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AGRONOMY

Stomata : The Plant's Port of Entry

By Dr. Karl Danneberger

Whether it is a golf course green, home lawn or athletic field, we often forget that a turf is composed of millions of individual plants. How each of those plants respond to environmental and cultural management programs dictates the quality of the turf. When we look at the structure and function of individual turfgrass plants, the complexity of life is easily seen.

In this paper, one small plant structure — stomata — will be discussed. Stomates are rather simple structures that allow for gas exchange and transpiration to occur. However, when you think of survival of turfgrass plants through the necessity to create usable energy from solar radiation via photosynthesis, and the dissipation of heat from the plant via transpiration, stomata play a critical regulation role.

Stomata structure

The stomatal area of the leaf blade includes the guard cells and the stomatal pore (Esau, 1977). The stomatal pore or opening is where carbon dioxide (CO2) enters the plant for photosynthesis and the point of transpiration of water from the leaf. Two cells called the guard cells define the stomatal pore. The guard cells are rather elongated and slightly constricted in the middle. When guard cells are turgid they create the open pore.

The stomatal area generally accounts for 1% of the total leaf surface. For turfgrass species, the stomatal density is approximately 2% to 3% of the leaf surface (Beard, 1973). The number of stomates can vary depending on the turfgrass species. Green et al. (1990) calculated the stomatal density for ten turfgrass species and found greater stomatal density on the adaxial (upper) leaf side then the abaxial (bottom). Densities ranged on the adaxial side from 68 stomata mm-1 for tall fescue to 203 stomata mm-1 for hard fescue. Interestingly, no stomata were found on the abaxial side of hard fescue, sheep fescue, chewings fescue and rough bluegrass.

Although we think of all plants having stomata, some plants do not. There are two major groups of astomatous plants (Woodward, 1998). The first group contains plants that never possessed stomates, like the gametophytes of bryophytes and lichens. The second group contains plants that were stomatous at one time, but developed effective astomatous characteristics. These types of plants are generally aquatic or parasitic in nature.

As previously mentioned, stomates play a role in gas (CO_2) exchange and transpiration. A question that can be asked is: What did stomates initially evolve to do? The earliest land plants were astomatous with a thick cuticle around their arial organ (Edwards et al. 1996).

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The absence of stomata along with a thick cuticle reduced any water loss from the plant. However, given the extremely low CO_2 diffusion rate into the leaf, a minimal level of photosynthesis occurred resulting in slow growth and development. These early plants probably evolved during periods of high CO_2 concentrations in the atmosphere.

Later, periods of low CO_2 concentration drove evolutionary forces toward high stomatal density in plants such as horsetails, ferns, conifers and angiosperms (Edwards et al. 1996). Stomata most likely evolved initially for gas exchange followed later as a mechanism to regulate water loss (Danneberger, 2000).

Let's look at the effect of stomata on gas exchange and transpiration.

Gas exchange

Photosynthesis is the process where plants convert radiant energy from the sun into usable metabolic energy. The overall equation for photosynthesis is:

$24H_2O$ + 12 CO_2 + radiant energy ($12O_2 + C_{12}H_{24}O_{12} + 12H_2O$

Where:

H_2O is equal to water

CO_2 is carbon dioxide as previously mentioned

Radiant energy is light from the sun

O_2 is oxygen and

$C_{12}H_{24}O_{12}$ is carbohydrate molecules where the usable energy for metabolic processes is stored.

The presence of atmospheric CO_2 is critical for photosynthesis. For CO_2 to enter the photosynthetic process, it must have an entrance point in the leaf. The port of entry for CO_2 is through stomata. The opening and closing of stomates follows a circadian rhythm in many plants.

During daylight when photosynthesis is active, the stomata open to allow for CO_2 diffusion, while at night when photosynthesis is not active, closure occurs. The exceptions are CAM plants (ex. desert plants). The trigger for stomatal opening is the CO_2 concentration in the intercellular spaces and not at the leaf surface or in the stomatal pore (Mott, 1988).

Thus, if CO_2 concentrations are high in the leaf ,stomata will close. Conversely, if CO_2 concentrations are low, the stomata will open. Light also plays a role in stomatal opening. Illumination increases pore opening by increasing the uptake of potassium and chlorine, along with increased synthesis of malate, which results in a swelling of the guard cells (Raschke, 1975).

Within the visible light spectrum, blue light elicits the greatest response in governing stomatal opening, although the blue light effect is enhanced in the presence of continual red light (Karlsson, 1986).

Transpiration's role

For turfgrasses, transpiration is the major mechanism for dissipating heat from the leaf blade. Favorable conditions for transpiration are low atmospheric humidity and high leaf temperature. The major mechanism in regulating transpiration is the opening and closing of stomata. The closure of stomata reduces transpiration.

