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IN THIS ISSUE

Winter Ice Cover Problems?

James B Beard

The injury mechanism and factors influencing low-temperature kill of turfs were discussed in the January–February 1998 Turfax™. During the past four decades numerous writers have included ice cover damage caused by oxygen suffocation under the ice layer as being a major cause of winterkill. A survey of the turfgrass research literature on this subject reveals no valid scientific data to support this ill-founded concept.

Misinterpreted Research. A commonly published guideline advises removal of an ice cover after 20 days in place. There is no validity to this guideline as related to the fibrous roots and small meristematic crowns of perennial grasses. The 1960s origin of this 20-day maximum is based on University of Wisconsin research with the very fleshy, high-carbohydrate, taprooted alfalfa species (*Medicago sativa*). Physiologically, the root-crown system of this legume is drastically different from that of a turfgrass, including the respiration rate.

Clarifying Research Conducted: Specific published studies[2,3,4] and numerous "real-world" field observations demonstrate that C_3, cool-season, perennial turfgrasses can survive more than 75 days under dense ice cover with no injury. Typically, an ice cover would be in place for a shorter duration than 150 days. The most complete ice cover study was conducted at Michigan State University by J.B Beard and J.W. Eaton. Three species were compared: creeping bentgrass (*Agrostis stolonifera*) at a 0.25-inch (6.4 mm) cutting height, Kentucky bluegrass (*Poa pratensis*) at a 1.5-inch (38 mm) cutting height, and annual bluegrass (*Poa annua* var. *annua*) at a 1.0-inch (25 mm) cutting height. Mature turfs of these three turfgrasses were allowed to fully harden well into December in East Lansing, Michigan, and then 4-inch (100 mm) turf plugs were collected. The turfs were placed in quart jars, which were then filled with water and slowly frozen. Then the top of the ice was capped off with a small amount of water, the cover plate was screwed tight with a rubber gasket and jar sleeve, and the ice encasement system was frozen. There were four replications involved, with the turfs encased in ice held at 25°F (–4°C) for 15-day durations of up to 5 months. A set of 4 replications were removed at 15-day intervals, thawed slowly, and evaluated for turf survival in a glasshouse.

The results—summarized in Table 1—revealed that **both creeping bentgrass and Kentucky bluegrass survived 5 months, or 150 days, of dense ice encasement without significant injury.** In contrast, **the annual bluegrass was killed between the 75th and 90th days.** These results revealed that ice coverage for up to 150 days may not be of concern where creeping bentgrass and Kentucky bluegrass turfs are involved. However, for annual bluegrass an ice cover persisting for more than 75 days is of concern. In the case of the annual bluegrass the cause of death was probably a toxic accumulation of respiratory gases under the relatively impermeable ice cover.

Why the Confusion? A common occurrence associated with ice covers is low-temperature kill in a pattern

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directly associated with the ice cover that existed the previous winter. **This type of turf kill occurs under the following scenario: (a) prior to formation of the ice cover, (b) following a period of surface water accumulation, which increases the grass crown hydration level, and (c) with a subsequent very rapid freeze to below ~20°F (–7°C).** Turf kill may also occur during the thawing period, when the resultant standing water where the ice cover existed causes increased crown hydration and is then followed by rapid freeze to below 20°F (–7°C). These crown hydration situations followed by a rapid freeze typically occur in locations where ice covers have been observed during the winter. Thus the confusion, in which the ice covers are assumed to directly cause the turf injury, when in fact that is not the case.

There are also preventive activities that can be misinterpreted. For example, in the early 1960s the midwestern United States had extensive turf kill on the putting greens, which at that time was attributed to ice covers. Only one golf course superintendent removed the ice from the greens, and these greens were the only ones that were not severely injured. It was assumed that removing the ice sheet prevented the accumulation of toxic gases around the grass, thereby avoiding kill. Another more appropriate interpretation of that situation would be that the removal of the ice sheets was a means of mechanically removing the water, which upon thaw would have created a high crown-node hydration situation. Essentially, the water was being physically hauled off the putting greens prior to thaw.

