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IN THIS ISSUE

Turfgrass Winter Stresses

by

Dr. James B Beard

Winterkill is a general term that encompasses all stresses that may damage turfgrasses during the winter period. It is important to properly diagnose the specific cause of winter injury in order to implement the appropriate practices that will minimize a potential reoccurrence in future winters. Seven types of winter stress are summarized in the accompanying table. Low temperature kill and winter desiccation are the most common winter stress problems. The low temperature pathogens that cause snow mold diseases are additional major winterkill problems and will not be discussed in this particular article.

Low Temperature Kill. Both cool- and warm-season turfgrass species are subject to severe injury caused by low temperature kill. **The extent of injury relates to the size of ice crystal formation within the plant tissues,** which results in mechanical damage to the living portions of cells. **The higher the water content or hydration level in the tissue, the greater the potential for low temperature kill.** Thus, any soil management or cultural practice—such as a low cutting height, high nitrogen nutrition level, low potassium level and/or impaired drainage—that increases the crown hydration level during the autumn hardening period will result in increased proneness to low temperature kill. Contrary to recent widely published reports, it is essential to understand that **high crown hydration is not a cause of winterkill, but rather a precondition** that contributes to increased proneness to lethal injury.

Chilling injury of warm-season species occurs at temperatures of 54 to 60°F (12–16°C), and should not be confused with low temperature kill, which occurs at temperatures well below 32°F (0°C). Chilling stress results in autumn low temperature discoloration of the shoots of warm-season turfgrass species, but does not kill the meristematic tissues of the crowns and the nodes on lateral stems.

Cold Hardening. Turfgrasses have a natural ability to cold harden during the autumn decline in temperature that occurs prior to freezing, which is **at temperatures between 35 and 45°F (2–7°C) for cool-season turfgrasses.** Basically, cold hardening involves physiological adjustments within the plant that maximize the ability of the plant to survive low temperature stress. Two key physiological processes during this event involve the accumulation of carbohydrates, which in turn result in exosmosis, or the outward movement of water from the tissues. The more low temperature hardy species, such as creeping bentgrass and rough bluegrass, have the capability to decrease their tissue water content from 85% to the 65 to 70% range during cold hardening. Accordingly, one should **select cultural practices during this cold hardening period that promote increased carbohydrate accumulation.** These include an elevated cutting height and a moderate to low nitrogen fertilization program. Cold hardened turfgrasses typically have enlarged stem and crown diameters in the autumn due to the accumulation of carbohydrates.

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FEATURE ARTICLE

The New Generation of Fungicides of Microbial Origin

Peter H. Dernoeden

By now, most golf course superintendents in the U.S. have applied or at least heard of the new fungicide Heritage®. What most people may not realize is that Heritage represents a new generation of fungicides, whose active ingredient was derived from a microbe. Use of natural products as fungicides, however, is not entirely new in the turfgrass market. Cycloheximide, which was sold under the trade name of Acti-dione®, was used in the 1960s and '70s on turf to control dollar spot, leaf spot and other diseases. Cycloheximide was a by-product in the production of the antibiotic streptomycin. Streptomycin was derived from the bacterium *Streptomyces griseus*. Cycloheximide was expensive to produce and could be phytotoxic to turf, thus its registration was withdrawn in 1981.

Fungicides of microbial origin can be produced by fermentation (i.e., growing large quantities of a desired microbe in an aerated vat) or the antifungal properties of the microbe can be identified and synthesized in the laboratory. Regardless of how the products are produced, they must undergo the same U.S. Environmental Protection Agency registration rigor that is required for all other pesticides.

Azoxystrobin. Heritage® represents a new class of chemistry referred to generically as beta-methoxy-acrylates. The origin of the first identified compound (i.e., strobilurin A) was a fungus from the mushroom family named *Strobilurus tenacellus*. The common chemical name for Heritage® is azoxystrobin. The strobilurin-based compound was stabilized by adding molecules to the structure to ensure that it was not rapidly broken-down by solar radiation. Because the original compound was slightly changed in the laboratory, azoxystrobin is best described as a synthesized analog of a natural substance.

