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IN THIS ISSUE

About Fairy Rings and Their Management

Peter H. Dernoeden

Fairy rings are commonly found in turf and pastures and may be caused by any one of 50 or more species of fungi. Fairy rings have been observed in areas where soil pH has ranged from 5.1–7.9. It is likely that fairy rings will occur under any soil condition that will support turfgrass growth. Nearly all of the commonly cultivated turfgrasses are known to be affected by fairy ring fungi. Fairy ring fungi belong to a group known as the basidiomycetes or "mushroom fungi." These fungi can cause the formation of rings or arcs of dead or unthrifty turf, or rings of dark-green, luxuriantly growing grass. Fairy ring fungi primarily colonize thatch and organic matter in soil and generally do not directly attack turfgrass plants, however, some are weakly parasitic. **Fairy rings are classified into three types according to their effects on turf: Type 1:** those that kill or badly damage plants; **Type 2:** those that stimulate grass, causing the formation of rings or arcs of dark-green turf; and **Type 3:** those that do not stimulate grass and cause no damage, but produce mushrooms or puffballs in rings.

The most destructive rings are of the Type 1 variety. Type 1 rings are very common, especially in lawns and golf courses situated on sites that previously had been pastures or woodlands. **Type 1 rings initially appear as circles or arcs of dark-green grass, but the dead zone generally does not appear until summer.** The most common fungi known to cause Type 1 fairy rings include *Agaricus* spp., *Calvata* spp., *Chlorophyllum* sp., *Clitocybe* spp., *Marasmius oreades*, *Lycoperdon* spp., *Scleroderma* sp., and *Tricholoma* spp. The fruiting body of most species is a typical mushroom with a cap and stem. The underside of the mushroom cap is composed of gills, upon which spores are produced. *Calvata* spp. and *Lycoperdon* spp. produce puffballs, which initially are white, fleshy, and egg-shaped. Puffballs turn brown as they age, and when they crack or are crushed they release large numbers of spores. The importance of spores in the spread of fairy ring fungi is unknown.

Type 1 rings are distinguished by three distinct zones: an inner lush zone where the grass is darker green and grows luxuriantly; a middle zone where the grass may be wilted or dead; and an outer zone in which the grass is stimulated and/or darker green. The distance from the inside of the inner zone to the outside of the outer zone may range from a few inches (3–6 cm) to 4 feet (1.2 m) wide. The darker green, stimulated zones are the result of the breakdown of organic matter, which releases nitrogen and results in more vigorous leaf growth. The outer green zone is caused by the breakdown of thatch and organic matter by the fairy ring fungus, which liberates nitrogen. The inner green zone develops in response to the release of nitrogen as bacteria degrade aging or dead mycelium of the fairy ring fungus produced in previous years. Mushrooms or puffballs generally are produced at the junction of the bare and outer green zone. Rings, how-

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About Fairy Rings...

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ever, may produce few or no mushrooms, especially on closely cut golf or bowling greens. The presence of the three zones may be noticeable from spring to winter.

On golf and bowling greens there may be green rings, dead rings, or dead circular patches surrounded by green rings. **Type 1 fairy rings may also appear on greens as solid circular patches of blue-gray or wilted turf 6 inches to 2 feet (15–60 cm) or greater in diameter.** On young greens, these circular and wilted patches could be confused with take-all (*Gaeumannomyces graminis* var. *avenae*) or localized dry spots. Normally, there will be a dark-green stimulated zone around the periphery of brown patches associated with fairy rings on greens. Fairy rings may appear and disappear on young and old greens. **Fairy rings are more numerous in wet years, but are most destructive when weather conditions become hot and dry.**

Type 2 fairy rings are commonplace and can appear in early spring and remain evident until winter. While a Type 2 fairy ring can develop into a Type 1 ring, Type 2 rings generally only affect the aesthetic quality of turf. **Type 2 rings tend to come and go mysteriously, but seem to be most prevalent during wet summer periods.** One of the more unique Type 3 rings found in turf, including greens, is caused by the "birds nest" fungus *Cyathus striatus*. The fruiting bodies of *C. striatus* are tan to gray-brown, nest-shaped, and about 0.25 inch (5 mm) in diameter. Sometimes "birds nest" rings will have two concentric rings of fruiting bodies. They are most often associated with extended rainy weather or excessive irrigation. They are found in the thatch and the nest-like structure will contain several black, egg-shaped bodies called peridioles. These egg-like structures contain spores. These "bird nests" are also commonly found in mulch.