Ice Cover Injury Prevention. Cultural practices that will reduce the turf injury caused by an ice cover include: (a) maintain a moderately low nitrogen level and (b) ensure a high potassium level. Soil management preventive practices include the following: (a) provide surface drainage by proper contours, catch basins, and ditches, (b) provide subsurface drainage by drain lines, slit trenches, dry walls, and possibly soil modification to a high-sand root zone, and (c) cultivate turf by coring as needed to sustain favorable soil infiltration rates. Specific protectants that might be utilized include placing a continuous polyethylene cover over the putting greens to minimize water accumulation and contact with the turfgrass tissues, which results in crown hydration.

If a substantial snow or ice accumulation occurs that will persist for too long a period of time, efforts should be made to remove the excess snow and ice by powered-mechanical means down to within 1 inch (25 mm) of the turf surface. Once temperatures rise sufficiently after removal of the excessive ice and snow cover, the application of a black charcoal or fertilizer material at temperatures of ~30°F (–1°C) and higher will aid in absorbing solar radiant energy, resulting in an enhanced rate of ice thaw.

Crown Hydration. Note that crown hydration is not the cause of turf kill, but it is a key precondition. The concept of winterkill crown hydration effects on turfgrasses is not new, as the original research was published in the 1960s.[1,2,5]

Ice Rinks. Numerous ice rinks are constructed across Northern America without injury to the turfgrasses. These are allowed to stay in place for extended periods of time over the winter period—certainly longer than 20 to 50 days. Some keys to success in this regard are as follows:

- Select a location where rapid drainage of water will occur in the spring at the time of thaw.
- Preferably apply the ice sheets to an area where the dominant turfgrass species is Kentucky bluegrass or a Kentucky bluegrass blend.
- Wait until at least a 2 inch (50 mm) snow cover has occurred.
- At night when temperatures are well below 32°F (0°C), start the application of water to build up an ice cover. Initially make light syringe applications of water, which will allow rapid freezing and ice formation. Gradually build up the ice cover over time during the nocturnal period until an ice sheet of the desired depth has been achieved.
- Typically, the areas most prone to damage associated with ice rinks are the entrance and exit points where freezing and thawing of the ice is more likely

Table 1. The percent plant survival after being encased in ice at 25°F (–4°C) from 60 through 150 days.

	Days Encased in Ice						
Turfgrass	**60**	**75**	**90**	**105**	**120**	**135**	**150**
Creeping bentgrass	100	100	100	100	100	100	100
Kentucky bluegrass	100	100	100	100	100	100	100
Annual bluegrass	100	100	0	0	0	0	0

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FEATURE ARTICLE

Traditional Fine-Leaf Fescue Putting Greens

James B Beard

Fine-leaf fescues (*Festuca rubra*) were the dominant grass species grown on putting greens of early links golf courses prior to 1850. **Its erect shoot growth, narrow leaves, reasonable shoot density under close defoliation, preference for the low nitrogen levels of sandy soils, and low susceptibility to Microdochium patch (*Microdochium nivalis*) were key characteristics that facilitated the adaptation of fine-leaf fescues to the sandy soil, seaside linksland of Scotland** and eventually to other parts of the British Isles. These northern seashore sites of the United Kingdom were characterized by a cool-maritime climate with few temperature extremes, frequent rainfall, sandy soils, and very few disease or insect problems.

During the evolutionary period for golf, rabbits (*Oryctolagus cuniculus*) were the primary defoliating agent on putting greens, followed subsequently by the hand scythe. The greens received no supplemental irrigation or fertilization and were subjected to minimal traffic stress from golf play. Sand topdressing was probably one of the earliest cultural practices, which provided surface smoothing, enhanced thatch decomposition, provided some earthworm suppression, and accentuated low nitrogen nutritional levels. Subsequently, composting of seaweed and sand for topdressing evolved.

