Volume 6, Number 3

TURFAX™

May–June 1998

of the International Sports Turf Institute, Inc.

The International Newsletter about Current Developments in Turfgrass

IN THIS ISSUE

Turfax Projections

The El Nino effect is causing major seasonal climatic changes in many parts of the world: extended winter cloudiness from Florida west in the United States: continual rainy periods along the Atlantic Coast states of the U.S.; mild winter in the North Central U.S. Summer droughts in Australia and parts of the South Pacific. A relatively warm winter in the United Kingdom and Scandinavia.

Turfgrass managers who implement cultural practices based on calendar dates or traditional seasonal changes could be faced with significant problems. These major climatic changes from the seasonal norms dictate adjustments in turfgrass cultural programs based on a sound understanding of basic principles.

* * *

Golf course construction and golf play remain very active due to favorable economic conditions in the United States; while a major slowdown has occurred in the Pacific Rim Countries which follows a strong period of growth. A slowing of new construction to more realistic levels has occurred in Europe.

Sports field and stadium constructions also are very active in many parts of the world. Certain countries are especially active. France has completed preparations for the soccer World Cup 1998 and Malaysia has completed construction for the Commonwealth Games of 1998. Australia is involved in major construction for the Sydney 2000 Olympics, and Japan/South Korea are progressing well in developments for the soccer World Cup in 2002.

There is a great need for more public golf courses in many parts of the industrialized world, including the United Kingdom, Japan, United States, and most European countries. The National Golf Foundation reports that 66% of the golf rounds played annually in the United States are on public golf courses. Furthermore, 79% of all golfers play a majority of their rounds on public golf courses.

The demand for sod to be used on new construction sites remains high in most regions of the United States. The problem for many sod growers is maintaining adequate inventories. **Sod marketing exclusives of proprietary cultivars are increasing,** especially for warm-season turfgrasses.

* * *

Consolidations of companies involved with the turfgrass industry are moving at a pace that has never before occurred, and will continue. During the past year:

- Jacobsen Division of Textron Inc. acquired Ransomes/Cushman/Ryan.
- The Scotts Company acquired Emerald Green, Miracle Garden Care Ltd., Levington Horticulture Ltd., Earthgro, Sanford Scientific, Inc. and the U.S. Home and Garden Consumer Products Business of AgrEvo Environmental Health, Inc.
- AgriBioTech, Inc. acquired 18 turfgrass and forage seed companies in the United States, including Fine Lawn Research Inc., Lofts Seeds, Inc., Willamette Seed Co., and Zajac Performance Seed.

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What Causes Weed Population Shifts in Turf?

Fred Yelverton

In the March–April issue of Turfax™, we discussed how repeated use of the same herbicide or herbicides with the same mode of action can result in herbicide resistance. This is brought about by exerting selection pressure on a resistant biotype of the weed species that already exists in a weed population. Another problem caused by utilizing the same herbicide or herbicides with the same spectrum of weed control year after year is a weed population shift. A weed population shift is simply a shift away from a weed species that used to be a problem to a weed species that was not a problem in the past, but has suddenly become a problem. To explain it another way, it is a shift away from an old weed problem to a new weed problem.

How do weed population shifts occur? **Because individual herbicides only control certain weeds, repeated use over time can successfully control the weed species you have been trying to manage, but weed species that are not readily controlled by that herbicide increase in abundance over time.** In some cases, these population shifts can occur very rapidly. The following is a hypothetical example of how a weed population shift can occur. Suppose you start a job as a golf course superintendent at a golf course that has a high crabgrass (*Digitaria* spp.) population. You decide to utilize the best crabgrass herbicide available. Also, suppose this herbicide only provides fair control of goosegrass (*Eleusine indica*). Over time, you might see a weed population shift from crabgrass to goosegrass.

A change in herbicide use practices also can cause weed population shifts. In this case, a new or different herbicide or class of herbicides is being used to manage specific weeds. An example of this is with the use of simazine for winter annual weed control in warm-season turfgrasses. Simazine is commonly used for annual bluegrass (*Poa annua*) control in nonoverseeded warm-season turf species in many areas of the world. Because of annual bluegrass resistance to simazine in some areas, turfgrass managers have had to shift to other herbicides, such as those used for crabgrass/goosegrass control or to pronamide (Kerb®). All of these herbicides are effective on the annual biotypes of annual bluegrass, but are not nearly as effective as simazine on many winter annual broadleaf weeds. As a result of switching to these herbicides, an increase in winter annual broadleaf weeds has occurred.

