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IN THIS ISSUE

Fast Putting Surfaces Cause Major Cultural Changes

by
James B Beard

The golfer movement to more fast putting green surfaces has changed the cultural practices on greens, including very close mowing of 5/32 to 1/8 inch (4.0 to 3.2 mm). These very close mowing heights tend to cause a reduced shoot density in many cultivars, and a resultant decline in surface turf quality and increased *Poa annua*, moss, and algae problems. The very close mowing also has emphasized:

1. the potential for proper turf rolling.
2. the problem of spike marks caused by traditional metal spikes.
3. the need for turfgrass cultivars that sustain shoot density and rooting at 1/8 inch (3.2 mm) cutting height.
4. changes in turfgrass cultural practices.

Turf Rolling of Putting Greens Constructed With High-Sand Root Zones

The potential benefits of rolling putting greens reentered the cultural picture due to (a) the extensive use of high-sand root zones in putting greens, thereby greatly reducing the potential for soil compaction problems from turf rolling and (b) the preference of golfers for fast ball roll speeds which have been achieved principally through very close mowing heights, which also result in further shortening of the root system, reduced turfgrass health and canopy density, and an increase in moss and algae problems.

This situation leads to the possibility that increased ball roll distance can be achieved by turf rolling rather than by extremely close mowing heights. The result would provide the opportunity to raise the cutting height, thereby achieving better overall turf health, rooting, and canopy density, plus an associated reduction in moss and algae. Research findings from turf rolling on creeping bentgrass putting greens are summarized as follows:

- a single turf rolling in early morning consistently **increased distance of ball roll by 10%** at the morning reading.
- combinations of 1, 2, 3, and 4 consecutive turf rollings each morning increased the distance of ball roll by 10 to 20%.
- a **2-day post turf rolling effect** can be achieved in most situations.
- there was no increase in the distance of ball roll when the turf rolling pressure was increased from 4.8 to 11.9 pounds per lateral inch (0.86–2.12 kg per lateral centimeter).
- the distances of ball roll were similar when the turf was rolled with the direction of mowing in comparison to when the turf was rolled against the direction of mowing.
- operating speed during turf rolling did not influence the distance of ball roll.

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- **there was a decided visual improvement in surface smoothness** as a result of turf rolling.
- turf rolling **should not exceed 2 to 3 times per week** on a long-term basis on high-sand root zones.

Note: No research data are available on turf rolling for bermudagrass putting greens.

Trend to Alternative Spiked Shoes

The demand for fast greens produced via very close mowing has resulted in increased problems with spike marks. Thus, the introduction of alternative spiked golf shoes is receiving increasing acceptance. The primary benefit to golfers is a major reduction in spike marks on putting greens. The grass shoot density on greens is sustained at a higher, more acceptable level where play does not involve the metal spiked shoes. **Studies also have shown that golf balls roll significantly farther and more true on turfs where alternative spiked shoes were used in comparison to metal spiked shoes.** Furthermore, there is less damage to other high traffic turf areas, such as entrances and exists to greens and tees and to the actual teeing area itself, especially for tees of relatively small size.

Additional benefits are derived for the golfer in terms of reduced costs for golf course maintenance, including reduced damage to wooden bridges and stairs, cart paths, golf carts, clubhouse flooring, synthetic mats, and even mowing equipment when a metal spike is lost from a shoe and subsequently is hit by the mower bedknife and blade, which causes severe damage and high repair costs. This multiplicity of benefits of alternative spiked shoes is causing a major usage change within the golfing community. **Now the question requiring research is which of the alternative spike designs is most beneficial?**

New Bentgrass Cultivars for Very Closely Mowed Putting Greens

The trend to faster greens has led to the development of new very-high-density creeping bentgrass (*Agrostis stolonifera*) cultivars that are quite tolerant of very close (1/8 inch [3.2 mm]) cutting heights. Among them are Penn A-1, Penn A-2, Penn A-4, Penn G-1, Penn G-2, and Penn G-6, which have recently been released by Pennsylvania State University. These cultivars have received more comparative, documented quantitative assessments over multiple years of research than the others recently released. The findings are:

- superior shoot density, usually exceeding 2,500 shoots per square decimeter.
- a finer leaf width, typically less than 0.7 mm.
- top ranked visual estimates of surface quality.
- top ranked rooting, especially under midsummer heat stress.
- very good tolerance to mowing of less than 4 mm.

