properly, tall fescue requires 25 percent less water and zoysiagrass requires 50 percent less water than Kentucky bluegrass to maintain a green, actively growing lawn in this zone.
- Turfgrasses in the Transition Zone rank as follows in resistance to leaf wilting and browning during summer dry periods: bermuda, zoysia, tall fescue, Kentucky bluegrass and perennial ryegrass.
- Taller grass has deeper roots and less tendency to wilt.
- Deeper roots draw moisture from a larger volume of soil and therefore require less supplemental irrigation.

Table 2. Approximate lawn water requirements.

Lawn type	Green turf ¹ inches of water per week	Dormant turf ² inches of water per week
Perennial ryegrass	1.5	1.0
Kentucky bluegrass	1.2	0.7
Tall fescue	0.8	0.5
Zoysia or bermuda	0.5	0.2
Buffalograss	0.50	0.2

Notes:

1. Lawn remains green and growing.
2. Lawn may turn brown but will not die.

Lawns that have unusual shapes also may require some hand-watering to avoid unnecessary irrigation of paved surfaces, mulched beds and buildings. Soaker hoses that have a narrow pattern and supply water at a slow rate can be useful in these areas.

Know how much water

Once you have decided on the best sprinkler for your lawn's size and shape, you must decide how long to operate it. This decision is best made by knowing how many inches of water your system puts out in a given amount of time. To calculate,

place shallow, straight-sided containers (tuna or vegetable cans work well) or rain gauges in a grid pattern around the sprinkler. Operate the sprinklers, using overlapping patterns where needed, for a given length of time, and measure the amount of water captured. Measure the depth of water in the cans with a ruler or read directly from the rain gauges. Then calculate what the output of your sprinkler system is per 15, 20, 30 or 60 minutes. You need to have some idea how many minutes it takes to apply ¼ or ½ inch of water.

The utility water meter connected to your home can also be used to check how effectively water is being applied. It accurately measures water in cubic feet or gallons. When no other water is being used in the home, water a known area for a set amount of time and use these conversion factors to determine your water application rate:

- 624 gallons (83.3 cubic feet) of water are required to apply 1 inch of water on 1,000 square feet of lawn.
- 7.48 gallons = one cubic foot of water.

Heavy soils, as found in much of Missouri and the Midwest, will take in only about ¼ to ½ inch of water per hour. If your sprinkler system delivers more than that amount, rotate it to a different location after each quarter- to half-inch of water has been applied. Then repeat the process until the full amount of water desired has been applied (Table 2).

Keep the application schedule flexible, and irrigate based on observations of soil moisture or wilting of plants. A screwdriver, pocketknife or soil probe pushed into the ground in several locations can be used to quickly assess soil moisture. The screwdriver will easily penetrate to the soil depth that has received sufficient water. The screwdriver test can also be used to determine where and when irrigation is needed.

Once you have decided to irrigate, use these recommendations to guide the irrigation schedule and the amount of water to supply. A general guideline for irrigation is to apply at one time only that amount of water that the soil can absorb in one hour, always avoiding puddles and runoff.

Identify best time of day to water

Early morning, between 4 and 8 a.m., is the best time to water a lawn. During this time, water pressure is highest and disruption of the water pattern from wind is low. Cooler morning temperatures reduce water loss from evaporation. Watering early also reduces the chance of turf diseases that require extended periods of leaf moisture from dew and guttation fluids. ("Guttation" refers to the physiological process in leaves where water or cell sap is forced out upon plant surfaces.)

Avoid irrigation during midday, when temperatures are higher; during late evening, which extends leaf wetness period and promotes disease; and during windy conditions, which cause water patterns to fluctuate.

Water new lawns with care

Newly seeded or sodded lawns require special attention with irrigation. Newly seeded lawns should be watered daily and may need as many as four to five light waterings in a single day. Watering with a light mist is best for establishing new lawns. Keep the seedbed moist, but not saturated, to a depth of 1 to 2 inches until germination occurs. A green cast to the lawn and seedlings that are $\frac{1}{4}$ to $\frac{1}{2}$ inch tall are evidence of germination. The first seven to 10 days are crucial for good seed germination. Once seedling growth is noticeable, you can reduce watering. Seedlings of a new lawn must not be stressed to the point of wilt. Continue with light applications of water — $\frac{1}{8}$ to $\frac{1}{4}$ inch — one to four times daily.

Applying straw, at a rate of one bale per 1,000 square feet, to a freshly tilled area at the time of seeding will help shade the ground and prevent rapid drying of the soil surface. Straw will also reduce seedling damage from the force of large sprinkler drops.

Newly sodded lawns require watering one or two times a day. Begin irrigation immediately after laying sod. Plan your sodding operation so that a section of laid sod can be watered immediately while other areas are being sodded.

Sod should be watered so that the sod strip and the top inch of soil below the sod are moist. The first irrigation will take about 1 to $1\frac{1}{2}$ inches of water to completely wet the sod. After watering, lift up pieces of sod at several locations to determine if it has been adequately irrigated. Continue to lightly water one to two times a day to prevent wilting and to ensure moist soil just below the sod layer.