A ring is broken when its mycelium encounters an obstacle such as a rock, pathway, or unfavorable soil condition. The ring may also disappear for no apparent reason. In general, two fairy rings will not cross one another, i.e., at the point of intersection the growth of each ring stops. This obliteration at the point of contact is caused by the production of self-inhibitory metabolites that will also antagonize other members of the same or different fungal species. On slopes, the bottom of the ring is usually open, giving the appearance of an arc rather than a ring. This may be due to the downward movement of self-inhibitory metabolites that prevent fungal development in turf on the lower side of the ring.

Growth of a fairy ring begins with the transport of fragments of fungal mycelium and possibly spores. The fungus initiates growth at a central point and continues outward in all directions at an equal rate. Rings vary in size from 1 foot (30 cm) to 10 feet (3.0 m) or more in diameter, and become larger each year. Rings greater than 200 feet (60 m) across have been reported. The annual radial growth ranges from 3 inches (7.6 cm) to as much as 20 inches (50 cm). The rate of outward movement, as well as overall ring diameter, is determined by soil and weather conditions. **In general, rings grow more rapidly in light-textured and moist soils than in heavy clay and dry soils.** Rings fade in the autumn or winter, but the bare zone remains visible until the turf recovers or the site is overseeded. Loss of ring visibility is due to the general brownish appearance of dormant turf during winter and because the turf is not metabolizing nitrogen in large enough quantities to produce the darker green circles or arcs. Green rings and arcs, however, may be evident during mild winters when soils do not freeze for extended periods. Type 1 rings are most conspicuous during hot and dry summer periods, but can fade rapidly with the advent of rainy weather.

Type 1 fairy ring fungi kill vegetation primarily by rendering infested soil impermeable to water. Probing will reveal that soil in the dead zone is dry when compared to adjacent soil. The dead zone most likely develops in response to an accumulation of fungal mycelium in such large amounts in soil that it prevents entry of rain or irrigation water, and thus plants die as a result of drought stress. It is quite characteristic for grass on the outer edge of the dead zone to display the blue-gray color of turf under drought stress. **When a plug of soil is removed from the edge of an active fairy ring, a white thread-like network of mycelium sometimes may be seen in the thatch layer or clinging to soil and/or roots of grass plants. When environmental conditions are optimum for fungal growth, the white mycelium may be seen on the surface of the thatch layer. Oftentimes, however, no mycelium is evident in the soil or thatch.** Fairy ring infested thatch and soil, however, will almost invariably have a mushroom odor, even if fungal mycelium is not evident. **Some fairy ring fungi, including *M. oreades,* are known to parasitize roots and produce compounds toxic to roots such as hydrogen cyanide. It is likely, however, that most damage to turf can be attributed to the fungal mycelium rendering the soil impermeable to water.** When soil moisture is abundant, dark-green arcs or rings may be evident, while the dead zone is absent. With the advent of warm to hot and dry weather, however, the dead zone appears. Hence, Type 2 rings can develop into Type 1 rings, and dead zones are most likely to appear during dry summer periods.

Control of fairy rings is made extremely difficult by the water-impermeable nature of the infested soil. Chemical control is frequently ineffective or short-lived because the fungus can grow deeply into the soil and lethal concentrations of fungicide do not come into contact with the entire fungal body. The two most common approaches to combating disfiguring fairy rings are suppression and/or the use of fungicide drenches.

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FEATURE ARTICLE

Turfgrass Culture Under Tree Shade

James B Beard

This article is the second in a series on tree shade adaptation and culture. The shade environment effects on turfgrass adaptation were discussed in the January–February 2002 issue of TurFax. It was emphasized that a major problem in the shade adaptation of cool-season grasses is disease and a shade microenvironment that results in turfgrasses growth characteristics that are more prone to disease plus a microenvironment favorable to increased causal pathogen activity. Many of the following guidelines are based on strategies that will minimize disease activity. The other shade stress dimension relates to the direct effect of the reduced irradiation level under the shade and is particularly important in relation to the growth of warm-season turfgrasses. Two major aspects in growing turfgrasses in the shade will be addressed, including (a) suggested cultural practices and (b) modification of the tree shade microenvironment.