The higher shoot density and finer leaf texture contribute to surface quality in terms of greater ball roll distance on greens. Also, a higher shoot biomass can contribute to better overall wear stress tolerance.

With this diversity of newer high-density cultivars, there may be a potential to use them on a selective regional climatic basis, which will be influenced primarily by the heat stress resistance and relative susceptibility to various diseases. The overall comparative disease susceptibility or resistance is not fully known for these cultivars, but should evolve over time as they become more widely used in various climatic regions. For example, Penn G-2 is showing susceptibility to the *Typhula* blights in the northern climates.

New Bermudagrass Cultivars for Very Closely Mowed Putting Greens

The dominant hybrid bermudagrass cultivar used on putting greens for more than 30 years has been Tifdwarf. However, at the very close mowing heights now in use, Tifdwarf shoot density is substantially thinned, resulting in openings for the invasion of moss, algae and *Poa annua*. Four new dwarf hybrid bermudagrass (*Cynodon dactylon* x *C. transvaalensis*) cultivars have been released that may minimize these problems.

Floradwarf was released from the University of Florida, with significant quantities of vegetative planting material being available since 1996. Limited published comparative quantitative research data are available. It has been described as having a very low unmowed growth habit, and appears to have slower leaf and stem growth rates and a higher shoot density than Tifdwarf, and is essentially nonflowering.

Champion was released in 1995, with substantial quantities of vegetative planting material available in 1996. Research data have been published for Champion comparing it to Tifdwarf and Tifgreen. The documented results for Champion are summarized as follows:

- vertical leaf extension rate on the order of 56% slower than Tifdwarf.
- leaf width was 13% narrower than Tifdwarf.
- stolon numbers on the order of 2.6 times greater than Tifdwarf.
- the length and number of internodes no different than for Tifdwarf and Tifgreen.
- substantially better wear tolerance than Tifdwarf at a 1/8 inch (3.2 mm) cutting height.
- significantly more rapid divot-opening recovery rate, being 1.8 times more rapid than Tifgreen and 3.4 times more rapid than Tifdwarf.
- substantially higher shoot density was sustained at a 1/8 inch (3.2 mm) cutting height, being 93% greater than Tifdwarf.

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FEATURE ARTICLE

Managing Earthworm Problems in Turfgrass

Daniel A. Potter

Earthworms have been called the "intestines of the earth" because of their importance in breaking down plant litter, recycling nutrients, and enriching the topsoil. **Generally, you'll have much healthier turfgrass where earthworms are abundant.** Their burrowing reduces soil compaction and improves air and water infiltration. Earthworm tunnels may account for two-thirds of the total pore space in soils. Earthworms enrich the soil with their fecal matter, called castings. Their feeding breaks down thatch while mixing topsoil into the thatch layer, enhancing its suitability for turfgrass growth. Thus, earthworms perform a function much like mechanical topdressing. Their activity encourages microbes that further decompose thatch and enhance soil fertility. **Conservation of earthworms is important in lawns and other turf sites where thatch is a concern.**

But on golf fairways, an abundance of earthworms can be too much of a good thing. Mud mounds abound where the earthworms have pushed up castings through the close-mowed grass. Golf carts and mower tires compact these mounds, smothering patches of grass. Golfers' drives may stop short on worm-softened fairways, and golf balls may be muddied where they land. Mower blades are dulled, and mowers return to the Operations Center caked with mud.