As sod becomes established and roots penetrate and grow, gradually reduce the frequency of watering and the amount of water applied. After sod has been mowed two or three times, follow regular watering practices outlined earlier.

Watering tip

Rotary sprinklers that are set to deliver a half or quarter sprinkler pattern will discharge two or four times the amount of water on a given area. Operate rotary sprinklers with half patterns for one-half the amount of time and sprinklers with quarter patterns for one-fourth the amount of time.

Managing Common Turfgrass Pests: Weeds, Diseases, Insects and Moles

Whatever pest problem you are having, there are five basic steps to effective pest management:

1. Properly identify the key pest and the damage it may cause.
2. Monitor pest populations regularly.
3. Determine the potential for economic loss from the pest.
4. Select the proper pest control tactic, such as cultural, biological or chemical.
5. Evaluate the control measure used.

Integrated pest management for lawns

A popular and positive trend in turf management, from both professionals and homeowners, is an interest in plant health care and reduced pesticide use. The degree of interest ranges from those who would prefer to use only organic or natural pest management practices, to others who would opt for a combination of improved cultural practices and chemical approaches. In either case, there is decided interest in the use of biopesticides (host-specific natural enemies, such as predators or pathogens), pest-resistant species and varieties, pheromones and other attractants that lure or confuse pests, hormones that prevent pest development, and naturally occurring chemicals that kill pests or suppress their activity. A pest management approach that embraces all of these alternatives is known as integrated pest management (IPM).

Weeds

A weed is simply a plant out of place. Any plant that disrupts the desired appearance, performance or functionality of a turf area is a weed. Weeds are opportunistic and can become a problem under several situations, including improper management (mowing height and frequency, fertilization, irrigation),

Components of an IPM program

1. Identifying the problem – both pests and any naturally occurring enemies.
2. Monitoring and record keeping – regular monitoring of populations of pests and natural enemies allows you to determine how season, weather, cultural programs, etc., influence populations and the resulting levels of pest-related injury.
3. Determining an injury/action threshold – determine how large the pest population can grow before causing enough damage to the yard or economic loss to warrant implementation of pest management practices.
4. Selecting a strategy – for each pest, choose a mix of tactics that will be effective, but least disruptive to beneficial insect populations and least hazardous to humans, animals and the surrounding environment.
5. Evaluating success – constantly evaluate the success of pest management strategies.

Possible treatment strategies

- Select pest-resistant/tolerant grass species or cultivars.
- Modify habitat: reduce attractiveness to pest or enhance attractiveness to beneficial insects.
- Modify human behavior: improve cultural and management practices, and alter attitudes and expectations regarding the appearance or uses of the yard.
- Implement physical controls: trapping, manual picking and barriers.
- Use biopesticides: natural enemies or pathogens (introduction or reintroduction).
- Use chemical controls: pheromones, juvenile hormones, naturally occurring toxins and synthetic poisons.

soil disturbance, thinned areas due to traffic, diseases, insects and poor seed establishment.

A turfgrass weed control program involves any practice that will prevent weed development in a turf or will shift factors favoring weed development to the point that turf growth and health are favored instead.

The primary step in any pest management program is proper identification. Proper weed identification is necessary before a decision can be made about control. It is possible that a simple change in a cultural practice could prevent a weed problem or at least decrease weed population levels to an acceptable level. However, in some situations, the use of chemical controls may still be needed.

When caring for your lawn and trying to keep it weed-free, “the best defense is a good offense.” Weeds are opportunistic and invade weakened lawns, thus the best weapon to fight weeds is a dense, healthy stand of grass. Good management practices give lawns a fighting chance against weeds. These practices include planting the appropriate grass for a particular location, reseeding bare areas in the fall, proper fertilization, and correct mowing and watering. Mowing height influences competition against weeds, such as crabgrass, because taller turfgrass shades sunlight from weed seeds. Watering practices in the spring should be limited for better deep-soaking to maintain a drier surface. Frequent light sprinklings with the warming temperatures of spring encourage weed seed germination.

If you decide to use weed-control products, read the label directions carefully. Do not overapply, either by excessive overlapping or applying more product than recommended to a specific area. Applying too much product can cause environmental problems, damage to turfgrass roots and unnecessary waste. Try to avoid routine, blanket applications of combination products to control just a few weeds. In this situation, spot treatment or hand-pulling is a better option. Determine the effective application width of your rotary spreader, and space out each spreader pass to ensure uniform coverage with minimal overlap. Also, for better distribution of the particles and to avoid striping, apply half the rate required in two directions.

Be careful about spreading crabgrass preventers or weed-and-feed products into areas not listed on the product label, such as flower beds and vegetable gardens; they will injure flowers and vegetables in those areas.