Perhaps the most common new turfgrass weed problem is the incidence of various sedge species in recent years. The most common of these has been with two species of kyllinga: **green kyllinga (*Kyllinga brevifolia*) and false green kyllinga (*Kyllinga gracillima*). These two sedges have come from relative obscurity to become major turfgrass weeds in the last 5 years** in many areas of the United States. In many southern states, they are now two of the most problematic weeds on golf courses. They are spreading rapidly and extending their range. New cases are being reported in the southern tier of states from the east to west coasts. In addition, false green kyllinga is spreading northward and is a major weed problem in cool-season turf in the mountainous regions of midwestern North Carolina and Tennessee where the climate is very similar to many northern and midwestern states. It remains to be seen how far into the cool-season turfgrass areas it will spread; however, botanical specimens have been collected as far north as southern New York and Connecticut. Green kyllinga appears to be less cold tolerant and will probably be restricted in distribution to the warm-season turfgrass areas of the United States.

According to botanical records, green kyllinga was established in the United States over 100 years ago. Why then has this weed only become a problem in the last several years? Of course nobody knows all the answers to this question. However, the occurrence of these weeds on golf courses in recent years is probably due to a change in crabgrass/goosegrass control strategies. Research has shown the arsenical herbicides (MSMA, DSMA, CMA) provide a relatively high level per year for crabgrass control. With the development of highly effective preemergence crabgrass/goosegrass herbicides in the last 20 years, the arsenical herbicides are used much less than in previous years. Research also has shown that the preemergence crabgrass/goosegrass herbicides offer essentially no control of these two *Kyllinga* species.

FEATURE ARTICLE

Pythium-Induced Root Dysfunction of Creeping Bentgrass Greens

Peter H. Dernoeden

Pythium species are associated with all turfgrasses and cause seed decay, postemergence damping-off, foliar blight, root and crown rot, and snow blight. **Foliar blight is known as Pythium blight, cottony blight, grease spot, and spot blight. This disease is most destructive during hot and humid periods. The initial symptoms of *Pythium* blight appear as small, circular spots or patches.** On creeping bentgrass (*Agrostis stolonifera*) greens, infected patches turn orange or brown and gray "smoke rings" may appear at the periphery of infected patches. Infected leaves appear slimy and matted, and eventually turn brown when dry. During prolonged periods of high humidity, fluffy grayish-white masses of mycelium may appear on collapsing leaves. Large areas of turf may die within hours due to the coalescence of numerous patches. Six Pythium species (i.e., *Pythium aphanidermatum; P. graminicola; P. myriotylum; P. torulosum; P. ultimum* var. *ultimum;* and *P. vanterpoolii*) are causal agents of *Pythium* blight. *Pythium aphanidermatum* was isolated as early as 1926 from diseased creeping bentgrass in Rossly, Virginia by Dr. John Monteith, and is the most common incitant of foliar blight in the United States during periods of high temperature and humidity.

Unlike foliar blight, ***Pythium* root and crown rot may occur throughout the entire growing season. It primarily develops during cool and wet periods of spring, causing a general decline of the turfgrass stand.** The symptoms of this decline are very difficult to describe and a **positive diagnosis requires a laboratory analysis.** In the northeastern United States, nearly all cool-season turfgrasses may be affected by *Pythium*-incited root diseases during prolonged periods of wetness, regardless of temperature. Annual bluegrass (*Poa annua*) and creeping bentgrass grown on greens, however, are the primary turfgrasses affected.