Turfgrass Shade Culture

Cultural practices can be modified to improve the growth and shoot density of shaded turfgrasses. Key practices in turfgrass shade culture include:

- raise the cutting height;
- avoiding excessive nitrogen fertilization;
- deep, infrequent irrigation;
- judicious traffic control;
- use of fungicides when needed; and
- use shade-adapted turfgrass species and cultivars.

A higher height of cut increases the leaf blade area, thus providing a greater capability to absorb solar radiation and synthesize carbohydrates. **A cutting height of 2.0 to 2.5 inches (50–63 mm) is beneficial for shaded lawns of most turfgrass species.**

Excessive nitrogen fertilization produces succulent shoot tissue that is more prone to injury from diseases and wear stress. **Carbohydrate depletion is moderated by using the minimum nitrogen fertilization level that meets the requirements of the turfgrass species.** Surface fertilization of trees is not desirable where the associated turfgrass species has a low nitrogen fertility requirement. The fine-leaf fescues are shade adapted species, but do not tolerate excessive nitrogen fertilization. The loss of fine-leaf fescue turfs may be minimized by deep-root feeding of trees.

Proper irrigation ensures adequate moisture for turfgrass growth. **Deep watering to a minimum soil depth of 6 inches (150 mm) is preferred. A critical aspect of irrigation is avoiding the enhancement of pathogen activity caused by excessive or improper timing of water applications.** The water application rate should not exceed the infiltration rate of the soil. Irrigations should be timed so the water is present on the turfgrass leaves for a minimum period of time, such as during the midday period of highest evaporation. The result is a less favorable microenvironment for infection by fungal pathogens.

Shaded turfgrasses should be protected as much as possible through the redirection or control of traffic because of the greater susceptibility to wear stress injury and reduced ability to recover from traffic stress damage. In the case of shaded tees on a golf course, the only alternative may be periodic resodding as needed.

Early autumn establishment of cool-season turfgrasses is preferred under deciduous trees. Autumn seedings provide the longest period of direct sunlight, extending from tree leaf abscission in mid-autumn until the initiation of new tree leaves in mid-spring. Mid-summer is the best time for planting warm-season turfgrasses in shaded areas. The immediate removal of fallen tree leaves is especially important during turfgrass establishment.

Modifying the Three Shade Microenvironment

An underlying principle of turfgrass shade culture involves modification of the microenvironment to improve conditions for turfgrass growth and development. Included are:

- pruning of lower tree limbs, especially for solo trees;
- selective removal of limbs in the canopy of trees;
- removal of dense shrub barriers; and
- pruning of shallow tree roots.

Pruning of tree limbs below 10 feet (3 m) improves the turfgrass quality under individual trees. The irradiance can also be improved through the selective pruning of limbs in the tree crown. This may be needed at 4 to 5 year intervals, depending on the rate at which the tree limbs regrow into the openings. Additional reductions in irradiance can be avoided by the immediate removal of excess clippings and fallen tree leaves. If the landscape plan requires a dense, low-growing shrub or tree that is not to be pruned, one should not attempt to maintain a turf under the canopy. In some cases tree removal is needed, especially on golf courses where a high initial tree density

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FEATURE ARTICLE

Another Insecticide Bites the Dust

Daniel A. Potter

Aventis recently requested voluntary cancellation of Turcam® 20% and 76% WP and 2.5 G turf insecticides, and all other products containing bendiocarb, its active ingredient. Turcam was registered for control of white grubs, as well as certain other turf pests (e.g., chinch bugs, sod webworms, mole crickets, and European crane fly larvae). It was also used as a drench for fire ant mounds. Turcam was classified as a restricted use pesticide due to bird and fish toxicity. It was also highly toxic to bees and earthworms. Turcam thus joins diazinon, chlorpyrifos (Dursban®), ethoprop (Mocap®), fonofos (Crusade®), isafofos (Triumph®), and isofenphos (Oftanol®) on the list of organophosphate (OP) and carbamate insecticides canceled or restricted by the EPA since 1990.