Control of annual grassy weeds

Crabgrass is the primary weed problem homeowners face each year. A summer annual, crabgrass is a coarse-textured grass that germinates in the spring and grows well throughout the summer’s heat. Its wide leaf blades, heat tolerance and prostrate growth habit make it an eyesore in lawns, and it smothers nearby turfgrasses. During the summer, crabgrass will produce seed heads even at low mowing heights. Crabgrass is killed by the first hard frost in the fall, which causes its seed heads to drop. In the spring, the new crabgrass seedlings emerge around the previous year’s plant. To prevent their emergence, reseed the open space during the fall with a desired grass and apply a preemergent to kill germinating crabgrass seedlings.

Preemergent products are so-named because they must be in place before crabgrass seedlings and other annual grassy weeds — such as goosegrass, foxtails, barnyardgrass and fall panicum — begin to emerge. Generally, crabgrass starts to germinate when daily high temperatures begin to reach 70 degrees F or above. In southern areas of the Transition Zone, these temperatures may occur as early as mid-March. Farther north, they may not occur until late March or early April. Highest crabgrass emergence begins to occur as daily high temperatures reach 80 degrees F. The general rule is that in areas south of Interstate 70, application should be made by March 15, and in areas north of I-70, application should be made by April 15. A natural guide, specific to each year’s fluctuating weather

IPM considers options

Integrated pest management involves the selection, integration and use of pest management techniques based on predicted economic, aesthetic, sociological and ecological consequences. IPM seeks to maximize the use of biological and naturally occurring pest management tools.

The IPM concept does not prohibit use of chemical-based pesticides. Instead, it considers their use as one of many options available in a pest management program.

Elimination of a particular pest is rarely the goal of a true IPM program. Such management programs attempt to keep pest populations below levels that have been previously determined to cause intolerable damage — economically, aesthetically, ecologically and sociologically.

Control weeds early

One practical guideline is to control weeds when they are small and to avoid blanket pesticide applications. When targeting only a few weeds, they can easily be hand-pulled or spot treated with a good ready-to-use (RTU) product.

patterns, is to have your preemergent in place before the yellow blooms of forsythia have all dropped.

Preemergent products will not kill crabgrass that has already emerged. A preemergent barrier must be present at the soil surface to kill the crabgrass seedling when its first root contacts the soil. Therefore, the preemergent must be applied at the right time and watered into the soil surface either by light irrigation or rainfall. Many effective products are available, almost all of which are combinations of fertilizer with the preemergent herbicide, or crabgrass preventer, in the same bag. These combinations are an effective way to fertilize a lawn and control crabgrass with one application. Both need to be watered in to be effective. Corn gluten-based organic fertilizers are also an excellent choice for control of many annual weeds. Corn gluten-based products will provide 60 to 70 percent control of many annual weeds.

Control of perennial grassy weeds

Control of annual grassy weeds is relatively easy with the use of proper cultural practices and preemergent products. Controlling perennial grassy weeds is a different story. Unfortunately, there are only two classes of selective herbicides to control perennial grassy weeds in turf, and they have highly specific uses. The sulfonyl-ureas are designed to control tall fescue, annual and perennial ryegrasses, and annual bluegrass in Kentucky bluegrass, bermudagrass and zoysiagrass. Another product, fluazifop-p-butyl, controls bermudagrass in tall fescue and zoysiagrass. Two selective herbicides recently released — mesotrione and topramezone — do provide some control of perennial weeds, such as nimblewill. These herbicides provide excellent control of specific weeds in specific grasses but do have limitations, so be sure to read the labels before using these products.

No selective herbicides are available to control weeds such as quackgrass, johnsongrass and zoysiagrass. Nonselective herbicides, such as Roundup and Finale, are the only way to stop further invasion of these perennial weeds. The use of these products will make brown spots in your desirable turfgrass, but reseeding or resodding can repair these areas.

Control of broadleaf weeds

Broadleaf weeds, in general, are easy to control thanks to the methods and large number of products available. Most of the products available for control of broadleaf weeds are systemic herbicides, which means that they move, or translocate, through the entire plant for more effective control. Most products are classified as postemergence; they are applied after the weeds emerge. One exception is Gallery (isoxaben), the only product designed as a preemergent product for broadleaves. Its primary use is to control winter annual broadleaf weeds (common chickweed, henbit, shepherd's-purse, etc.) and summer annual broadleaf weeds (spurge, purslane, knotweed, etc.).

Some of the preemergent products you use for crabgrass prevention will also control many summer annual broadleaf weeds (carpetweed, purslane, knotweed, pigweed and spurge). Other broadleaf weed problems in the spring can be controlled with one of many combination broadleaf herbicides, such as 2,4-D, MCPP and dicamba. Best spring control is achieved when applications are made in mid-May. Applications made at this time will control not only the annual broadleaves but also many of the perennials and the few biennials that emerge from seed.

Perennial broadleaf weeds (dandelion, plantains, oxalis, clovers, curly dock, etc.) are more easily controlled in September. Perennial broadleaf weeds have large taproots that store carbohydrates late in the summer to prepare for the long winter. This translocation process makes it easier to move systemic broadleaf herbicides into the roots, which helps provide the most efficient control of perennial broadleaf weeds.