Pythium species are common inhabitants in the roots of creeping bentgrass and other grasses. The name Pythium root rot was probably first used by Dr. Robert Endo in 1961 to describe damping-off of turfgrass seedlings as well as a root rot of more mature plants in California. Hodges and Coleman (1985) described a secondary root Pythium disease of turfgrasses, which they named ***Pythium*-induced root dysfunction.** The occurrence of root dysfunction on secondary roots of creeping bentgrass was associated with renovated golf greens grown on high–sand content mixes in Iowa. They found that secondary roots of plants infected with *Pythium aristosporum* and *P. arrhenomanes* were not killed, and root lesions or rotting were not observed, although plant growth was reduced extensively. Spore-bearing sporangia and the thick-walled, resistant oospores were rarely found in infected roots by Hodges and Coleman (1985). These observations suggested that *P. aristosporum* and *P. arrhenomanes* were not virulent pathogens of creeping bentgrass. According to Hodges and Coleman (1985), the level of injury inflicted by these root infecting *Pythium* species depends on plant growing conditions and high temperature stress.

In recent years, the pathogenicity of *Pythium* species that infect turfgrass roots has received more study. In 1991, Nelson and Craft reported *Pythium* root rot in New York State and found *P. graminicola, P. aphanidermatum, P. aristosporum, P. torulosum,* and *P. vanterpoolii* were pathogenic to creeping bentgrass seedling roots maintained under both cool 55°F (13°C) and warm 82°F (28°C) temperatures. Based on recovery frequency and virulence studies, Nelson and Craft (1991) concluded that *P. graminicola* was the principal species associated with turfgrass root rot in New York State. In North Carolina, Abad et al. (1994) obtained 237 *Pythium* isolates from creeping bentgrass. They reported that 29 of 33 *Pythium* spp. isolated from turfgrasses were pathogenic to primary roots of creeping bentgrass seedlings. Among these species, *P. arrhenomanes, P. aristosporum, P. aphanidermatum, P. graminicola, P. myriotylum, P. tardicrescens, P. vanterpoolii,* and *P. volutum* were highly aggressive. Sixteen of the 29 species were only weakly or nonpathogenic. They concluded that *P. arrhenomanes* was the most important pathogen causing root and crown rot of creeping bentgrass in North Carolina. Both Nelson and Craft (1991) and Abad et al. (1994) found that *P. torulosum* was the most frequently recovered species from turfgrasses exhibiting symptoms of root and crown rot. *Pythium torulosum* also was reported to be commonly isolated from the roots of cool-season grasses in California (Endo, 1961). Several researchers, however, reported that *P. torulosum* was weakly pathogenic or nonpathogenic.

Feng (1998) found eight species of *Pythium* (i.e., *P. aristosporium, P. aphanidermatum, P. catenulatum, P. graminicola, P. torulosum, P. vanterpoolii, P. ultimum* var. *ultimum,* and *P. volutum*) associated with the roots of creeping bentgrass greens in Maryland and adjacent states. *Pythium torulosum* was the most common species isolated.

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Although most *P. torulosum* isolates had low virulence or were nonpathogenic it appeared that this species must be able to cause root dysfunction when found in high populations. *Pythium aristosporium* was the most common and virulent species isolated from Maryland putting greens. ***Pythium*-induced root dysfunction was primarily found during mid to late spring (May and June) on new golf courses or older greens recently renovated with methyl bromide.** The most destructive cases appeared just after seeding in October and November or in the spring following an autumn seeding. As noted below, *Pythium*-induced root dysfunction and not root rot was the primary problem found on Maryland greens. Clearly, more research information is needed to help diagnosticians distinguish between Pythium root rot and root dysfunction. *Pythium*-induced root dysfunction, however, appears to be more commonly associated with new golf courses or methyl bromide–renovated greens.

Symptoms. The symptoms of *Pythium*-induced root dysfunction are nonspecific, making it one of the most difficult diseases to diagnose. In immature bentgrass greens, the leaves of infected plants are yellow, stunted, and tend to be narrower than leaves of healthy plants. In most situations, there are dark green, perfectly healthy looking plants dispersed throughout pockets of chlorotic and diminutive plants. **Mixed within chlorotic areas, small patches turn brown and die. Death of plants generally first appears at the outer periphery of the greens.** This is due to two reasons. First, the *Pythium*'s likely ingress at the point where the mineral soil and greens' mix meet. Death of plants, however, is due to a combination of mechanical injury from mowing stressed plants with dysfunctional root systems. More mechanical injury occurs at the point where the greens mower enters a curved area, where the mower must turn. The turning action twists and grinds infected leaves and stems, placing a lethal stress on infected plants. **Eventually, large areas throughout the entire putting surface may die. The disease is generally more severe on shaded or pocketed greens.**

In mature creeping bentgrass, leaves of infected plants may be chlorotic or they may develop a reddish-brown color and the turf exhibits a loss of density. These symptoms mimic basal rot anthracnose. For annual bluegrasses (*Poa annua*), the leaves appear yellow-brown or reddish-brown in color before plants die. Disease develops primarily in pockets and often is most pronounced in low areas or follows the drainage pattern. Some injury, however, may be observed throughout the putting surface even in higher, well-drained areas. *Pythium*-induced root dysfunction, however, was seldom observed in greens older than 3 years in the Maryland and Iowa studies.