A need exists to preserve the traditional turf character on the putting greens of the oldest linksland golf courses as part of golf's historical heritage. Also, there is interest in duplicating these early turfgrass conditions in other parts of the world. **Annual bluegrass (*Poa annua*) invasion and eventual dominance is the greatest threat to sustaining a fine-leaf fescue turf on putting greens. It must be recognized that sustaining successful fine-leaf fescue dominant putting greens can only be achieved under certain specific climatic, soil, and biotic conditions, including:**

- A cool-temperate climate, where soil temperatures do not rise above 76°F (24°C).
- A humid, moist climate characterized by periodic short-duration plant water stresses, which impair annual bluegrass (*Poa annua*) growth.
- Sandy soils with reasonably good internal drainage of excess water.
- Soil pH greater than 5.0.
- Areas where Helminthosporium diseases do not occur, including Bipolaris leaf spot (*Bipolaris sorokiniana*) and net blotch (*Drechslera dictyoides*), as the fine-leaf fescues are highly susceptible to these diseases.
- Low traffic stress on the greens and/or very large putting greens that spread out the traffic via regular hole changing.
- Minimal play or closure of the golf course during cold winter periods when fine-leaf fescue has a slow shoot growth rate, which can result in turf thinning from wear stress and subsequently annual bluegrass (*Poa annua*) invasion.
- A golfer attitude that accepts periodic brown areas on the green during planned water stress to control the invasion of other grass species.

There also are certain cultural practices required to sustain fine-leaf fescue turfs on putting greens, including:

- Mowing at a cutting height of 5 mm or higher, with a frequency of 6 days per week.
- Infrequent nitrogen fertilization at from 1 to 3 lb per 1,000 square feet (0.5–1.5 kg per 100 m^2) per year.
- Potassium applied as needed based on an annual chemical soil test.
- Regular topdressing at 4 to 6 times per year.
- Minimal irrigation only as needed to prevent death and loss of the fine-leaf fescue crown.
- Turf cultivation as needed to correct a developing soil compaction problem.
- Minimal to no use of pesticides, and only as needed to prevent critical loss of turf.

Under optimal cool-temperature, moisture, soil, and mowing conditions, plus a balanced, living soil ecosystem and low traffic stress and/or a large putting green size, acceptable quality mature turfs of fine-leaf fescue have been sustained over multiple years on putting greens with minimal nitrogen fertilization, irrigation, or pesticide use.

FEATURE ARTICLE

Some Causes for Yellow or Chlorotic Putting Greens

Peter H. Dernoeden

Throughout the year pathologists receive numerous samples of yellow bentgrass (*Agrostis* spp.) or annual bluegrass (*Poa annua*) from putting greens. In autumn or spring, superintendents sometimes suspect yellow tuft (*Sclerophthora macrospora*) or yellow patch (*Rhizoctonia cerealis*) diseases are the problem. These diseases, however, generally do not cause a uniform chlorosis throughout large portions of greens.

Yellow tufted infected plants are distinctively tufted and are most conspicuous during cool, wet periods. The yellow tuft fungus produces large numbers of tillers. Healthy plants have 4 to 8 tillers, whereas yellow tuft plants from putting greens typically have 15 or more tillers. Furthermore, yellow tuft plants are easily detached from the putting surface, because the roots of infected plants are short and bunchy. Yellow tuft is most commonly observed from late winter to early summer following an autumn seeding or heavy interseeding.

Yellow patch appears in distinctive circular patches or rings that may be yellow or reddish-brown in color. Yellow patch can develop from autumn to spring, but is most common during excessively wet, overcast periods in the spring.

When turf on putting greens develops a chlorosis in the summer, many believe they have a root pathogen such as parasitic nematodes or a *Pythium* disease. The latter can elicit a chlorosis, but the disease symptoms caused by these pathogens are nonspecific, and only a lab analysis can confirm their presence. **Many samples of chlorotic turf sent to our lab turn out to be negative for disease.** A negative disease diagnosis frustrates most superintendents, and other causes for the yellowing must be sought.