Biennial broadleaf weeds (mallow, prickly lettuce, yellow rocket and thistles) do not exist in large numbers, but they can be difficult to control. Biennials have two-year growth cycles. The first year, vegetative growth occurs and small rosettes are formed. The second year, a tall flower stalk develops, flowering occurs and seed is produced. The best time to control biennials is in the first year, when vegetative growth is taking place and most of the plant's energy is moving downward into the root system. Stands of biennial weeds will have first- and second-year plants present and will require herbicide applications over two or three years. The same systemic broadleaf herbicides used for perennial broadleaf control will also work for these weeds.

Weed-and-feed combinations of fertilizer and broadleaf weed control herbicides such as 2,4-D often fail to effectively control target dandelions and other broadleaf weeds because of poor herbicide contact and uptake by the weed. The problem is usually one of placement. To kill dandelions, the herbicide must be taken up by the foliage. Most granules will bounce off leaf surfaces down to the soil surface, but root uptake of 2,4-D is poor. These products perform better when applied to wet leaf tissue as with a heavy dew in the morning. Many product labels recommend this practice.

Control of miscellaneous perennial weeds

Some miscellaneous perennial weeds include wild garlic, wild onion, star-of-Bethlehem and yellow nutsedge. Each is unique.

Wild garlic and onion have slender leaves with a heavy, waxy cuticle layer. They develop from bulbs and return every year. The best control for these are ester formulations of 2,4-D with dicamba. Many of the combination broadleaf herbicides mentioned previously will control these weeds.

Star-of-Bethlehem is another bulb-type plant in the lily family. It emerges and flowers in the spring and can be controlled with several broadleaf herbicides.

Yellow nutsedge can be identified by a triangular stem at the soil surface. It grows from seed and underground nutlets and usually grows in thinned-out areas of low-lying turf that hold water. Eliminating wet areas and maintaining a dense lawn will reduce yellow nutsedge infestations. Once it is established, removal will require a chemical control.

Diseases

Three factors must interact for a turfgrass disease to develop. These factors are a susceptible host plant (turfgrass), a causal agent (pathogen or fungus) and a favorable environment (weather conditions). Think of each factor as one side of a triangle. All three corners must be present for a turfgrass disease to develop (Figure 5).

Selecting disease-resistant varieties of turfgrass species is the foremost best step to reducing potential disease problems. Using good turfgrass management practices that lead to a healthy plant is the second. Managing plant growth and carefully selecting the appropriate varieties for your conditions come next.

Knowing what conditions diseases favor — especially any diseases that have historically been at that site — can help you prepare for prevention. Here are a couple of examples: Dollar spot is a disease that favors lower fertility, primarily infects bluegrass and ryegrass, and likes 80-degree F days with moderate humidity and nighttime temperatures in the 60s that produce heavy morning dews. Brown patch favors high nitrogen in turfgrasses; primarily infects fescues and ryegrasses; and follows the 6-8 flip-flop rule, occurring when nighttime temperatures are 68 degrees F or higher, combined with daytime temperatures of 86 degrees F or higher.

This information can help you decide how to change management or cultural practices to favor your lawn and not the disease. It can also

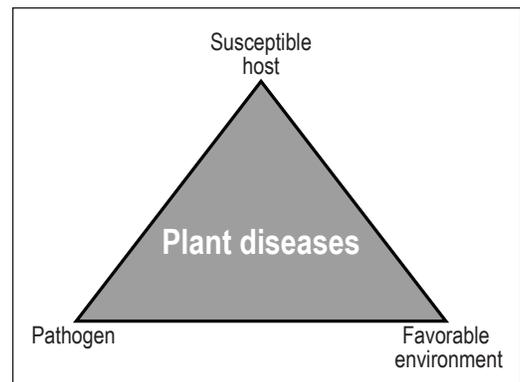


Figure 5. Plant disease occurrence triangle.

help you decide the best possible time to apply fungicides to prevent diseases (preventive approach), for example, applying fungicide early to avoid an infection. The other approach is to manage your lawn the best you can and apply fungicide on an as-needed basis (curative approach).

The following is a list of the more common turfgrass diseases in the Transition Zone.

Cold weather diseases

Pink snow mold (*Fusarium nivale*). Pink snow mold is nonspecific to all turfgrasses. It does not require snow cover. This snow mold can be lethal and is found primarily on golf courses.

Gray snow mold (*Typhula* spp.). Gray snow mold is nonspecific to all turfgrasses. It requires snow cover and is promoted by wet conditions, poor drainage and high nitrogen.

Cool weather diseases

Red thread (*Laetisaria fuciforme*). Red thread affects ryegrass and fine fescues with low nitrogen under cool, wet conditions. It rarely causes permanent damage.

Powdery mildew (*Erysiphe graminis*). Powdery mildew affects primarily bluegrass when nights are damp, humid and cool, and days are mild and cloudy. It usually occurs on shaded, poorly drained soils.