Cancellation of Turcam should have little impact on the industry's ability to control surface-feeding pests. Newer, reduced-risk products, especially pyrethroids (bifenthrin [Talstar®], cyfluthrin [Tempo®], deltamethrin [DeltaGard®], and lambda-cyhalothrin [Scimitar®] or spinosad [Conserve®]), work great on cutworms, armyworms, and sod webworms. Liquid halofenozide (MACH 2® 2SC) is also effective against those pests. Chinch bugs and greenbugs can be spot-treated with pyrethroids or controlled by soil-applied imidacloprid (Merit®). Fipronil (Choice®, TopChoice®) is especially effective against mole crickets. For fire ants, several new baits and drench products are generally more effective than was Turcam. For white grubs, most of the industry has shifted to preventive control with Merit or MACH 2.

Loss of Turcam does significantly reduce remaining options for curative grub control, especially "rescue" treatments after damage appears. Turf managers who practice selective preventive control must often spot-treat grub-damaged areas, especially where skunks and other predators are digging. Fast-acting soil insecticides provide the safety net to fall back on an IPM program for grubs.

In the United States, only trichlorfon (Dylox®) and carbaryl (Sevin®) remain for rapid control of large, third-instar grubs. University trials indicate that Dylox® has generally been faster and more consistently effective. Carbaryl also has the drawbacks of high use rate (8 lbs AI/acre), and being highly toxic to earthworms and bees. MACH 2 is also effective as an **early** curative (controls first and second instar grubs), but is it too slow-acting to discourage skunks and other varmints once grub damage appears. Turf managers should support Bayer in defending Dylox®, because its loss would leave few options but preventive control.

Turcam was among the most toxic of turf pesticides to earthworms. Although not labeled for earthworm control, some golf superintendents who used it were probably motivated by the "added value" of suppressing earthworms and castings on closely mowed playing surfaces. Other pesticides that suppress earthworms as a side-effect include Sevin and the fungicide thiophanate-methyl, but neither product is labeled for that purpose. Earthworms are generally beneficial in turf because their activities alleviate soil compaction, increase air and water infiltration, and help to break down thatch.

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Suppression is the most practical approach to combating Type 1 fairy rings in most situations. The suppression approach is based on the premise that fairy rings are less conspicuous and less numerous where turf is well watered and fertilized. **This approach involves a combination of aeration, deep watering, use of wetting agents, and proper fertilization.** Aeration is beneficial since it aids in the penetration of air and water. The entire area occupied by the ring, to include a 2-foot (60 cm) periphery beyond the ring, should be aerified to remove soil cores on 2- to 4-inch (5.0 to 10 cm) centers. The area should then be irrigated to a depth of 4 to 6 inches (10 to 15 cm). Use of a wetting agent should help improve water infiltration. **The ring area should be re-treated in a similar fashion at the earliest indication of drought stress—that is, repeat the process whenever the dark-green grass turns blue-gray and begins to wilt.** When an aerator is not available, a deep root feeder with a garden hose attachment may be useful to force water into the dry soil. Apply recommended

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FEATURE ARTICLE

The Effects of Drought on Weed Control with Postemergence Herbicides

Fred Yelverton

The effectiveness of postemergence herbicides can vary widely depending on a variety of conditions that exist at application. Of course, application rates, spray volumes, size of weeds, and application accuracy and precision are all very important for controlling weeds with postemergence herbicides. However, **a very important aspect of control involves weather conditions around the time of application.** In particular, the physiological growth state of the weeds that are the target of control measures is extremely important. **Weeds that are actively growing are much easier to control than those that are not actively growing.**

What are the conditions that lead to actively growing weeds? There are several, but none are more important that soil moisture. **Drought-stressed plants (weeds) are extremely difficult to kill with postemergence herbicides.** This is because of the effect a lack of water has on the leaf cuticle. Before this relationship is discussed, it is important to understand what the leaf cuticle is and its importance in herbicide uptake.

The leaf cuticle is the outermost layer of all aerial plant parts. It is composed of a complex layer of waxes and the outermost coating of the cuticle is called the epicuticular wax. The cuticle prevents excess water loss from transpiration and provides plants some protection against a variety of things including insects and diseases. This waxy cuticular layer is hydrophobic, which essentially means that it repels water. The best analogy of how water interacts with the cuticle of plants is when wax or polish is applied to a vehicle. When wax is applied to a vehicle, water is repelled due to an increase in surface tension. This is exactly what happens when a spray solution is applied to a leaf surface. Further, the thicker this waxy cuticle is, the more surface tension exists and the more water is repelled.