Washing soil from infected plants and observing roots for symptoms often provides no useful clues. Infected roots may have lesions or a generalized light-tan to brownish discoloration, which can only be seen with a microscope. In North Carolina, researchers sometimes observed brown colored and twisted root tips (Abad et al., 1994). Discoloration or rotting of crowns and roots of infected plants was observed by researchers in New York and North Carolina (Abad et al., 1994; Nelson and Craft, 1991). Hodges and Coleman (1985), however, found no rotting or discoloration of the root system from bentgrass greens in Iowa. Similarly, in Maryland we also have found a general lack of any pronounced discoloration or lesion development on bentgrass roots, including roots containing huge numbers of oospores.

Disease Management. The disease must be aggressively managed by a combination of cultural and chemical means. *Pythiums* grow and reproduce rapidly in wet soils, so **drying the soil is essential.** This is obviously difficult, because the root systems of infected plants are unable to absorb and translocate sufficient amounts of water and nutrients. Irrigation from sprinkler heads must be replaced by **frequent hand syringing on an as-needed basis. Affected greens should only be mowed when dry and with a lightweight, walk-behind greensmower.** Never mow affected greens on rainy days or when the surface is excessively wet. Mowing height should be increased (i.e., >5/32″) and frequency of mowing reduced to 4 or 5 times weekly. Remove grooved rollers from mowers and replace them with solid rollers. Avoid other potential mechanical stresses by delaying topdressing, brushing, vertical cutting, and both core and water injection cultivation until the disease has been controlled.

There are no published studies that have investigated the performance of fungicides against *Pythium*-incited root diseases. In most cases, a battery of fungicide applications is recommended. This may involve an application of fosetyl-aluminum + mancozeb (Aliette® + Fore®), followed in 5 to 7 days with an ethradiazol (Koban®) or chloroneb (Terraneb SP®) drench. Thereafter, alternating metalaxyl (Subdue MAXX®) and propamocarb (Banol®) applications on a 10 to 14 day interval is suggested. **Experience has shown that some fungicides ameliorate the condition and some do not. This is due to the many different species of *Pythium* that can be involved, and it is likely that various *Pythium* species will be affected differently by fungicides having varying modes of action.** Of the aforementioned, only Aliette® + Fore® is not watered-in. The others should be watered-in to a depth of 0.5 to 1.0 in. (1.0–2.5 cm). A syringe cycle from the irrigation system usually provides sufficient water to move fungicides into the effective zone immediately following a fungicide application. Among these five fungicides, most superintendents find one or two products that perform best. In extreme cases, a fungicide application may be required on a 7 to 10 day interval throughout much of the growing season, particularly in wet years. Applications of biostimulants and micronutrients are proposed along with fungicides, but their overall impact on the condition is unknown. The disease in young bentgrass greens can recur for 2 to 3 years following an autumn seeding. Mature bentgrass greens appear to be less susceptible to injury. Conversely, annual bluegrass on greens in more northern climates may be more chronically affected.

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New Prospects for Controlling Ants on Putting Greens

Daniel A. Potter

Small mound-building ants can be a big problem on golf courses, especially on high-sand root zone putting greens. These ants nest underground, pushing up small, volcano-like hills of soil around the nest entrances. The mounds are unsightly, deflect golf balls, and dull mower blades. Unlike fire ants (*Solenopsis* species), which are a hazard in warm-season turfgrasses in the southern U.S., these nuisance ants don't bite or sting. However, with current insecticides, they often require a high frequency of treatment to prevent the mounds from smothering the closely mowed putting green turf, especially bentgrass. Control usually is only partial, at best.