Over the past decade, my research team ran several multi-year field tests to evaluate the effects of turfgrass pesticides on earthworms. My original intent was to help turf managers to avoid killing earthworms, but I've since learned that there are two sides to this issue. Indeed, most of the interest in our earthworm research has been from golf superintendents who were more concerned with suppressing earthworms. Here are some options for managing this problem:

Strictly speaking, turf managers in the United States cannot apply pesticides for earthworm control because no chemicals are labeled for such use. **However, several products will kill a portion of the earthworms as a non-target effect when they are applied for control of insects or diseases listed on their labels.**

According to our research, the insecticides **bendiocarb** (Turcam®), **carbaryl** (Sevin®), **ethoprop** (Mocap®), or **fonofos** (Crusade®) are toxic to earthworms. Any of these products, applied at rates labeled for grub control and watered in (1/2 to 1 inch [1.25–2.5 cm] of irrigation), generally will give an 85 to 95% reduction of earthworms. The fungicide thiophanate-methyl (Cleary's 3336®) provides similar suppression. The impact is greatest if the application occurs when the soil is moist and the earthworms are active near the surface. One application often will reduce casting activity for 2 months or longer, not from residual toxicity, but because the earthworms are slow to reproduce or recolonize treated areas.

In England, carbaryl (Twister®), and the fungicides carbendazim (Turfclear®) and gamma HCH and thiophanate-methyl (CastAway Plus®) are registered for "control of earthworm casts." These products are not labeled for worm control in the United States. Availability and registration of products in other countries varies.

Most earthworm species are intolerant of acidic soils. Application of aluminum sulfate or sulfur to lower the soil pH to 5.8 or less may reduce their populations.

The Moss Network

James B Beard

Under the leadership of superintendent Frank Dobie of the Sharon Golf Club in Ohio, a group of 18 superintendents from 8 different states, ranging from New Jersey to Pennsylvania to Ohio to Illinois to Nebraska to Arizona, participated in a networking arrangement. The objective was an interchange of information on the relative success of various methods of moss control on putting greens. Based on an interchange of results from previous control methods that had been attempted, each of the 18 superintendents selected certain chemical control approaches that each was interested in trying during the 1997 growing season. Based on these tests a strong consensus evolved as to the most effective material in controlling moss with minimal damage to bentgrass (*Agrostis* spp.) and annual bluegrass (*Poa annua*) putting green turfs.

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FEATURE ARTICLE

Summer Bentgrass Decline Complex May Be More Physiological Than Pathological

Peter H. Dernoeden

The decline of cool-season turfgrasses during stressful summer months is not a new problem. **Creeping bentgrass (*Agrostis stolonifera*) root decline begins as soil temperatures rise in early summer.** The condition accelerates in response to low mowing heights and a reduction in soil oxygen. The latter commonly occurs in greens with poor water infiltration and percolation rates during wet periods or in response to excessive irrigation and/or soil compaction. Shade and poor air and surface water drainage intensify the problem. Dr. Bingru Huang and coworkers at Kansas State University have been investigating the root loss phenomenon in field grown creeping bentgrass. Dr. Huang's findings were presented recently at the 1997 American Society of Agronomy Meetings and the 1997 Kansas Turfgrass Conference. According to her findings, there was a greater and more rapid loss of roots in field plots maintained at 1/8 inch (3.2 mm) vs. 5/32 inch (4.0 mm) mowing height. Using a clear tube rhizotron and video photography, she could detect root loss beginning as soil temperatures rise in late June or early July. Root loss actually begins close to the crown, because roots emanating from the crown are subjected to higher temperature stress than roots growing deeper in the soil profile. In greenhouse and growth chamber studies, Dr. Huang and coworkers demonstrated that root loss occurs more greatly in overwatered, undrained soils vs. well-watered, drained soils. Root mortality also was increased when plants were maintained at higher temperatures of 95°F day/77°F night (35/25°C), when compared to lower temperatures of 77/58°F (25/14°C). The mechanism of accelerated root loss in wet soils is likely due to displacement of air and therefore a depletion of oxygen. Plants grown in wet soils and a high-temperature environment exhibited leaf chlorosis, increased respiration and a reduction in photosynthesis. Most golf course superintendents will likely agree that their most troublesome greens tend to be in low-lying, pocketed or shaded sites. The soils in pocketed greens remain wetter longer and plants growing in these greens invariably are much more poorly rooted when compared to plants grown on greens in the full sun. Wet soils also retain heat longer than well-drained soils. Dr. Huang's findings have shown that root mortality is increased by excessive soil wetness, high temperature, and reducing mowing height. Hence, root decline in creeping bentgrass is clearly a response to abiotic stress factors.