Fairy rings (*Marasmius* spp., *Psalliota* spp.). Fairy rings usually appear in spring and summer as rings or arcs of dark green grass with or without mushrooms. Some rings may appear dead. The rings vary in size from a few inches to several feet in diameter.

Warm weather diseases

Dollar spot (*Sclerotinia homeocarpa*). Dollar spot disease affects bluegrass, ryegrass and fine fescues. It is a low-nitrogen disease promoted by temporary drought, and warm days with cool nights and heavy dew. It is often lethal to low-cut turf.

Leaf spot (*Helminthosporium* spp.). Leaf spot affects bluegrass, ryegrass, fine fescues and tall fescues. It is promoted by excessively high or low nitrogen, improper mowing, and alternating wet and dry cycles. It may progress to melting-out during the summer. Some leaf spot is a natural spring occurrence on bluegrass.

Hot weather diseases

Rust (*Puccinia graminis*). Rust affects bluegrass, ryegrass and fescues. It appears in warm to hot, dry periods when grasses are growing slowly or not at all. It is promoted by low fertility. It is favored when plants are under moderate soil moisture stress and receiving heavy morning dews and frequent light rains.

Pythium (*Pythium* spp.). Pythium primarily affects ryegrass and can affect bluegrass and fescues. It appears during periods of extreme high heat and water-logged conditions, usually after thunderstorms that are followed by immediate sunshine and heat.

Brown patch (*Rhizoctonia solani*). Brown patch affects tall fescue, ryegrass and fine fescues. It is promoted by high levels of nitrogen, and it is favored by hot, humid, wet weather. It can be lethal on low-cut turf.

Summer patch (*Magnaporthe poae*). Summer patch affects primarily bluegrass and some fine fescues. It is promoted by excess nitrogen and develops following high temperatures and heavy rainfall in July and August. Summer patch becomes active in the soil in the spring, but symptoms do not appear until late summer when grasses are under stress. It commonly occurs on slopes with a southern exposure, where it creates dead rings of grass that have a "frog eye" appearance.

Insects

Insects are one of the most populous forms of animal life on earth. However, only a small number of insects are a potential threat to turfgrasses at some point in their life cycle. Turfgrass insects can be somewhat cyclical, and population levels depend on several factors, including weather, suitable food sources, desirable habitat and predators.

A healthy, growing plant is the best defense against turfgrass pests. Many plants become more susceptible to pests if they are stressed. Following good turf management practices with proper mowing, watering, fertility, aeration, thatch control and overall sanitation (by removal of leaf litter, mulches and other debris) produces good, healthy, dense turf that is pest-resistant.

Turfgrass damage is usually not observed until an insect species population reaches a threshold level. Insects may always be present but not always at damaging levels. For example, if you were to find only one or two white grubs while doing yard work, treatment would not be needed. However, if you peel back dead sod and find more than five white grubs per square foot, then treatment is called for.

Turfgrass pests cannot be controlled for long periods solely through the use of pesticides. A properly designed integrated pest management program will not only maintain control of existing pests but will also help prevent reoccurrence of these pests and the possibility of new outbreaks. Plan for possible pest problems before you plant. Keep records of problems in your lawn, and talk to neighbors about pest problems they have experienced.

The more common turfgrass insect pests in Missouri are described below.

Subsurface-feeding insects

White grubs. White grubs are the primary insect problem many homeowners face annually. Damage is usually noticed in late July to early August. Damage from the previous year's generation can occur in mid-May. Small or large patches of dead or dying grass will have roots pruned, resulting in sod that can be pulled up or rolled back like a loose carpet. Numerous C-shaped, whitish larvae with brown heads will lie in the upper soil directly below the dead sod. Animals such as skunks or birds digging for grubs can cause additional related turfgrass damage. Adults are scarab beetles, including billbugs, black turfgrass atenius beetle, green June beetle, Japanese beetle, masked chafer and May/June beetle. Identification of white grub species can be made based on the time of the year the grub is present, size of the grub, and raster patterns on the grub's abdomen.

Bluegrass/Hunting billbug. Damage by billbugs can be confused with that caused by drought, disease, chinch bugs or white grubs. Billbug injury creates spotty, dead turf patches that are easily pulled up, with the stems breaking off at the crown. The stems are hollowed out or filled with a light brown frass (dry insect waste). The best time to control billbugs is in May, to kill overwintering adults before they lay eggs.

Green June beetle. The feeding activity of green June beetle grubs rarely causes severe turf damage. Instead, the damage they cause to a lawn generally is mechanical. The grubs burrow in and out of the turf, producing mounds. These beetles are attracted to soils with high organic content; the decaying organic matter is the primary food for the grubs.

Japanese beetle. Japanese beetles are now considered a threat in Missouri, where they have been found in most counties of the state. Adult beetles are known to feed on about 400 ornamental host plants. Grubs feed on roots of turfgrasses, causing a wilting appearance and gradual thinning. Dead turf sod can be rolled back under heavy infestations. Adult beetles can damage leaves of turf and ornamentals. White grubs should be treated in the first or second developmental stage during July and August.