Heritage® can be taken up by roots and move via the xylem throughout the plant. When sprayed on leaves, it penetrates and moves through the leaf, where some molecules enter the xylem and move upward in the plant from the point of uptake. Because Heritage® only moves upward from the site of uptake, **it is not truly systemic and therefore it is best described as being an acropetal penetrant.** The fungicide provides disease control by interfering with respiration of sensitive fungal pathogens. It blocks electron transfer in the cytochrome bc complex and thus it is single site specific. That is, it only blocks one biochemical event, which means that **the probability for resistance to occur increases greatly** when compared to compounds with multi-site activity.

Heritage® is remarkably broad spectrum and is one of the few turf fungicides with a diverse target list, which includes both root and foliar pathogens as well as *Pythium* diseases. It's demonstrated target strengths include brown patch (and other *Rhizoctonia* diseases such as yellow patch and zoysia patch), summer patch, take-all patch, anthracnose, red thread, and *Helminthosporium* leaf spot. There is not a great deal of evidence, however, that it is as strongly effective against snow molds or *Pythium* diseases as it is against the aforementioned diseases. **Heritage's® greatest known weakness is dollar spot.** It

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Turfgrass Winter Stresses

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Low Temperature Stress Tolerance. Both turfgrass species and cultivars vary greatly in low temperature hardiness. Therefore on sites subject to periodic low temperature stress, **it is important to select cold hardy cultivars as well as species.** Among the cool-season turfgrass species the perennial ryegrasses (*Lolium perenne*), tall fescues (*Festuca arundinacea*), and annual bluegrasses (*Poa annua*) are typically prone to low temperature kill. In contrast, rough bluegrass (*Poa trivialis*) and creeping bentgrasses (*Agrostis stolonifera*) are excellent in low temperature stress tolerance, followed by the Kentucky bluegrasses (*Poa pratensis*).

Among the warm-season turfgrasses Japanese zoysiagrass (*Zoysia japonica*) is the best low temperature hardy species, followed by the dactylon bermudagrasses (*Cynodon dactylon*) and seashore paspalum (*Paspalum vaginatum*). Carpetgrass (*Axonopus* spp.), St. Augustinegrass (*Stenotaphrum secundatum*), and bahiagrass (*Paspalum notatum*) are very poor in low temperature tolerance. **In both the bermudagrasses and the zoysiagrasses, the vegetatively propagated cultivars as a group tend to be more low temperature tolerant.**

Symptoms, Causes, and Prevention of Turfgrass Winter Kill.

Type of Injury	Turf Symptoms	Stress Cause(s)	Practices That Minimize Turfgrass Injury: Cultural	Practices That Minimize Turfgrass Injury: Soil	Specific Protectants
• LOW TEMPERATURE KILL below 30°F (–1°C).	Leaves initially appear water-soaked, turn tan colored and progress to dark brown; leaves limp and tend to lay as a mat over soil; distinct, putrid odor may be evident; occurs most commonly in poorly drained depessional areas as large, irregular patches.	Rapid decrease in temperature, particularly soil temperature; most commonly occurs at soil temperatures below 20°F (–7°C) during late winter/early spring freezing and mid-winter thawing periods.	Maintain a low shoot growth rate for tissue hardening such as by moderately low nitrogen (N) level and high potassium (K) level; use a high cutting height; eliminate any thatch problem; avoid excessive irrigation.	Provide rapid surface drainage by proper contours, open catch basins, and ditches; adequate subsurface drainage by drain lines, slit trenches, and dry wells; modify root zone with high-sand, cultivate turf, especially by coring when compaction is a problem.	Use winter protection cover, especially one that prevents water from reaching the turf to prevent crown hydration; enhance snow accumulation with snow fence or brush; natural organic mulches; soil warming.
• CHILLING STRESS, between 54 and 60°F (12–16°C); occurs only to warm-season turfgrasses.	Leaves of warm-season grasses turn tan to white when exposed to tissue temperatures below 60°F (16°C).	Chloroplast/chlorophyll complex disrupted, thus photosynthesis ceases and green color of leaves is lost.	Maintain moderately high nitrogen (N) level; use chill-tolerant warm-season species/cultivars.	Maintain a moist soil.	Use gibberellin within 12 hours of exposure to chilling temperatures, assuming subsequent temperatures rise above 60°F (16°C).
• TRAFFIC on frozen turfgrass leaves, at tissue temperatures below (32°F) (0°C).	Erect, white to light tan leaves appear in shape of footprints or wheel tracks where they were impressed onto the turf.	Pressure of traffic (shoes, animals, or wheels) on rigid, frozen leaves that mechanically ruptures cells; commonly occurs during early morning.	Apply a light application of water in early morning when soil is not frozen and air temperature is above freezing.	Maintain a moist soil.	Withhold or divert traffic from turfgrass areas during periods when leaf and stem tissues are frozen.
• TRAFFIC on wet slush-covered turf, followed by a rapid freeze to ~20°F (–7°C) or lower.	Leaves initially appear water-soaked, turn whitish brown and progress to dark brown; leaves limp and tend to lay as mat over soil; appear as irregular shapes associated with previous patterns of traffic.	Snow thaws to slush, causing increased hydration of grass crowns; traffic, e.g., snowmobiles and skis, forces wet slush into contact with crowns; kill occurs if followed by a decrease in temperature to ~20°F (–7°C) or lower.	Raise mowing height; maintain a high potassium (K) level and a moderately low nitrogen (N) level.	Provide rapid surface drainage by proper contours, open catch basins, and ditches; physical removal of slush may be needed.	Withhold traffic on turfgrass areas during wet, slushy conditions, especially if drastic freeze is anticipated to ~20°F (–7°C) or lower.