The "summer bentgrass decline complex" has been described as a disease caused by interacting factors including high temperature stress, high humidity, shade, soil compaction and root pathogens. *Rhizoctonia solani* and *Pythium* species that attack roots are said to be the pathogens that interact with abiotic stresses to cause the summer bentgrass decline complex.

The pathogen connection to this theory is based only on a favorable color response and overall improvement of turf quality when stressed greens are treated in the summer with Aliette Signature® (fosetyl aluminum) fungicide tank-mixed with either Daconil® (chlorothalonil) or Fore® (mancozeb).

Research conducted at the University of Maryland does not entirely support the view that *R. solani* and root-attacking *Pythium* are major contributing factors to this malady. It is true that Aliette Signature plus either Fore, Daconil or Chipco 26019® (iprodione) effectively control brown patch, and that Aliette Signature is an excellent *Pythium*-targeted fungicide. These Aliette Signature tank-mix partners even have been shown at times to provide improved *Rhizoctonia* brown patch control, when compared to any component applied alone. What we learned from our research in Maryland, however, is that *R. solani* rarely attacks roots of even severely blighted plants and that the *Pythiums* that attack bentgrass roots are more damaging during cool and moist weather of the spring and autumn rather than during the summer months. *Pythium* spores, however, are common inhabitants of roots and their presence in high numbers can cause roots to dysfunction in the summer. In several studies conducted in Crenshaw and Penncross creeping bentgrass (*Agrostis stolonifera*) monostands mowed to a height of 3/16 inch (4.8 mm), **we demonstrated a consistent improvement in turf color and overall turfgrass quality with Aliette Signature + Fore and Aliette Signature + Daconil applications. The enhanced quality appeared in the absence of disease during periods that were either cool and moist or hot and dry.** The improvement in turf quality usually becomes apparent within a week following spraying plots, and persists for 1 to 2 weeks. We quantified the nutrients and chlorophyll levels in grass clippings collected from the fungicide- and non-fungicide-treated plots several times. While Aliette Signature sometimes was associated with elevated phosphorus levels in tissues, Aliette Signature + Fore-treated leaves consistently contained greatly elevated manganese levels and sometimes elevated zinc, magnesium and sulfur levels. There was, however, no increase in manganese or other micronutrients in tissues from plants treated with the equally beneficial Aliette Signature + Daconil treatment. Hence, it appears that manganese and other enhanced micronutrient levels in fungicide-treated plants cannot be directly correlated with the improved color responses observed. Because color enhancement from the fungicides occurs during diverse environmental conditions in the absence of disease, it would appear that the improved quality is more physiological than chemotherapeutic. Perhaps these fungicide tank-mixes are enhancing other pigments (e.g., *anthocyanins, carotenoids*, etc.) or possibly they in some way promote more efficient rooting, photosynthesis, respiration, or other physiological processes.

The decline in bentgrass that we see in Maryland during mid-to-late summer appears to be mostly a combination of abiotic stresses including one or more of the following: high temperature, high humidity, shade, excessively wet soils; or mechanical injury from mowing too low or from grooming greens during hot weather when bentgrass is not actively growing. The research conducted at Kansas State University indicates that bentgrass roots will shorten and darken in color as soil temperatures rise in the summer. The decline in roots will naturally occur throughout the summer until root initiation and regrowth of the root system resume with the advent of cool and moist weather in the autumn.