May/June beetle. The earliest symptom of May/June beetle grubs feeding on turfgrass roots is a gradual thinning and weakening of the stand. Damage may progress from sudden wilting of the grass, even with adequate moisture, to small patches of dead grass that easily peel back. These beetles have a three-year life cycle. Adult beetles can damage trees and ornamentals. White grubs should be treated during late July to early August to control any newly hatched larvae. However, during the second year of the grub's life cycle, treatments can be made from April through September.

Masked chafer. Turfgrass infested with masked chafers exhibits the typical symptoms of white-grub damage: wilting, irregular dead patches of turf. This beetle has a one-year life cycle. Treat grubs about four weeks after the adult beetles start to emerge, when egg deposits begin to hatch in late July to early August.

Surface-feeding insects

Armyworms. Young armyworm larvae begin to feed on tender foliage. Feeding injury by the first two developmental stages causes skeletonized foliage. The third through sixth developmental stages consume all of the plant. When populations are large, feeding produces circular bare areas in turf. Treatments should be applied mid- to late day, just before nighttime feeding. This insect has several generations per year.

Chinch bugs. The chinch bug feeds by sucking sap from grass stems and foliage. They tend to favor sunny areas first. Damage starts as small yellow or brown discolored areas that expand in size as the insect population increases. Generally, control measures are needed during the summer generation only. Best control results when the entire lawn is treated.

Sod webworm. The appearance of irregular brown spots in the lawn is the first indication of sod webworms. Grass blades will be chewed off at or just above the soil surface. Fresh clippings and green fecal pellets are also present. Larvae live in silken-lined tubes in the thatch layer, so look for pencil-sized holes in the thatch. Larvae feed at night, so surface treatments should be made in the early morning or late afternoon and allowed to dry.

Moles

Although most people have never seen a mole, they are aware of the damage moles cause to lawns and flowerbeds. Most people think moles feed primarily on the roots of plants, causing the plants to die. The truth is, moles feed very little on plant material. It is the air pockets moles create around roots and flower bulbs when digging their tunnels that causes the plants to dry out and die.

The eastern mole (*Scalopus aquaticus*) is Missouri's predominant species. It lives most of its life underground and is highly specialized for a subterranean way of life. The mole is a small, sturdy animal, 5.5 to 8 inches long, with a somewhat cylindrical body and elongated head. It is grayish-brown on the back to pale or more brown on the belly. Its velvety fur often has a silvery sheen. Occasionally, bright orange or cinnamon-yellow markings will occur. The mole has a fleshy snout that serves as a highly sensitive organ of touch and smell to seek out numerous food sources. Its tiny eyes are concealed in fur and covered by fused eyelids, and its sight is limited to distinguishing light from dark. The greatly enlarged front feet are normally held with the soles vertical and pointing outward. They have well-developed claws with a specialized bone attached to the wrist that aids in digging.

Moles construct networks of tunnels at the soil surface (Figure 6). Many of these are built after rains when the mole is in search of new food sources, and they are usually not reused. Moles normally dig surface tunnels at a rate of 1 foot per minute. They also create mounds of soil, called molehills, by pushing up soil as they develop deeper permanent tunnels and nesting cavities.

Moles tend to feed and rest on two-hour cycles, 24 hours a day. Animal foods constitute about 85 percent of their diet. They feed primarily on earthworms, which are their main source of water, and grubs; however, they also eat considerable amounts of millipedes, centipedes, spiders, sow bugs, snails and slugs. Moles are insatiable eaters and can consume 70 to 80 percent of their body weight daily. Moles generally move up or down within the soil profile to follow food sources such as earthworms, which move with soil moisture. This behavior is why you do not see much mole activity during a droughty summer, but with spring and fall rains, activity abounds.

Mating occurs in the spring with a single annual litter of two to five young produced in March, April or early May. The presence of two to three moles per acre is considered a high infestation.

Controlling and trapping moles requires time and patience. Several home remedies to control or repel moles exist, including human hair, Juicy Fruit gum, poison peanuts, mothballs, flooding tunnels with a garden hose and water (flooding creates a moist environment favorable for earthworms), a hose connected to a car exhaust and, finally, pets (some dogs and cats can be effective). Ultimately, though, successful control of moles is likely to depend on locating active runways and properly placing baits or traps.

Locating active runways

Before placing mole baits or traps, you need to locate active feeding runways. To do so, poke holes in various runways over the entire network using a small stick or broom handle. Come back two hours later and inspect these holes. The tunnels in which the holes have been plugged are part of active feeding runways. You will want to place your baits or set your traps in these tunnels.

Control products

Mole-control products are available to homeowners and can be bought at local nurseries or garden centers. Many products tend to work as repellents, with castor bean oil as the active ingredient. Many have been tested and appear effective on the Eastern mole. These products need to be sprayed with a garden hose-end applicator or applied as granules through a spreader every 30 days to maintain a barrier that repels moles. The repellent-type products are marketed as natural and safe, but information about effectiveness is mixed. Check with your local garden center for available products. Formulations vary with each. Mole-control products generally treat 5,000 to 10,000 square feet.