Type of Injury	Turf Symptoms	Stress Cause(s)	Practices That Minimize Turfgrass Injury: Cultural	Practices That Minimize Turfgrass Injury: Soil	Specific Protectants
• ICE COVER, occurs in depressional areas.	Irregularly shaped, tan patches corresponding to sites where ice cover persisted; infrequent occurrence, with annual bluegrass (*Poa annua*) being most prone to injury.	Impermeable ice layer causes buildup of gases to toxic levels; most likely to kill annual bluegrass after 60 to 75 days ice coverage; while creeping bentgrass and Kentucky bluegrass may survive 150 days coverage.	Maintain a moderately low nitrogen (N) level and high potassium (K) level; mechanically remove upper ice cover from annual bluegrass after 60 to 75 days.	Provide surface drainage by proper contours, catch basins and ditches; subsurface drainage by drain lines, modifying with a high-sand mix, slit trenches, and dry wells; cultivate by coring.	Apply black charcoal or fertilizer at temperatures above 32°F (0°C) to absorb radiant energy that thaws ice; may use a continuous polyethylene cover on greens to prevent crown hydration.
• HEAVY INJURY, most commonly occurs on newly emerged seedlings.	Young seedlings, including crowns and roots, lifted out of soil; roots broken and plants turn tan.	Repeated freezing and thawing of ice layers on surface of wet soils lifts seedlings out of soil, and they are killed by desiccation.	Avoid late planting dates in the autumn; encourage deep rooting.	Provide surface drainage by proper contours, catch basins and ditches; subsurface drainage by drain lines, modifying with a high-sand mix, slit trenches, and dry wells; cultivate by coring.	Apply straw mulch to seeding planted late in autumn; enhance snow accumulation by use of snow fence or brush; roll-in heaved seedlings at time of first thaw.
• WINTER DESICCATION, typically occurs in locations and times when a snow cover is absent.	Leaves turn distinctly white, but remain erect; meristems very dry and brittle; occurs most commonly on high locations exposed to drying winds; can range from small irregular patches to extensive kill of large areas.	Lethal plant water stress caused by a dry environment, including high winds and low humidity; extended periods of soil drought due to lack or precipitation or snow; or soil water absorption reduced or may be inoperative because soil is frozen.	Maintain moderately low nitrogen (N) level; eliminate any thatch problem; irrigate during the winter as needed by tank/truck when temperature is above freezing, especially for greens and tees.	Do not core in late autumn and then leave the holes open.	Use a winter protection cover, or certain geotextiles; 4–6 mil polyethylene cover; late-season topdressing at 0.4 $yd^3/1{,}000\ ft^2$; natural organic mulches; or enhance snow accumulation with snow fence or brush.