Our research suggests that most of the ant problems on putting greens or tees in the eastern United States are caused by a single species, *Lasius neoniger*. This small brown ant prefers to nest in open, sunny areas and also is found in lawns, cultivated fields, and grassy road strips. The nest is composed of many shallow, interconnected chambers, most less than 1 ft (< 30 cm) underground, but sometimes as deep as 2 ft (60 cm). Each nest has multiple openings that are marked by small, 1 to 3 inch [2.5 to 7.5 cm] craters, often 10 or more per square yard (1 m^2). A nest has only one reproductive female, or queen, who lays eggs in a deep chamber. Each colony also contains thousands of workers that excavate chambers, tend to the queen, care for the eggs and larvae, and forage on the surface for food, which includes small insects, seeds, and the sugary excrement of aphids. Winged reproductive ants are produced in late summer. After swarming and mating, each new queen flies to a suitable nest site to start a new colony.

***Lasius* ants are important predators on eggs of cutworms, sod webworms, and white grubs.** In our research, we allowed black cutworm moths to lay eggs on a creeping bentgrass turf and then transplanted cores containing hundreds of eggs into fairways and roughs. Ants consumed >90% of the eggs within one night! Thus, these ants are beneficial except when the nests occur in high profile areas.

Ant control on golf courses is a frustrating and often futile experience. This is because **insecticide applications kill some worker ants foraging on the surface, but fail to eliminate the queen. Among the currently labeled products, lambda-cyhalothrin (Scimitar®), bifenthrin (Talstar®), and chlorpyrifos (Dursban®) will provide temporary control, often suppressing mound-building activity for 3 weeks or longer.** It works best to initiate control measures in early spring, as soon as the first mounds appear. At that time, the colonies are small and still weak from overwintering, so the treatment may kill enough worker ants to further stress the colony and possibly eliminate the nest.

Several new ant baits have quickly gained wide use by the structural pest control industry, and this concept may soon provide better options for golf course superintendents, too. **These baits contain special combinations of protein, carbohydrates, fats, and other attractants that draw the ants to the bait. The active ingredients, either abamectin, hydramethylnon, or spinosad, are not detected by the worker ants, have no known resistance, and have very low toxicity to humans and other nontarget species.** The granules are picked up by the worker ants and carried back to the nest. Importantly, these selective insecticides act slowly enough to allow the foraging ants to make several trips to the bait before they're killed, ensuring that the entire colony, including the queen, is exposed and eliminated. The baits could be sprinkled selectively to eliminate individual nests, or broadcast at low rates. Because the ants seek out the bait, it may be possible to spot-treat the approach or bordering rough without treating the green itself. Several effective baits are already in use, or soon to be labeled, for fire ants, and products for general, outdoor ant control are being tested. Some fine-tuning may be necessary to ensure that these baits are attractive to nuisance species such as *Lasius*.

Fipronil, the active ingredient in Chipco Choice®, is another target-selective insecticide with exceptional activity against ants. It is presently labeled for mole crickets, and registration for fire ants is pending. Applied as a broadcast (non-bait) treatment, the residues adhere to worker ants as they move through the turf. The insecticide is passed from ant to ant during grooming and other activities so the colony, including the queen, is quickly eliminated. Fipronil residues are persistent in soil, providing the potential for season-long control from one application. Researchers are working on a granular fipronil product to be applied by superintendents.

So, as you battle recurring ant problems on putting greens, take solace in the likelihood that effective new products are on the horizon.

Daniel A. Potter is Professor of Entomology at the University of Kentucky. His new book, "Destructive Turfgrass Insects: Biology, Diagnosis, and Control" *is available from Ann Arbor Press.*

...Root Dysfunction...

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Turfax Projections

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- Central Garden and Pet acquired Pennington Seed, Inc. and Seeds West, Inc. (formerly Farmers Marketing).
- The Toro Company acquired James Hardie Irrigation, Exmark Manufacturing, and Dingo™ Digging Systems.
- J.R. Simplot Company acquired Jacklin Seed.
- The Monsanto Company and American Home Products recently have announced plans to merge, which includes the Crop, Turf, and Ornamental Section of American Cyanamid.

A key driver in these acquisitions is the **rapid biotechnology developments** toward transgenic turfgrass cultivars and the progress being made in biological control agents for pests of turfgrasses.