Two bait products, Lesco's Kaput Mole Gel Bait and Bonide's Moletox Baited Gel, are water-based gels containing warfarin as the active ingredient and flavored like the mole's primary food, earthworms. Both products are packaged in syringe-type applicators that inject bait into the tunnels. Both claim excellent control.

The latest mole baits are a bromethalin-based product that actually looks, feels and tastes like earthworms. Each "worm" contains a lethal dose of bromethalin. Many bromethalin-based baits that simulate white grubs are also now available. Talpirid, Motomco and TomCat are the more common brands of these types of mole bait and claim 98 percent effectiveness.

Some poisonous granular baits of a different class than the previously mentioned baits are also available. These include Moletox II and Mole-Nots, both of which are cracked corn baits laced with 2 percent zinc phosphide. One teaspoon of material will treat an active tunnel. Some results indicate excellent control with these products, but keep in mind that moles do not prefer grains in their diet. A mole's diet consists mostly of earthworms and insects. For this

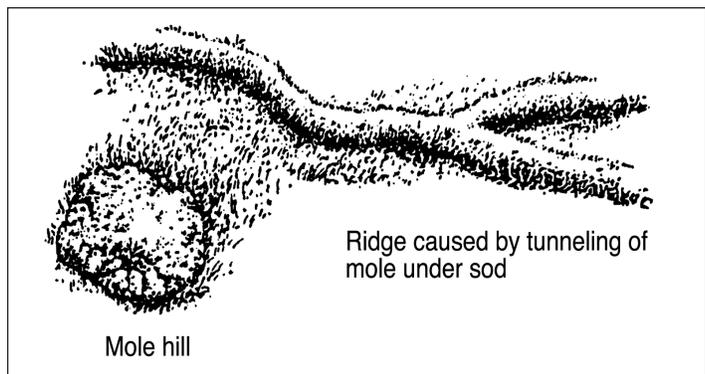


Figure 6. Mole signs.

More on moles

For more information on moles, read *The Wild Mammals of Missouri* by Charles W. Schwartz and Elizabeth R. Schwartz, the source for the descriptive information in this section.

reason, poison peanuts are also unlikely to be effective. Although these baits are less expensive than others, they are not as effective.

Another granular bait, Mole Patrol Bait, contains chlorophacinone, an anticoagulant (blood thinner) historically used by the rodenticide industry. This ready-to-use, pelletized bait has unique attractants and is highly palatable to moles. Some studies indicate it offers 100 percent control.

Many homeowners see mole activity in the early spring and automatically assume they have white grubs. Their first reaction is to apply a grub insecticide. The application of soil insecticides for controlling grubs will also control earthworms to some degree, up to 70 percent, sometimes causing moles to move out. But this approach to mole control can present hazards to the environment and should not be tried. Saturated soils from spring rains bring earthworms to the surface, providing moles with a food source. White grubs are deeper in the soil and are not part of the mole activity being observed in early spring. Controlling earthworms is not recommended because they are considered a beneficial organism that aerates the soil and breaks down organic matter. Grub control products should be used only when appropriate for grub control, usually in late July and August.

Trapping

If you have a mole actively building mounds, you cannot do much unless you catch it in the act and move quickly with a spade or shovel. Even so, your success is likely to be limited. Instead, you might want to try trapping it.

Trapping can be effective if you can see evidence of a network of shallow runways used for feeding. The key to trapping is to locate the active feeding runways, as previously described. You will want to set your traps in these tunnels.

Several types of mole traps are available (Figure 7). Three are briefly described below. Whatever trap you choose, follow the manufacturer's instructions for setting it.

The Victor harpoon or gig-type trap has had the highest success rate among traps tested at the MU Turfgrass Research Center. To use it, push down a 4-inch swath of the runway with your foot. Before setting the harpoon, place the gigs