Leaves that develop under conditions of low soil moisture tend to develop a thicker epicuticular wax than those that develop under high soil moisture. Why is this important to control with postemergence herbicides? Because all postemergence herbicides must be absorbed through this cuticle. **The thicker the cuticle, the more difficult penetration of herbicides becomes.** Less penetration and absorption into the leaf translates into reduced herbicide performance (reduced control).

It is also noteworthy to comment on the roll of stomata in herbicide uptake. The primary roll of stomata in plant growth involves gas exchange and evapotranspiration (plant cooling). In addition, the location of stomata is primarily on the lower leaf surface, although some can be found on the upper surface and there is species-to-species variation in their distribution. But the important point is **stomata have an insignificant roll in the uptake of herbicides. Postemergence herbicides are primarily absorbed through tiny cracks in the leaf cuticle.** And a cuticle that is thin is more easily penetrated than a thick cuticle.

In summary, postemergence herbicide performance will be reduced when applied to drought-stressed plants. This can be alleviated to a significant degree by watering a couple of days prior to application of herbicides if a drought condition exists.

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amounts of nitrogen at the appropriate time of year to help mask fairy rings. Fairy rings, however, can be stimulated by excessive nitrogen or organic matter.

Fungicides are sometimes effective in suppressing Type 1 fairy rings. Aerification followed by drenching with either Bayleton® (triadimefon), Heritage® (azoxystrobin), or ProStar® (flutalonil) have been shown to suppress, but not necessarily eliminate, some fairy rings. A fungicide should be tank-mixed with a wetting agent and watered-in as deeply as possible. For best results, affected sites should be aerified (or at least spiked if core aeration is not an option) and pre-irrigated to moisten soil, thus improving movement of the fungicide and wetting agent into the soil. **Fungicide-wetting agent combinations should be applied in large amounts of water (i.e., 150 gal water per acre; 1,400 L/ha) and watered-in as deeply as possible on a 4-week interval or whenever drought symptoms recur.**

Research Summary

Polystand Composition Succession of Cool-Season Turfgrass Communities

Investigations were conducted in which turf-type tall fescue (*Festuca arundinacea*), dwarf tall fescue, Kentucky bluegrass (*Poa pratensis*), and perennial ryegrass (*Lolium perenne*) were seeded in eight combinations as species mixtures at two locations under irrigated and non-irrigated conditions. The experimental site was established in 1991 on a silt loam soil in central Missouri. The turfs were mowed at 0.75 and 2.0 inches (19–51 mm), twice weekly with the clippings returned. The experimental area was fertilized with 1.0 lb per 1,000 ft^2 (48 kg • ha^{-1}) of 20 N-4 P - 8 K in March, September, October, and November, for an annual total of 4 lb per 1,000 ft^2 per year (192 kg • ha^{-1} yr^{-1}). A modified Brinkman Traffic Simulator was applied to the turfs in October 1993, involving 15 passes on one-half of each mowed plot at an interval of three times per week for two weeks. The plot layout was a randomized complete block design in a split-split-plot arrangement with three replications. The study involved a five-year period of observations.

Perennial ryegrass became the dominant species in all polystands with tall fescue, Kentucky bluegrass, or both. This study revealed that the seed mixtures containing only 20% perennial ryegrass by weight with Kentucky bluegrass will eventually result in dominance by the perennial ryegrass under the conditions of this investigation.

After five years the turf-type tall fescue comprised 82% of the polystand with Kentucky bluegrass, while dwarf tall fescue comprised 48% of the polystand with Kentucky bluegrass.

The Kentucky bluegrass was more competitive to tall fescue in the irrigated than in the non-irrigated experimental area. The mowing height caused small changes in polystand composition from year to year, while the one period of simulated traffic had little effect on the polystand composition one year following the stress simulation treatment. In terms of turf recovery following traffic stress stimulation, polystands containing Kentucky bluegrass with tall fescue recovered more rapidly than a blend of tall fescue cultivars.

There was a distinct advantage in using a mixture of species, compared with the use of an individual species in terms of reducing the severity of disease occurrence. Dollar spot (*Sclerotinia homoeocarpa*) was the most prevalent disease during the five-year period and infected primarily the perennial ryegrass, with little occurrence on Kentucky bluegrass. Brown patch (*Rhizoctonia solani*) occurred primarily on the tall fescue, and occasionally on the perennial ryegrass. The irrigated turf plots tended to have more dollar spot. Brown patch damage was more apparent on the non-irrigated plots of tall fescue, possibly because of the slow recovery rate from disease injury.