* * *

Putting green construction with **a high-sand root mix and a perched hydration zone will continue to increase** worldwide, on greens subject to intensive play.

The next 5 years will see **a major emphasis on the conversion of putting greens** composed of creeping bentgrass (*Agrostis stolonifera*) or dwarf hybrid bermudagrass (*Cynodon dactylon* x *C. transvaalensis*) to the newer cultivars that can sustain high shoot densities at cutting heights below 4 mm.

Emphasis on **use of slow-release nitrogen and potassium carriers** as a key part of turfgrass fertilization strategy.

Increased use of a fertilization strategy for putting greens involving **macro applications of granular fertilizer combined with micro applications of foliarly applied nutrients** at light rates to make short-term, minor adjustments in turfgrass responses as needed.

Increasing use of **intensive sand topdressing on poorly drained, clayey fairways.**

The use of **three-dimensional, interlocking mesh in root zone stabilization** of turfed sport fields, race tracks, and golf course tees and cart paths will increase worldwide.

A very desirable trend which is not yet at a significant level would be **the use of composted, living organic matter sources** in the original construction of root zones and in subsequent topdressing mixes.

The trend is to a smaller total area devoted to fairway turf on many golf courses, but with a higher intensity of culture and with an increased area of intermediate rough.

Genetic transformation will provide for cultivars that better resist pests and tolerate herbicides. Some genetically improved germplasm will be delayed entering the market due to legal and patent problems.

Some relatively effective biological agents will be marketed in the next several years. Because of environmental factors, consistently efficacious biological agents may never be developed that will match the performance of the chemical pesticides.

Many new effective pesticides will be developed from chemicals produced naturally by plants and microorganisms.

Rough bluegrass (*Poa trivialis*) is rapidly surpassing annual bluegrass (*Poa annua*) as one of the most difficult-to-manage weeds on golf courses where cool-season turfgrasses are grown. Currently, there are no herbicides that selectively control rough bluegrass in cool-season grasses. It must be spot-treated with a nonselective herbicide or physically removed.

Moss problems will increase rapidly on closely mowed putting greens, with **more effective moss control methods being developed.** A warning on moss control programs you may read about in the press: **any product used to control moss is technically illegal unless moss control is stated on the label.** Any product used to mitigate a pest problem is considered a pesticide by the U.S. EPA, and thus must be labeled for that use.

Look for a trend of **even greater restrictions regarding setbacks from wetlands and aquatic ecosystems.** Policy-makers continue to ask more questions about the fate of nutrients and pesticides applied to golf courses.

"Open House" Approach

How many times has one heard the comment that the golf course superintendent is the guy that mows the grass? What can be done to alter this image and improve the overall perspective that the golf course superintendent is a true multi-dimensional professional? One idea is to hold an open house of the Operations Center for club members/golfing clientele. **Note the term Operations Center is used, rather than barn or shed. Image is very important!**

An open house can involve stops where (a) the Irrigation Specialist is present to explain the irrigation system operation, maintenance, and repair activities, (b) the Mechanic is present to discuss the preventive service and repair of equipment, (c) the Assistant Superintendent could be in the office area explaining the computer setup, and (d) the Golf Course Superintendent can serve as greeter. Such an open house may not result in a great turnout, but even the opportunity to show 10, 15, or 20 members around the Operations Center can pay dividends in the long run. It is also an event that forces a total cleanup and organization of the Operations Center both inside and outside. Most facilities need this overall cleanup effort at least once a year. **J.B Beard**

RESEARCH SUMMARY

An Assessment of Mercurial Fungicide Residues in Golf Course Soil and Clippings

During 1997, the Pesticide Management Branch of Alberta Environmental Protection (AEP) sampled ten golf course putting greens throughout Alberta, Canada, that had a wide-ranging history of mercurial fungicide application. Mercury levels in the surface 1.6 in. (40 mm) of soils from greens were often above the Canadian Council of Ministers of the Environment residential/parkland guideline of 6.6 mg/kg total mercury, with average levels ranging up to 139 mg/kg. Mercury levels at a depth of 4.3 to 5.9 in. (110–150 mm) were below the CCME guideline, except at older courses with a long history of mercury application. Fresh grass clippings obtained from the same putting greens showed mercury levels ranging from below the detection level to 5.61 mg/kg. Selected soil and clippings samples were also submitted for leachate testing to determine if the samples would be regulated as hazardous waste. Leachable levels of mercury present were approximately 2 to 3 orders of magnitude (100 to 1000 times) below the regulatory level of 0.2 mg/L.