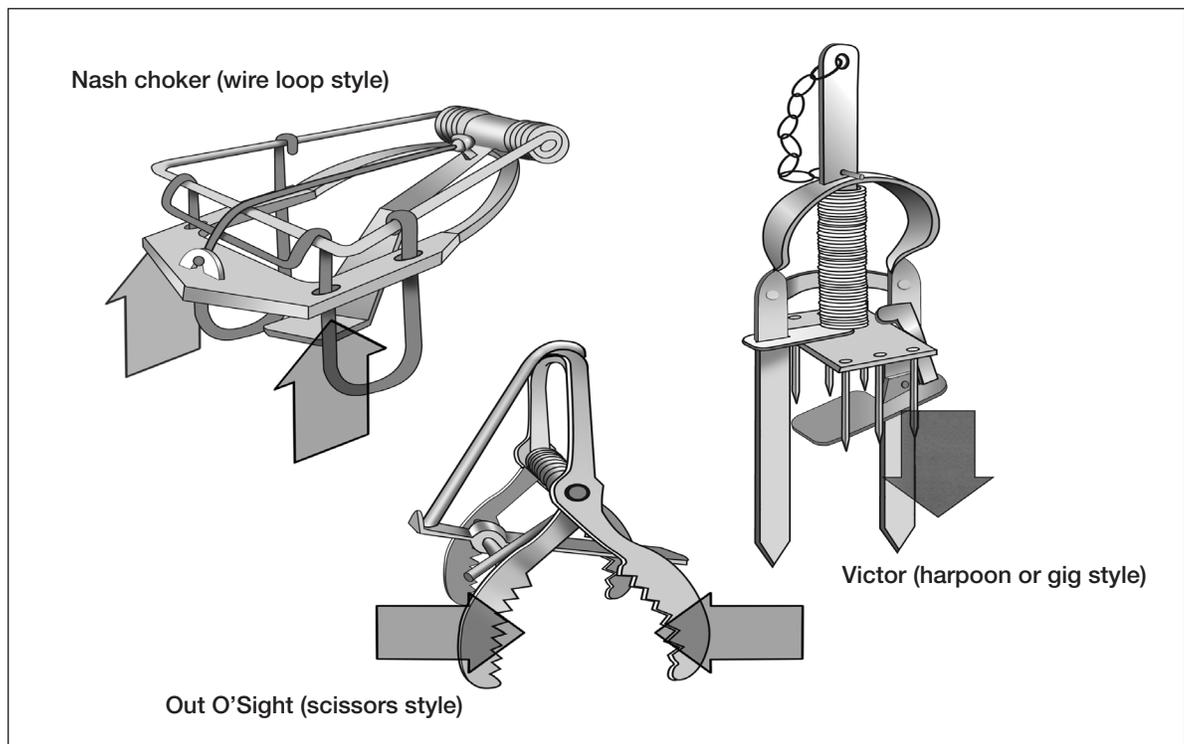


Figure 7. Types of mole traps.

over the runway and push the trap into the soil. Move the trap up and down several times to reduce the friction of the soil against the gigs. Doing this will ensure a quick and decisive thrust of the harpoon. With the trap in the soil, set it by pulling the harpoon up and locking it in position, with the trigger pan (flat plate) slightly touching the depressed runway.

The Nash trap (wire loop type) and the Victor Out O' Sight trap (scissors type) also work but seem to be more difficult to set. However, the Easy Set Mole Eliminator, another scissor-type trap, is easy to set. With the scissors closed, push them into an active runway, allowing the trap to stand freely. Then step on top of the trap with one foot and push downward, spreading the scissors and locking the trap in place. As a mole pushes back through the runway, the trap is sprung and the mole is caught.

To prevent injury to pets with any of these traps, place a 5-gallon bucket over the trap and place a rock or brick on the bucket to hold it in place.

For further information

If you have questions that this publication or other references do not answer, contact your local extension center.

MU Extension publications at <http://extension.missouri.edu>

Lawn Establishment

- G6700 *Cool-Season Grasses: Lawn Establishment and Renovation*
- G6705 *Cool-Season Grasses: Lawn Maintenance Calendar*
- G6706 *Establishment and Care of Zoysiagrass Lawns*
- G6708 *Thatch: Enemy of Lawns*
- G6720 *Home Lawn Watering Guide*
- G6725 *Grasses in Shade: Establishing and Maintaining Lawns in Low Light*
- G6730 *Establishment and Care of Buffalograss Lawns*
- G6749 *Natural Lawn Care*
- G6770 *Bermudagrass for Athletic Fields*
- G6772 *Cool-Season Grass Cultivars for Athletic Fields*
- G6954 *Soil Testing for Lawns*

Mowing

- G6956 *Making and Using Compost*
- G6958 *Grass Clippings, Compost and Mulch: Questions and Answers*
- G6959 *"Don't Bag It" Lawn Care*

Pest Control

- G6750 *Home Lawn Weed Control*
- G6751 *Calibrating Sprayers and Spreaders for Athletic Fields and Golf Courses*
- G6756 *Turfgrass Disease Control*
- G9440 *Controlling Nuisance Moles*
- IPM1009 *Turfgrass and Weeds*
- IPM1020 *Turfgrass and Insects*
- IPM 1029 *Identification and Management of Turfgrass Diseases*

Related reading and websites

- Christians, Nick. 1998. *Fundamentals of Turfgrass Management*. Hoboken, N.J.: Wiley and Sons.
 - Dunn, John, and Kenneth Diesburg. 2004. *Turf Management in the Transition Zone*. Hoboken, N.J.: Wiley and Sons.
 - McCarthy, L.B., J.W. Everest, D.W. Hall, T.R. Murphy, F. Yelverston. 2001. *Color Atlas of Turfgrass Weeds*. Chelsea, Mich.: Ann Arbor Press.
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 - Tani, Toshikazu, and James B. Beard. 1997. *Color Atlas of Turfgrass Diseases*. Chelsea, Mich.: Ann Arbor Press.
 - Turgeon, A.J. 2001. *Turfgrass Management* (6th ed.). Upper Saddle River, N.J.: Prentice Hall.
- National Turfgrass Evaluation Program (NTEP) at <http://ntep.org>.