Comments. The relative competitive ability and the resultant composition of cool-season turfgrass polystands can vary with the location in which the experiment is conducted. This is to be expected in that the environmental stresses and types of disease/insect problems may vary in severity and in relation to the particular turfgrass species they most strongly influence. Thus, **in the interpretation of results from polystand composition studies one should consider the particular regional environment rather than making broad continent application.**

Source. *Turf performance of mixtures and blends of tall fescue, Kentucky bluegrass, and perennial ryegrass* by J.H. Dunn, E.H. Irvin, and B.S. Fresenburg. *HortScience* 37(1):214–217, 2002.

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was planted to achieve the desired initial landscape effect. The original intention was for many of these trees to be removed over time as adjacent trees grow larger.

Wind movement can be improved by judicious pruning and/or the elimination of thick underbrush and shrub plantings that form dense encircling screens. **Maximum air drainage is achieved if selective clearing of underbrush is done in the direction of prevailing winds.** The beauty of a landscape is sometimes enhanced by new vistas through selective shrub or tree removal. More favorable temperature and relative humidity regimes are the benefits of unimpaired air movement. Disease development is also reduced due to the lower relative humidity and more favorable conditions for drying.

Most tree species are shallow rooted. The roots will extend beyond the perimeter of the tree drip line into adjacent irrigated turf areas. Root competition for water is especially critical in dryer climates and in situations where trees are growing adjacent to an irrigated turf. **Pruning of shallow tree roots is an effective practice in alleviating competition for nutrients and water. The best approach is trenching to a 2- to 3-foot (0.6–0.9 m) depth at a 4- to 5-year interval.** The installation of vertical physical barriers is seldom effective.

JB Comments

Spring Turfgrass Cultural Strategies

Spring is the season between winter and summer, which is defined in the northern hemisphere by the period from the March ~ 21 equinox and the June ~ 22 solstice. The initial seasonal appearance of green grass shoots as the spring temperature and moisture conditions become favorable for growth, which thereby breaks winter dormancy, is termed **spring greenup.**

Cool-Season Turfgrass Responses. **The temperature of the soil is the primary factor affecting the initiation of new root and shoot growth of cool-season turfgrasses in the spring.** Cell division in the roots of certain cool-season turfgrasses, such as Kentucky bluegrass (*Poa pratensis*), has been noted to occur at temperatures as low as 34°F (1°C). However, other species, such as creeping bentgrass (*Agrostis stolonifera*), require higher temperatures. **Significant root growth of most species does not occur until soil temperatures are above 42°F (5°C).** The roots formed at suboptimal temperatures tend to be thick, white, less branched, and shorter than at more optimum root growth temperatures of 50 to 65°F (10–18°C). Typically, rhizome growth occurs at comparable temperatures to that of root growth in case of perennial, C_3, cool-season turfgrasses.

Shoot growth tends to be initiated at somewhat warmer soil temperatures than are observed for root and rhizome growth. Typically, the optimum temperatures for tillering of cool-season turfgrasses are somewhat lower than the optimal for shoot growth. Also, tiller growth at suboptimal temperatures tends to be more horizontal in nature. The rate of new leaf appearance is the most rapid during the spring growing period.

This is followed by a rapid leaf extension rate that dictates the need for timely mowing to avoid removing no more than one-third of the leaf tissue at any one time. **If an excessive amount of leaf growth is allowed to occur that is subsequently defoliated severely at any one mowing, it typically results in a cessation in root growth and possibly even dieback of the root system.** This is caused by the physiological process of carbohydrate partitioning. The severed defoliation causes plant hormonal activity that results in carbohydrates being directed principally to recovery of leaf growth. If there are not enough carbohydrates available, the result may be a slowing of root growth or even root death. If for some unavoidable reason an excessive amount of shoot growth occurs during the spring period, a return to the original cutting height should be accomplished by lowering the height gradually over a series of mowings.