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not only does not control dollar spot, but it can actually enhance this disease. Hence, Heritage must be tank-mixed with another fungicide whenever dollar spot is active.

Fludioxonil. Novartis recently has registered Medallion® for use in controlling *Rhizoctonia* diseases in greenhouse crops, ornamentals and turfgrass. This fungicide also will be marketed as a pre-packaged mixture with Banner MAXX® under the trade name Foundation®. Medallion® and Foundation® will be sold under an experimental use permit in selected states in 1998. The common chemical name of Medallion® is fludioxonil. **Fludioxonil is an analog of a natural product called pyrollnitrin.** Pyrollnitrin is produced in nature by the bacterium *Pseudomonas pyrocinia*. As was the case with azoxystrobin, pyrollnitrin had to be stabilized to protect it from rapid solar radiation degradation.

Unlike azoxystrobin, **fludioxonil is a contact fungicide.** As such, its residual activity is relatively short-lived, and this is one reason why it will be offered in a prepackaged mixture with Banner MAXX®. Fludioxonil interferes with membrane transport processes in sensitive fungi. It is unclear whether this compound has single-site or multisite activity. While fludioxonil has activity on summer patch and snow molds, its strength appears to be as a brown patch and *Helminthosporium* leaf spot fungicide. Early testing indicates that fludioxonil has curative activity, but generally performs better when applied preventively. Fludioxonil is the first contact fungicide to enter the turf market in over 30 years. Another interesting aspect of this product is that **its residual activity is enhanced not only by mixing it with Banner MAXX®, but also by the plant growth regulator Primo® (trinexapac ethyl).** When Primo® is applied a few weeks prior to the application of fludioxonil, the effectiveness of the fungicide is improved. Evidently, the reduction in clippings removal accorded by the use of Primo® keeps fludioxonil on leaves longer, thereby increasing its residual effectiveness.

Polyoxins. The "polyoxins" are a class of antifungal compounds produced by the fermentation of *Streptomyces cacaoi* var. *asoensis*. Polyoxorim is a fungicide from this group (proposed trade name from PBI Gordon is STOP-IT®), which was shown to be extremely effective in controlling brown patch at remarkably low rates. The status of polyoxorim and similar compounds for use on turf is currently unknown.

Summary. Hence, turfgrass disease management strategies have been expanded to include not only the direct application biological agents, but also the development of microbial-based analogs of naturally occurring, antifungal compounds.

Winter Coloration of Warm-Season Turfgrasses

J.B Beard

Annual visits to Japan have revealed a different philosophy in terms of winter color on dormant warm-season turfed fairways. Approximately 60% of the golf courses do not winter overseed, but rather apply a colorant to their zoysiagrass fairways. Typically **colorant applications are made from 2 to 4 times during the winter dormancy period.** They find this approach to be much less costly than winter overseeding of cool-season turfgrasses with its associated costs of mowing and other cultural practices throughout the winter. Most golf course fairways in Japan are composed of manila zoysiagrass (*Zoysia matrella*), except on the northern island of Hokkaido. Colorant application is being done on golf courses with 35,000 to 50,000 rounds of golf per year involving a substantial amount of play during the winter period.

It should be noted that many Japanese golfers tend to pick the ball off the zoysiagrass fairways during their stroke, which results in minimal divoting. The strong resistance to divoting typical of zoysiagrass turfs may be one of the reasons why this approach to hitting balls from fairways is quite common in Japan. Consequently, divot openings are not as extensive as on turfs in other parts of the world. Also, golf carts are not as widely used as in the United States.

Typically, the earlier usage of colorants on winter-dormant fairways in the United States had involved a single application. Do multiple winter colorant applications have the potential for use elsewhere in the world? Is this approach effective where extensive divot openings and intense golf cart traffic are a concern? Time will tell!

FEATURE ARTICLE

Understanding Halofenozide (Mach 2®) and Imidacloprid (Merit®) Soil Insecticides

Daniel A. Potter

Root-feeding white grubs are a familiar problem for professional turfgrass managers, but two novel soil insecticides offer new options for controlling these destructive pests. Imidacloprid (Merit®) and halofenozide (Mach 2®) have longer residual life in soil and thatch than do the traditional grub control products. Thus, they can be applied preventively, weeks or even months before the grubs have hatched. **Both products are used at low rates, have very low toxicity to non-insect groups, and pose relatively little hazard to the environment.** Nevertheless, there are some important differences in activity and performance between halofenozide and imidacloprid. Understanding these differences will help you to use these products more effectively.