Fast Putting Surfaces

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- has not been observed to form seedheads in over 9 years of observation.
- exhibited slightly better low-temperature hardiness than Tifdwarf and Tifgreen.
- Champion, Tifdwarf, and Tifgreen all had poor shade adaptation.

Based on these research assessments, Champion may be described as a **vertical dwarf hybrid bermudagrass in that it has a slow vertical leaf extension rate but rapid lateral stem development.** It is the first cultivar to exhibit this unique type of morphological-growth characteristics. The high shoot density, fine leaf texture, and slow vertical leaf extension rate of Champion contribute significantly to improved surface ball roll distance on putting green surfaces, with distances easily exceeding 9 feet (2.7 m) and well into the 10 foot (3.0 m) range. Champion has been successfully winter overseeded, but for best performance requires adjustments in the procedures followed.

MS Supreme was released by Mississippi State University in 1997, with significant quantities of vegetative planting material being available in 1998. Limited published comparative quantitative research data are available. It would appear to be a vertical dwarf type, with a substantially higher shoot density than Tifdwarf. It has good tolerance to a 1/8 inch (3.2 mm) mowing height.

TifEagle was released from the Georgia Coastal Plain Experiment Station in 1997, with some vegetative material available in 1998 and substantial quantities in 1999. Limited published comparative quantitative research data are available. TifEagle has improved shoot density compared to Tifdwarf, but preliminary data show it to be significantly lower in density compared to Champion, especially at a 1/8 inch (3.2 mm) cutting height.

At this time not much is known about the comparative characteristics and long-term performances among these four new dwarf bermudagrass cultivars. This is particularly true in the areas of growth-morphology, and in disease, insect, and nematode resistance and/or susceptibility. Further research is obviously needed.

Turfgrass Cultural Changes

The very high shoot density bentgrass and bermudagrass cultivars will perform best at mowing heights of 1/8 inch (3.2 mm). Less time, chemicals, and money will be spent on *Poa annua*, moss, and algae control. However, **it should be emphasized that these very-high-density cultivars will require some changes in the turfgrass cultural program to maximize their performance.** Included may be (a) up to weekly high-density, mini-tine cultivation, especially during periods of rapid shoot growth, (b) up to weekly, regular vertical cutting for biomass management, especially during periods of rapid shoot growth, and (c) a somewhat lower nitrogen fertility program.

FEATURE ARTICLE

Potential Problems with Continuous Use of the Same Herbicide

Fred Yelverton

Are there problems with using the same turfgrass herbicide year after year? The answer is a very emphatic "yes." Continuous use of the same herbicide, or herbicides with the same mode of action, can cause either of two major problems. It can cause the development of herbicide resistance, and/or weed population shifts and the development of new weed problems. The following is a discussion of herbicide resistance. A discussion of weed population shifts will be included in a later issue.

Weed populations that are resistant to herbicides are becoming more common in turfgrass management and agricultural production. Insect resistance to insecticides and pathogen resistance to fungicides were documented long before herbicide resistance in weeds. Before any documented cases of herbicide resistance, it was generally believed that herbicide resistance would not occur in weed populations. The reasoning was that weeds, unlike insects and plant pathogens, are not mobile; where a weed germinates is where it completes its life cycle. Of course, hindsight is always more accurate than foresight and weed scientists were definitely wrong on this prediction.

What is herbicide resistance and how does it occur? **A weed is herbicide resistant when it can survive an herbicide dose several times greater than normally necessary for control. It is important to point out that herbicides do not cause any genetic alteration in plants. Herbicide resistance is nothing more than selection pressure for a resistant biotype of the weed that already exists in a weed population.** For instance, suppose on a golf course there are one million annual bluegrass (*Poa annua*) plants and in this population there is one plant that has the genetic makeup to survive an herbicide that normally kills annual bluegrass. You continue to use this same herbicide each year and control the susceptible annual bluegrass plants, but this one resistant plant continues to pollinate, produce seed and increase in numbers. For a few years, you may not notice there is a problem because you are getting acceptable control. But, control continues to get worse as you continue to control the susceptible plants, while the resistant weeds increase in numbers. After a while, the annual bluegrass population is made up of mostly resistant biotypes that this particular herbicide will not control. How long does it take? Generally, **herbicide resistance can occur in 7 to 10 years of continuous annual use of the same herbicide or herbicide family.** There are documented cases of annual bluegrass resistance to the triazines in North Carolina, Mississippi, and California, just to name a few. There are also documented cases of goosegrass (*Eleusine indica*) resistance to dinitroaniline herbicides in several states. Other cases of herbicide resistance are suspected with various herbicides and weeds.