During the period of peak leaf growth in the spring at temperatures of 60 to 75°F (16–24°C), the carbohydrate reserves tend to be depleted or even exhausted in case of cool-season turfgrasses. Accordingly, it is important to minimize the application of nitrogen fertilizers in this peak shoot growth period, as excessive amounts of nitrogen force even greater shoot growth to the detriment of the carbohydrate reserves and the root system.

Warm-Season Turfgrass Responses. Typically the roots of perennial, C_4, warm-season grasses remain white and apparently functional throughout the winter dormancy period when the aboveground leaves have died and turned tan to brown due to chill stress injury. **The initiation of new green shoots from the meristematic areas on the lateral stems typically occurs when soil temperatures at a 4-inch (100 mm) depth reach 64°F (18°C). If there is a continued rapid rise to higher soil temperatures at this time there is a great likelihood that spring root decline (SRD) will occur in the warm-season turfgrass species.** SRD is characterized by the death of the roots of perennial, C_4, warm-season turfgrasses during rapid soil warming after winter dormancy. It is associated with very rapid shoot growth that causes a partitioning of carbohydrates away from the roots. Typically all the roots die, with new replacement roots originating from the meristematic nodes on the grass crowns and lateral stems. Root regrowth may not occur for two to three weeks after the occurrence of SRD. **Accordingly, the implementation of cultural practice such as (a) close mowing, (b) nitrogen fertilization, or (c) severe vertical cutting of shoots after spring root decline has occurred will significantly delay replacement of the root system.** Should spring root decline occur, it is very critical that frequent, timely irrigations be practiced to minimize the chance of shoot loss by desiccation.

As optimum shoot growth of warm-season turfgrasses does not usually occur until temperatures are in the 80 to 95°F (27–35°C) range, peak shoot growth typically does not occur during the spring period.

Strategy for Spring Turfgrass Culture. With the rapid shoot growth and minimal environmental stresses of cool-season turfgrasses in the spring, turfgrass managers can be falsely lulled into a secure mind-set that problems will be minimal. However, **the very rapid leaf growth makes it critical that the proper frequency of mowing and a very modest to minimal use of nitrogen fertilization be practiced in order to sustain proper carbohydrate reserves for root growth.** A similar type strategy is important in relation to vertical cutting and nitrogen fertilization of warm-season turfgrasses, especially if spring root decline occurs. Also, an application of iron can prove beneficial during the spring greenup period for warm-season turfgrasses. Maintaining high potassium levels during the spring growth period is important, especially in terms of

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root growth and lateral stem development of both warm- and cool-season turfgrasses.

In the case of cool-season turfgrasses, a pre-greenup application of water soluble nitrogen at a controlled rate can stimulate earlier spring greenup. A similar increase of approximately two weeks in early spring greenup can be achieved through the application of gibberellic acid. This strategy generally should not be utilized unless there is a critical need for early spring greenup, such as on baseball fields.

In terms of timing the application of preemergent herbicides, it is important that they not be applied until after root initiation and downward extension to a depth of 2 to 3 inches (50–75 mm) has been achieved. This strategy can be especially important with creeping bentgrass and the warm-season turfgrasses.

Ask Dr. Beard

Q. *Concerning the USGA Method of high-sand root zone construction, is it better to include the intermediate coarse-sand layer or to eliminate it?*

A. Research has shown that either method can be used. From a personal standpoint, I definitely prefer to include the intermediate layer. The interest in eliminating the intermediate layer on the part of certain individuals is primarily a cost-driven issue. In this approach there also is a mind-set that if you can eliminate the intermediate layer one also can be more "flexible" in varying the underlying gravel layer and the above high-sand root zone. Point in fact, **it is more critical to be well within the specifications for these two root zone layers if the intermediate layer is not included and that greater attention is needed in accomplishing proper construction.**

Also we must remind ourselves that the USGA Method guidelines involve a set of ranges and not absolute single values. It is important that the constructions materials used and the specified depths are within this range. Otherwise it is not a USGA Method construction. Frequently I encounter the term "modified USGA construction," wherein the materials or depths used are outside the guideline ranges. In many cases these fail to perform adequately. **The point is that there is no such thing as a valid "modified USGA construction" in terms of successful long-term performance.** Construction utilizing materials and techniques outside these guidelines greatly increase the probability of failure. One of the problems in this regard, is that the failure may not appear until four to six years later. The original decision maker with minimal technical knowledge cannot relate the subsequent failure to the original decision to not follow the USGA Method guidelines.

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