The results point out the need to develop and implement operational guidelines for the utilization or disposal of grass clippings and turf cultivation cores from putting greens treated with mercurial fungicides. Composting or disposal of clippings or cores in inappropriate locations could result in off-site contamination of soils or water bodies. Also, **course renovations to greens or tees that had been treated with mercurial fungicides must take into consideration the levels of mercury present,** in order that proper management of these contaminated soils can occur, such as temporary on-site storage, on-site entombment, or off-site disposal. **[G. Byrtus, Pesticide Management Branch, Alberta Environmental Protection, in Prairie Turfgrass Research Centre, 1997 Annual Report. pp. 43–47.]**

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JB COMMENTS

The Need for a Gravel Drainbed

A comparison of the rate of water movement through the high-sand root zones of two distinctly different root zone profile constructions reveals an important lesson. Assume profile A involves a 12 in. (300 mm) deep high-sand root zone with an infiltration rate of 4 in./hr (100 mm/h) constructed over a gravel drainbed. Profile B is constructed of a 12 in. (300 mm) deep, high-sand root zone with no gravel drainbed underneath, but with 4 in. (100 mm) diameter drain lines placed at a 12 ft (3.6 m) spacing. In both profiles it is assumed that (a) the construction is over a relatively impermeable clay soil, (b) the high-sand root zone mixes are of the same particle size distribution and physical characteristics, and (c) a water saturated condition exists in the root zone. **In the case of profile A, only 1.5 hrs. are required for water entering the surface of the root zone midway between the drain lines to reach the free-draining condition of the underlying gravel drainbed, while in the case of profile B, more than 48 hrs. are required for water to reach the free-drainage condition of the subsurface drain lines.**

A second major benefit of the gravel drainbed (profile A) is the more uniform moisture conditions. While the moisture content of the overlying root zone mixture will increase with depth, it will be relatively uniform laterally as you go from one location to another across the area. **When the gravel drainbed is omitted, as in the case of profile B, the area midway between the drain lines remains much wetter than the areas above and immediately adjacent to the drain lines.** This unevenness in moisture content makes proper water management difficult.

These comparisons illustrate the vital importance of a gravel or crushed stone drainbed for rapid drainage and the need to use a proper intermediate coarse sand layer and/or a root zone particle size distribution that minimizes the potential for clogging of the gravel or crushed stone drainbed. In the case where no gravel drainbed exists, much of the drainage capacity is related to the water holding capacity of the high-sand root zone, which can eventually become filled during a period of very intense rainfall.

ASK DR. BEARD

Q *Is the use of sugar applications to turfgrasses beneficial?*

A Based on the research conducted by J. Beard in 1957 and 1958, it has been documented that the leaves of creeping bentgrass (*Agrostis stolonifera*) have the capability to take up foliar applied water-soluble carbohydrates, such as glucose, fructose, or sucrose. The first two are monosaccharides and the third is a disaccharide. Further, it was demonstrated that these foliar applied carbohydrates are readily translocated to metabolic sites in the plant where they are utilized in growth processes for the leaves, stems, and roots.

When adequate carbohydrate supplies are not available via photosynthesis and from storage sites within the plant, a foliar application of a water-soluble carbohydrate may prove beneficial. Such conditions include (a) closely mowed turfs growing in the spring and autumn period under favorable temperatures for rapid shoot growth, (b) severe turf scalping that results in root dieback, (c) loss of the root system following spring root decline of warm-season turfgrasses, and (d) during periods of tissue hardening prior to the onset of an environmental stress. Applications of water-soluble carbohydrates are not effective during severe heat stress conditions of midsummer.

While the basic concept of foliar carbohydrate applications has been demonstrated through research conducted 40 years ago, it is only recently that interest has arisen concerning this technique. **Additional practical field research is needed concerning the most effective timings and rates of application.** A potential negative dimension in the use of foliar applied carbohydrates is the potential to induce accelerated spore germination/fungal invasion of turfgrass leaves, which increases the severity of attack by certain fungal causing diseases.

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