Until recently, control of grubs relied on curative treatment with short-residual organophosphates or carbamates such as bendiocarb (Turcam®), carbaryl (Sevin®), diazinon, ethoprop (Mocap®), fonofos (Crusade®), isofenphos (Oftanol®), and trichlorfon (Dylox®). With such products, applications are targeted for a week or two after egg hatch (mid- to late summer in most areas where cool-season grasses are grown), when grubs are still small. Timing can be tricky, however. Insecticides applied too early may degrade before the eggs have hatched, whereas with late applications or "rescue" treatments severe turf damage may already have occurred. Also, large grubs are much harder to kill. Not surprisingly, many turfgrass managers are turning to the new, longer-residual insecticides for preventive control.

Basic Grub Biology. White grubs are the larval, or immature, stage of a group of beetles known as scarabs. Most of the important species, e.g., Japanese beetle (*Popillia japonica*), masked chafers (*Cyclocephala* species), European chafer (*Rhizotrogus majalis*), green June beetle (*Cotinis nitida*), Oriental beetle (*Exomala orientalis*), and Asiatic garden beetle (*Maladera castanea*) have annual, or 1-year life cycles. The beetles are active in summer, mainly from June until mid-August in the United States. Eggs are laid in moist turf soils. Eggs hatch in about 2 weeks, and the young grubs begin feeding on grass roots. They grow quickly, molting (shedding their skin) twice and normally becoming nearly full-sized by autumn. Grubs that have molted once, or twice, are referred to as second or third instars, respectively. About the time of the first frost, the grubs move deeper in the soil for hibernation. They return to the root zone and resume feeding in early spring. When mature (typically late spring, depending on species and geographic location), the grubs form an earthen cell and transform into pupae. The new beetles emerge a few weeks later to complete the 1-year life cycle.

Damage from grubs with annual life cycles usually is more sever in summer through early autumn when the grubs are vigorously feeding and the turf is otherwise stressed. With severe infestations there may be 50 or more grubs per ft^2 (54 or more grubs per 0.1 m^2). Often, the roots are entirely consumed, causing patches of dead turf that can be easily lifted from the soil. Skunks, raccoons, crows, armadillos, moles and other varmints may dig or tunnel in the turf to prey on these juicy "land shrimp." Grub injury usually is less apparent during the spring feeding period. Green June beetle grubs have somewhat different habits. They feed mainly on organic matter, but damage turfgrasses by tunneling and pushing up small mounds of soil.

The black turfgrass ataenius (*Ataenius spretulus*), a sporadic pest of golf courses, departs from this pattern. It has two generations per year in Ohio and farther south, with grubs present from late spring to early summer, and again in mid to late summer. There is only one annual generation in upstate New York and New England, with grubs present from early to midsummer.

Imidacloprid. Imidacloprid (Merit®) belongs to a new class of synthetic insecticides called chloronicotinyls. Unlike organophosphates and carbamates, which are broadly toxic to vertebrates as well as insects, **imidacloprid has selective activity on the insect nervous system. Thus, it poses relatively little hazard to humans, other vertebrate animals, or the environment.** Imidacloprid is applied at low use rates, 0.3 to 0.4 lb active ingredient per acre (0.34 to 0.45 kg/ha), compared with 2 to 8 lb (2.24 to 8.96 kg) for most traditional soil insecticides. It kills insects both by contact and ingestion. It is translocated within plants, providing good control of stem-tunneling larvae of billbugs or annual bluegrass weevil as well as grubs. It is not, however, very effective against caterpillars, which include sod webworms, cutworms, and armyworms. Imidacloprid is available as wettable powder (75 WP or WSP) or granular (0.5 G) formulations. It is registered for all turfgrass use sites, except for commercial sod farms.