Chlorosis or yellowing can be caused by a lack of chlorophyll production or abnormal breakdown of chlorophyll levels. **Chlorosis may be induced by nutrient-related deficiencies, senescence, environmental stress, or genetic factors.** The most common nutritional problems would include low nitrogen (N) fertility; high nitrogen use in combination with low potassium-levels in some soils; and iron (Fe) or magnesium (Mg) deficiencies. While growth limiting FE and Mg deficiencies are relatively uncommon in most soils, even in high-sand USGA method root zone mixes, creeping bentgrass (*A. stolonifera*) often exhibits a "green-up" response following an application of Fe and Mg. Other factors, however, can limit Fe or Mg uptake, such as extremes in soil pH, and possibly cold or wet weather. Because problems with nonuniform chlorosis often appear during spring and autumn, it seems probable that environmental conditions may be interfering with root uptake of Fe, Mg, or other micronutrients. It is also likely that these weather conditions inhibit chlorophyll production and/or retention levels in plants. Both spring and autumn are characterized by generally warm days and cool nights. These conditions are ideal for growth of cool-season grasses. It is therefore probable that cool to cold nights impair the ability of plants to produce sufficient chlorophyll levels in rapidly growing leaf and sheath tissues, and as a result the turf develops a yellow appearance. **Some biotypes of annual bluegrass and creeping bentgrass are naturally yellow-green in color and their color cannot be darkened significantly by applying nutrients.** Annual bluegrass plants often turn yellow in the spring and early summer when producing seedheads. Furthermore, prolonged periods of overcast and rainy weather from spring to early winter induce chlorosis, particularly in low-lying or poorly drained sites. This yellowing is partially attributed to oxygen deprivation in excessively wet soils.

Autumn chlorosis is also very common on creeping bentgrass and other cool-season grass fairways, intermediate roughs, and green surrounds. The chlorosis in these areas often develops in pockets. Normally, there is no apparent relationship between the appearance of chlorosis and soil condition, i.e., well drained vs. wet. Chlorosis, however, is more common in shaded or wet sites, but these factors are not associated with all warm-day/cool-night related chlorosis problems.

Creeping bentgrass, annual bluegrass, and other cool-season grasses may also develop a chlorosis with the advent of hot and humid conditions in summer. This is particularly true when soils are extremely wet as a result of extended rainy weather or excessive irrigation. Annual biotypes of bluegrass typically turn yellow in response to high temperature stress. Many annual bluegrass biotypes are simply yellow-green in color.

In creeping bentgrass, distinct yellow and circular spots or patches 2 to 3 inches (25 to 75 mm) in diameter may appear in the summer. This often is a clonal or biotype

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FEATURE ARTICLE

Year-End Report Card on New Turf Insecticides

Daniel A. Potter

Despite years of research and field testing that precede registration of insecticides, the strengths and limitations of new products often aren't fully revealed until they're put to use by turfgrass professionals. Here are some of the patterns that emerged from 1998:

Halofenozide (MACH 2®), the newest soil insecticide, was registered for use in most states in 1998. MACH 2® belongs to a new class of synthetic insecticides called Molt Accelerating Compounds (MACs) which disrupt the hormonal system that controls growth and molting in target insects. It has very low vertebrate toxicity and is one of the least toxic materials you can use for grub control. **Professionals have obtained excellent preventive control of Japanese beetle and masked chafer *(Cyclocephula)* grubs, as well as black turfgrass ataenius, with MACH 2® applied any time from mid-May to early August.** MACH 2® also kills billbug larvae, and the liquid (2SC) formulation has performed well against sod webworms and cutworms.