It is important to note that herbicide resistance will not always appear. In fact, with some herbicides there have never been documented cases of herbicide resistance. For resistance to occur, the resistant biotypes must be in the weed population. If they are not present, then resistance will not develop. How can you prevent herbicide resistance? **Rotating among herbicides with different modes of action can be very effective in preventing the development of herbicide resistance. This means rotating herbicides in different herbicide families that have a different mode of action.** For instance, in the case of triazine-resistant annual bluegrass, most of the documented cases have been with continuous use of simazine. Rotating with another triazine, such as atrazine, will not break the resistance cycle because these two herbicides have the same mode of action. However, rotating with pronamide (Kerb®) or a dinitroaniline (pendimethalin, prodiamine, oryzalin, etc.) will delay the development of herbicide resistance. Weed control modeling research has predicted that using a triazine 2 years in a row and another herbicide with a different mode of action in the third year (and continuing this cycle) can delay the onset of resistance for 45 years. Alternating a triazine one year and another herbicide family the next year continuously can delay resistance for 60 years. Of course, these are computer models, but they are probably fairly accurate.

Understanding herbicide resistance and the practices that can prevent the development of resistance are important for turfgrass managers. Remember that herbicide use in turfgrass management has not been in practice very long from a historical perspective. The incidences of herbicide resistance will increase in the future unless management practices are put in place to prevent its occurrence.

The Moss Network
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The best treatment was Ultra Dawn dishwashing detergent which was mixed at 4 ounces in 1 gallon of water (30 grams per liter) and applied by spot treatment using a backpack sprayer. Each moss spot was thoroughly soaked. The symptoms of effective control were that the moss turned orange-brown within 24 hours. **Generally the best control was achieved when air temperatures were between 55 and 80°F (13–27°C), on days with full sunlight.** If the Ultra Dawn treatment was applied at temperatures above 80°F (27°C) a slight discoloration of the surrounding desirable turf was observed, but the turf did recover within a few days.

Concerning the conditions under which moss was most likely to occur, there were no definite trends in terms of grass species, root zone mix, cutting height, soil pH, age of green, nitrogen fertility rate, or topdressing source. However, **in many cases, the moss was most prevalent if there was a thatch layer that was kept moist, even on greens with good drainage.** Typically, the moss problem occurred in full sun. If one green on a golf course had moss, it would readily spread to the other greens within a few years.

The 18 superintendents generally considered treatments involving iron sulfate or ferrous ammonium sulfate to be relatively ineffective. The material DeMoss® did kill the moss, but resulted in excessive damage to the surrounding turf.

These results represent the coordinated findings from one year. Thus, most probably there will be some touch-up applications required in the following years before cleanup of the moss problem stabilizes. Superintendent Frank Dobie has prepared a summary of the test observations conducted by various superintendents around the country. Those interested in further information or possible participation in 1998 can contact Superintendent Frank Dobie, The Sharon Golf Club, P.O. Box 8, Sharon Center, OH 44274; Phone: 330-239-2383; Fax: 330-239-1390.

RESEARCH SUMMARY

Fungicide Effects on Bacteria Used as Biological Control Agents

Seven fungicides were evaluated for their effect on six bacterial populations that are being assessed for use in the biological control of specific turfgrass diseases. The bacteria included *Azospirillum*, *Enterobacter*, *Pseudomonas,* and *Serratia* species. Nearly all the tank-mixed fungicides resulted in statistically significant reductions in each of the bacterial populations. The most consistently inhibitory fungicide was Banner® (propiconazole), which inhibited all 6 bacterial strains tested. Certain fungicides such as Daconil® (chlorothalonil) and Chipco 26019® (iprodione) enhanced some bacterial populations. **These results indicate that many of the commonly used turfgrass fungicides have negative impacts on bacteria used for the biological control of diseases.** This research covers the first year of a multi-year study.