Imidacloprid will provide residual control of white grubs for 3 to 4 months or longer in turf. This prolonged residual allows a broad treatment window, as well as multiple targeting of pests. For example, imidacloprid applied in mid to late spring on golf courses for control of first-generation black turfgrass ataenius grubs also gives residual control of annual grubs (Japanese beetles, masked chafers) that hatch in midsummer.

Turfgrass managers who use imidacloprid for grub control must rethink the traditional guidelines for treatment timing. Imidacloprid is highly active against young, newly-hatched grubs, but it is much less effective against older, second or third instars. Thus, **imidacloprid must be applied preventively, before symptoms of turf damage appear.** Other soil insecticides generally work better for curative control of large grubs in late summer or autumn.

The half-life of imidacloprid in soil is about 5 months. So, if your primary target is the major, annual grubs such as Japanese beetle, masked chafers, or European chafer, it makes little biological sense to apply imidacloprid in early to mid-spring, several months before the target date. Indeed, applying it too early may result in reduced levels of control. In general, the optimal treatment window for controlling annual grub species with imidacloprid is from about 4 to 6 weeks before egg hatch until the first newly hatched grubs are present. This interval extends from late spring through midsummer in the cool-season and transition turfgrass zones.

Halofenozide. Halofenozide (Mach 2®) is the first insect growth regulator (IGR) to be registered for the turfgrass market. **IGRs act by disrupting the hormonal systems that control growth and molting in insects. These target sites are not found in humans or other vertebrates, so IGRs typically have very low toxicity to non-insect groups.** Halofenozide belongs to a new class of synthetic IGRs called "MACs," or Molt Accelerating Compounds. It works by mimicking the action of ecdysone, the hormone that regulates insect molting. Ingestion of even a tiny amount of halofenozide "signals" the insect to initiate a premature, ultimately lethal molt. Affected insects stop feeding within hours, and death occurs within 1 to 3 weeks.

Because of the unique mode of action of halofenozide, insects may be less likely to become resistant to its and other IGRs than to traditional insecticides. It would be difficult for the pests to evolve a whole new molting system that would be immune to these products.

Two formulations will be available in 1998: a granular (1.5 G) product which is labeled for all turfgrass use sites, and a liquid (2 SC) which lists golf courses, commercial turf, and sod farms, but is not yet registered for residential lawns, housing complexes, or athletic fields. Halofenozide is currently registered in all states except California, New York, Utah, and Arizona. Registrations in California and New York are not expected in time for the 1998 use season.

Although its persistence is not quite so long as that of imidacloprid's, halofenozide will provide residual control of grubs for 2 to 3 months after application. Halofenozide is highly active against newly hatched grubs so, as with imidacloprid, the optimal treatment window for preventive control is during the month or so before egg hatch. Because it is active against second-instar and early third-instar grubs, **halofenozide also can be used for early curative control into mid to late summer.** Halofenozide also is active against turf-infesting caterpillars, which allows multiple targeting. Applications for white grubs also will suppress sod webworms, cutworms, and armyworms for a month or more.

Comparing the Products. Imidacloprid and halofenozide both have relatively long residual activity, affording flexibility in terms of application timing. Applied preventively, both products give excellent control of newly hatched white grubs. Both products require some rainfall or irrigation to move them into the grubs' feeding zone, but they provide more leeway than traditional insecticides in this regard. Good control can be expected even if irrigation is delayed for a week or more.

Halofenozide generally is more effective than imidacloprid against turf-feeding caterpillars and mid- to large-sized grubs. Imidacloprid must be used preventively, whereas halofenozide can provide either preventive or curative control. Imidacloprid has a somewhat longer residual, which is useful for multiple targeting of first-generation black turfgrass ataenius and the annual grubs on golf courses. Also, imidacloprid may be active against a wider range of grub species. Both products give excellent control of Japanese beetle and masked chafer grubs, but halofenozide seems to be less effective against European chafer and oriental beetle grubs.

Clearly, **imidacloprid and halofenozide will pave the way for other selective insecticides which pose minimal hazard to other organisms.** Strategies for getting the best possible control from preventive or curative grub treatments will be covered in future issues of this newsletter.

Author's Note: This article was adapted from a small section of the new book *Destructive Turfgrass Insects: Biology, Diagnosis, and Control* which is available from Ann Arbor Press (121 S. Main St., P.O. Box 310, Chelsea, MI 48118; tel. 1-800-858-5299; fax 313-475-5299).