Despite advertised claims that it is effective for curative control, we know now that **MACH 2® works too slowly against large grubs to put a stop to digging by skunks, raccoons, birds, or other vertebrate predators.** Although large (3rd instar) grubs stop feeding soon after ingesting MACH 2®, it may take 3 weeks or longer before they die and decompose to the point that they no longer attract digging varmints. Remember, MACH 2® works by disrupting molting, so it works best if applied early—before or soon after egg hatch—to target small grubs that are actively growing. **Once grubs are large enough to cause noticeable damage, you're better off with a fast-acting, short-residual product such as Dylox® (trichlorfon).** Also, recent research has shown that **MACH 2® is less active against European chafer and Asiatic garden beetle grubs than against other grub species.** So, it pays to know what kind of grubs you're dealing with, especially with this product.

Merit® (imidacloprid) continues to give excellent preventive grub control when applied any time from May until egg hatch (early August). Some golf course superintendents reported failure of Merit® for grub control this last season. Usually, these problems were traced to too-early an application (March or April) motivated by the intent to multiple-target the first generation of black turfgrass ataenius grubs, which hatches in mid- to late May. These early spring applications do not kill the large, overwintered grubs of Japanese beetle, masked chafers, European chafer, or other annual species, and the product "runs out of gas" by August when the new brood of these grubs arrives. The same problem can also occur with MACH 2®. **In most areas, the optimal window for preventive control of annual grub species with either product is from early June to mid-July.** If your intent is to control both black turfgrass ataenius and annual grubs with the same treatment, wait until mid-May before making the application.

Both Merit® and MACH 2® are more forgiving than other grub insecticides if not immediately watered in. However, both products, especially the sprayable formulations, are susceptible to photodegradation upon prolonged exposure to sunlight, and neither can kill grubs unless the

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Winter Ice...

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to occur during high traffic periods. A solution to this problem is the use of protective wooden-floor entrance ways at these locations.

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...Chlorotic Putting Greens

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response to heat stress and high humidity, but usually there is no turf thinning. Thinning and turf loss, however, may be the result of a pathogen. When in doubt, samples should be sent to a diagnostic lab. Excessive irrigation, soil compaction, poor internal drainage, supraoptimal temperature stress, and shade also cause yellowing during the summer. The yellowing is due to altered physiological processes—such as lowered photosynthesis and increased respiration—leading to senescence, low soil oxygen levels, impaired transpiration, or possibly an inability of roots to effectively take up nutrients. In the aforementioned situations, it is important to promote soil drying and cooling by restricting irrigation and syringing judiciously, avoiding mechanical injury, and improving air circulation with fans or by selective tree and bush removal.

In most situations, the chlorosis that develops in response to abrupt temperature or relative humidity changes or extremes dissipates within a few weeks or months. Nutritionally related chlorosis can debilitate plants, especially annual bluegrass and creeping bentgrass on greens. **Should thinning of the turf become evident, an application of 0.1 to 0.2 lb N per 1,000 ft^2 (0.5 to 1.0 kg N per ha) from a quick-release nitrogen source or a micronutrient product may alleviate the condition.** Because Fe and Mg are involved in chlorophyll production and elicit a shoot green up response, they are frequently recommended. **Iron sulfate (1 to 2 oz per 1,000 ft^2, 30 to 60 g per 93 m^2) or chelated Fe materials are suggested. Epsom salts or $MgSO_4$ (2.0 oz per 1,000 ft^2; 60 g per 93 m^2) are good sources of Mg.** Also, the next time large increments of nitrogen (i.e., >0.5 lb N per 1,000 ft^2; 25 kg N per ha) are to be applied use a complete fertilizer, i.e., N + P + K. The application of other micronutrients and biostimulants may also be beneficial. If the yellowing is clonal, i.e., genetic, a significant greenup in response to N, Fe, Mg, or other micronutrient applications is unlikely. Covering chlorotic greens during unusually cold spring or autumn nights may be somewhat beneficial. Promoting soil drying and evaporation, as previously noted, is recommended in the summer.

There are other causes of a generalized chlorosis, including the following: (a) integrating applications of plant growth regulators and biostimulants containing gibberellic acid; (b) certain pesticides applied during warm to hot weather can scorch on yellow turf; (c) use of extremely high seeding rates, which result in huge numbers of plants occupying a small space; (d) excessively wet or poorly drained soils that become temporarily anaerobic; (e) prolonged periods of overcast or rainy weather; (f) iron chlorosis due to alkaline soils; (g) plant parasitic nematodes; (h) *Pythium*-induced root dysfunction; and perhaps (i) viruses and other diseases. In the case of these latter situations, the chlorosis could develop at almost any time of the year.