Additional studies are needed to assess the relative effects of these fungicides on the actual disease control efficacy of each bacterial strain under field conditions. Certain fungicides may have a strong negative effect on disease control where bacterial populations are being applied. By the same token, there is evidence that continued research may identify fungicides that are compatible with the bacteria so they can be used in combination to maximize disease control with minimum chemical fungicide usage. **[By E.B. Nelson and C.H. Craft in 1996–1997 Cornell Turfgrass Annual Report. pp. 14–19.]**

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JB COMMENTS

Understanding the New Dwarf Bermudagrass Cultivars

The new high shoot density dwarf hybrid bermudagrass (*Cynodon dactylon* x *C. transvaalensis*) cultivars are being grouped together under one description by a number of authors and speakers. However, this is inappropriate and in fact can be very misleading to the golf course superintendent. These cultivars may vary substantially in their stem morphological-growth characteristics, and consequently the specific cultural practices required for their maintenance on putting greens at a 1/8 inch (3.2 mm) mowing height and lower also may vary. Their only common attribute may be a higher shoot density in comparison to Tifdwarf and Tifgreen.

One morphological-growth group termed **vertical dwarf has a distinctly slower leaf extension rate than Tifdwarf and Tifgreen, but has lateral stem number and growth characteristics that are much greater than for Tifdwarf , Tifgreen and Tifway.** An example of the vertical dwarf growth habit type is the cultivar Champion. This type of cultivar requires a distinctly different cultural strategy in terms of stem biomass management. Mowing at less than 4 mm is essential, plus frequent vertical cutting and high-density mini-tine cultivation of up to weekly during periods of rapid shoot growth. A lower nitrogen nutritional level than for Tifdwarf also is probable, depending on the specific cultivar.

A second cultivar grouping would have a slower leaf extension rate than for Tifdwarf and a lateral stem morphology and development comparable to that of Tifdwarf. Finally, a third group would be those cultivars with a vertical leaf extension rate and a lateral stem development both of which are much slower than those for Tifdwarf. A cultivar with much less lateral stem development could be significantly slower in its establishment rate and recovery from turf injury, especially on putting greens.

Certain of the recently released high-density dwarf bermudagrass cultivars are yet to be characterized as to their comparative stem morphology-growth characteristics. **This research is needed in order to guide selection of the most appropriate cultural strategy to be employed.**

Ask Dr. Beard

Q *The use of covers to protect against winter injury has been employed increasingly on putting greens in our colder, northern regions. What is the possibility of turfgrass kill under these covers by heat stress?*

A Under certain conditions it is possible for temperature buildups to occur under covers that would result in turfgrass kill, especially for cool-season grasses. The potential temperature rise is greater under clear covers than under opaque or black covers. In the case of clear covers, the solar radiation is transmitted through the cover and is both absorbed and reflected by the grass canopy. A major portion of the absorbed energy is reradiated at a longer wavelength, which in turn is trapped under the cover, resulting in an accumulation of heat. **Temperatures in the grass plant would have to reach 104°F (40°C) for kill of annual bluegrass (*Poa annua*) to occur.** Kill to other species would involve higher tissue temperatures. Conditions under which these temperatures most likely would occur include intense solar radiation for an extended period of time, relatively warm soil temperatures, dry soils, and a mild atmospheric temperature with minimal wind. If conditions are right, the heat buildup under a transparent cover can occur relatively rapidly. Thus, **it is very important to monitor temperatures under these covers when such conditions exist.** If there is a potential lethal heat stress problem developing, the cover must either be removed or a means of introducing cooler air under the cover must be employed.

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