RESEARCH SUMMARY

Turfgrass Wear Stress: Effects of Golf Cart and Tire Design

Two types of golf cart tire design were assessed in terms of wear stress on Tifway hybrid bermudagrass (*Cynodon dactylon* x *C. transvaalensis*) mowed at 0.5 inch (13 mm). The stress treatments involved 85 passes of a golf cart over 4 replicated plots utilizing a 22 foot (6.7 m) radius semicircle pattern. This operational procedure resulted in both vertical and lateral pressures from the tires on the turfgrass shoots, which is a more significant wear stress than straight-line operation. Turfgrass effects were observed for a subsequent two-week period, including visual turf quality, percent green coverage, leaf bruising, and verdure or green biomass per unit area.

Significantly less turfgrass wear resulted from the tubeless, 4-ply, 4.8 mm v-shaped tread tire (Power Rib—0F0220) with more rigid sidewalls operated at an air pressure of 18 psi (124 kPa). The 2-ply, radial, 1.0 mm deep dimpled tread tire (Bogie Buster—0F0510C) with flexible sidewalls operated at a low pressure of 7 psi (48 kPa) created consistently more turfgrass wear when operated on each of three different golf cart models. In contrast, the three different golf cart models tested did not produce significant wear stress differences under the condition of this study.

These data indicate that **tire design can significantly affect the degree of turfgrass wear stress, and should be considered in tire selection for golf carts.** Further research is required to define the tire design components that contribute to less turfgrass wear. For example, how much is attributed to the tread design versus the degree of sidewall rigidity? ***By R.N. Carrow and B.J. Johnson, HortScience* 31(6):968–971**

JB COMMENTS

Avoid Soil Organic Layers

Fully decomposed organic matter intermixed into a root zone is a vital soil component, especially in high-sand mixes. It contributes substantially to enhanced nutrient and water retention and to physical attributes that are important for a quality root zone. However, **a concentrated organic matter layer with minimal mineral content within the root zone can result in major problems.**

Typically an organic layer within a root zone is a man-made problem. It may occur during renovation of a turf, where the existing unwanted grass stand is killed off with a translocated grass herbicide, such as glyphosate or glufosinate, followed by the addition of a root zone soil layer and/or transplanted sod with attached soil layer. The result is an organic layer that becomes dense and relatively impermeable, with a subsequent **blockage of downward water movement and a water saturated zone that impairs root growth as well.** This problem commonly occurs on greens, but it also occurs on sports fields and other intensely used recreational turfs.

I have also observed organic layer problems where the sod has been killed off, left in place, and then a 10-inch (250 mm) high-sand root zone placed over the top. The resulting problems are similar to those previously described. Another problem situation observed is where a high-sand root zone is constructed over a clay base with a concentrated organic layer of seaweed placed between the two.

It is amazing how often I observe these organic layer problems where turf renovation has been attempted. **It is extraordinarily difficult to provide a root zone microenvironment that will encourage the decomposition of such an organic matter layer.** Very intensive coring over an extended period of time is generally required, and still the problem may linger. The best approach in turf renovation is to:

- Treat the unwanted live, green sod with a nonselective herbicide, such as glyphosate and glufosinate.
- Remove all sod with a mechanical sod cutter.
- Conduct root zone fumigation, as appropriate.
- Initiate reestablishment of the turf.

Ask Dr. Beard

Q The temperature fell to 10°F (–12°C) in Dallas, Texas. Have my putting greens of Tifdwarf bermudagrass been killed?

A **There is not a specific, meaningful soil temperature at which each turfgrass species or cultivar is killed that can be predicted reliably.** This is because the temperature at which low temperature kill occurs varies greatly depending on the hydration level of the tissue. In addition, a faster rate of freezing, a faster rate of thawing, and a greater number of times freezing and thawing occurs will result in a higher killing temperature. Note that the soil temperature adjacent to the meristematic area of the plant crowns and the nodes of lateral stems is the more critical temperature, and not the above air temperature. Obviously the lower the temperature decline that occurs, the greater the potential or probability for kill.

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