...New Turf Insecticides

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residues are leached down to the root zone. That's why they should be watered-in soon after application.

Conserve® (spinosad) is a new insecticide derived from fermentation by-products of a naturally occurring microbe. It has an LD_{50} of >3,000, which places it in the "virtually nontoxic" category for vertebrates. **Conserve® is providing very good to excellent control of cutworms, armyworms, and sod webworms.**

DeltaGard GC™ (deltamethrin) is a new, fast-acting pyrethroid that gives excellent control of turf caterpillars (cutworms, sod webworms, armyworms), as well as many other surface-active insects. As with other pyrethroids, such as Scimitar® (lambda-cyhalothrin), Talstar® (bifenthrin) and Tempo® (cyflothrin), DeltaGard is a Restricted Use Pesticide due to its toxicity to fish and aquatic organisms.

Naturalis-T® is a new product containing the insect-specific fungus *Beauveria bassiana.* When the fungus comes into contact with the target pest, ostensibly it sticks to its outer surface, penetrates the body wall of the insect, and causes death by rapid loss of water and nutrients. Natural epidemics of *Beauveria bassiana* sometimes suppress populations of chinch bugs and certain other insects under moist conditions. The commercial product has performed poorly in my cutworm and grub trials. So far, I've not seen convincing evidence that Naturalis-T® provides reliable, consistent control of turfgrass pests.

Note: Additional information on insecticides is included in the author's new book *Destructive Turfgrass Insects: Biology, Diagnosis, and Control,* which is available from Ann Arbor Press (121 South Main Street, P.O. Box 310, Chelsea, MI 48118; tel 1-800-858-5299; fax 734-475-5299).

RESEARCH SUMMARY

Visual Golf Course Effects

This research investigation addressed whether visual exposure to a natural environment can be stress reducing. Specific emphasis was on the influence of roadside environments dominated by natural elements as they might mitigate travel-related stresses. It was assumed that motorists and passengers are aware of the environment they travel through, that they have definite opinions about the attractiveness of those areas, and that their behavior can be influenced by the scenic quality of the environments through which they drive.

A total of 160 college-age participants, both male and female, viewed one of four different videotaped, simulated drives through outdoor environments immediately following and preceding mildly stressful events. The simulated drives were represented by (a) an urban structure-dominated environment, (b) a native vegetation forest-dominated drive, (c) a mixed structural and nature forest drive, and (d) a golf course environment. The investigators found **that average blood pressure levels and skin conduction levels were significantly lower in those participants exposed to the golf course environment, than for the other three environments. Further, participants who had viewed the golf course environment performed more accurately on the subsequent mental arithmetic tasks than those viewing the other three environments, including the natural forest environment.** Also, those participants who had previously viewed the golf course environment also performed more accurately on mental arithmetic tasks than those who performed the same tests prior to viewing the simulated golf course drive. The causal aspects of these golf course responses relative to the native forest remain to be clarified. This represents the first definitive data documenting the aesthetic benefits of a golf course environment. Could one conclude that golf course superintendents should have the ability to perform mathematical calculations at a higher level?

By R. Parsons, L.G. Tassinary, R.S. Hebl, and M. Brossman-Alexander. The View from the Road: Implications for Stress Recovery and Immunization. *Journal of Environmental Psychology.* Vol. 17, No. 3. 1998.

JB COMMENTS

Just returned from a week in Japan. Golfers in Japan are now paying 25 to 30% less to play a golf course. This obviously has implications for the golf course maintenance budgets.

Made a brief visit to the Japan Sumitoma VISA Masters Competition at the Taiheiyo Club. A big emphasis on the sports pages of Japanese newspapers was the fast greens—faster than they had ever experienced in Japan. One should note that zoysiagrass putting greens are still in use at some golf courses, and are very slow. Obviously, the trend to higher putting green speeds is becoming global in impact. Many people now travel world-wide via the easy access of air travel and are playing golf throughout the world. When playing on the higher-speed surfaces of putting greens at certain golf courses, golfers make comparative evaluations, and many may ask for increased putting speeds on the golf courses they play regularly.

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JB COMMENTS

Takeall patch (*Gaeumannomyces graminis* var. *avenae*) was originally recognized primarily as a problem of bentgrasses in the U.S. Pacific Northwest. It then became an increasing problem on the European continent. More recently *G. graminis* var. *graminis* has emerged as a problem of closely mowed hybrid bermudagrass (*Cynodon dactylon* x *C. transvaalensis*) putting greens, which is called bermudagrass decline. **Now *Gaeumannomyces graminis* var. *graminis* has emerged as an increasing disease problem of zoysiagrass turfs in Japan.** The world is becoming a global economic community, with global diseases of turfgrasses.

The Japanese authorities are progressing on schedule in the construction of new stadia to host the World Cup of Soccer in the year 2002. There will be a diversity of stadium designs, ranging from the traditional open stadium to the retractable dome to a **domed stadium with a turfed soccer field that is stationed outside the stadium for regular maintenance and exposure to normal solar radiation, and then is moved as one unit into the stadium for soccer competitions.** This design has been very successful from a turf standpoint at the new Arnhem, Netherlands stadium. One Japanese stadium also will have **(a) specially designed, large air ducts extending through the stadium at field level to enhance air movement, and (b) an upper profile shape and a stadium orientation designed to minimize shading of the turfgrass.**

I visited the Toyama Soga Athletic Park in western Japan, where a three dimensional interlocking mesh system has been installed on a baseball complex of two fields, with two more fields being added. These fields are planned for use as car parking areas when the main stadium is in use. They are minimum-maintenance sport fields planted to Japanese zoysiagrass (*Zoysia japonica*). **These fields are maintained at a very low nitrogen fertility level, as a yellow-green color for turfs is very acceptable in Japan, and in fact desired.** In this case, their mowing schedule is five times per year, with a 6 to 7 month growing season—quite a different concept from what is done in many other locations around the world.

ASK DR. BEARD

Q. Should I raise the cutting height on my putting greens during the winter period?

A. In almost all cases **it is beneficial to raise the cutting height on putting greens during winter periods when suboptimal temperatures occur.** This is especially true when an extraordinarily low cutting height—less than 5/32 inch or (4 mm)—is being employed. There are two situational aspects: (a) one involves severe cold environmental conditions where golf play does not occur, and (b) the second involves intermediate suboptimal temperatures where winter play is more common.

Severe Cold-Snowy Climates. Raising the cutting height prior to the winter period is especially beneficial on putting greens composed of such species as annual bluegrass (*Poa annua*) and hybrid bermudagrass (*Cynodon dactylon* x *C. transvaalensis*). The higher cutting height with resultant greater leaf area is important in increasing the photosynthetic capability of the turf canopy. This produces higher plant-available carbohydrate levels, which result in increased rooting, thereby reducing winter desiccation problems. **The higher carbohydrate levels also are involved in a key phase in the development of low-temperature hardiness of turfgrasses.** This hardiness phase occurs at temperatures between 35 and 45°F (2 and 8°C).

Intermediate Suboptimal Temperatures. A higher cutting height is equally important during winters with intermediate suboptimal temperatures allowing winter golf play. In this case the shoot growth typically is at a very slow rate, which results in minimal to no recuperative capability. **The higher cutting height results in a greater turf biomass, which increases the wear tolerance of the turfgrass during this winter nongrowth period.** Sustaining extraordinarily close mowing heights during the winter typically results in thinning of the turf during intense wear stress. Traffic and the allied wear stress, which results in significant thinning of the turf, has the potential consequence of increased *Poa annua* invasion.

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