Although I previously mentioned that, from an evolutionary stand point, stomata evolved initially for CO_2 exchange, the evolution of stomatal density most likely allowed for the development for more advanced and taller plants.

If we look at water movement through the plant xylem (the plants' water transport system), the tension of the water increases when transpiration increases and soil moisture decreases. If this water tension increases to a point where the column of water breaks in the plant, air enters the xylem, disrupting water flow.

This process is called xylem cavitation. It is postulated that increased stomatal density enhanced the evolutionary process of plants by preventing xylem cavitation, thus allowing for longer xylem pathways to develop for taller plants (Woodward, 1998).

Only 1% to 3% of the water absorbed by a plant is actually used for metabolic processes. The vast majority of absorbed water is used for transpiration, with 90% of that water escaping through stomata (Beard, 1973). Thus, stomatal opening or closure can have a drastic effect on the cooling of a turfgrass plant.

A field study at Rutgers University looked at the effect of summer stress on the performance of two Kentucky bluegrass cultivars (Perdomo et al., 1996). They found that the cultivar that gave the best quality during summer stress (drought and high temperature) had more open stomata during conditions of decreasing leaf water.

The more open stomata on the higher quality cultivar allowed for greater cooling. Structurally, stomata that are under moisture stress are smaller and have less turgor than stomata from well-watered plants.

Related to water loss but not necessary stomata action, mowing can add to summer stress. Increased transpiration has been detected immediately following mowing due to injury to leaf cells and the cut ends (Hull, 2000; Kneebone et al., 1992).

This is significant on frequently mowed turfs (Hull, 2000). During summer stress times, mowing with a sharp blade versus a dull blade (causes more damage to the leaf) would be an important factor in water loss.

How antitranspirants work

In some cases, it would make logical sense if you could limit transpiration — by restricting water loss, you could conserve plant moisture. You could argue, however, that a turfgrass plant undergoing water stress would close stomata on its own.

There are two major types of antitranspirants. The first is stomata inhibitors — synthetic compounds that induce stomata closure by affecting the stomatal mechanism. They include certain plant growth regulators, herbicides and fungicides.

The second type of antitranspirant are film-forming products. Film forming products coat the leaf, acting as a physical barrier to water loss. Unfortunately, these products tend to cause a greater reduction in photosynthesis than transpiration (Martin et al. 1983).

Conclusion

Turfgrass health depends on the ability to capture and store energy through photosynthesis and cool itself through transpiration. A major regulating mechanism for these processes are stomata. Although small and relatively insignificant when compared to the entire leaf surface, stomata play a critical role in turfgrass health.

LITERATURE CITED

Beard, J.B. 1973. Turfgrass: Science and Culture. Prentice-Hall, Inc. Englewood Cliffs, NJ.

Danneberger, T.K. 2000. Humidity effects on plant growth. Plant Environmental Interaction. Marcel-Dekker, Inc. (in press)

Edwards, D., G.D. Abbott, and J.A. Raven. Cuticles of early land plants: a palaeoecophysiological evaluation. In: G. Kersteins, ed. Plant cuticles: An integrated Functional Approach. Oxford: Bios:1-31.

Esau, K. 1977. Anatomy of Seed Plants. John Wiley and Sons, New York, pp. 88-99.

Green, R.L., J.B. Beard, and D.M. Casnoff. 1990. Leaf blade stomatal characterizations and evapotranspiration rates of 12 cool-season perennial grasses. HortScience 25:760-761.

Hull, R.J. 2000. Mowing: Its impact on turfgrasses. Turfgrass Trends 9(1): 1-8.

Karlsson, P.E. 1986. Blue light regulation of stomata in wheat. I. Influence of red background illumination and initial conductance level. Physiological Plant 66:202-206.

Kneebone, W.R., D.W. Kopec, and C.F. Mancino. 1992. Water requirements and irrigation. In (eds.) Waddington, D.V., R.N Carrow, and R.C. Sherman. Turfgrass. Agronomy Monograph No. 32. ASA, WI.

Martin, E.S., M.E. Donkin, and R.E. Stevens. Stomata. In: E Arnold, ed. Studies in Biology 155:48-53.

Mott, K.A. 1988. Do stomata respond to CO2 concentrations other than intercellular? Plant Physiology 86: 200-203.

Perdomo, P., J.A. Murphy, and G.A. Berkowitz. 1996. Physiological changes associated with performance of Kentucky bluegrass cultivars during summer stress. HortScience 31:1182-1186.

Raschke, K. 1975. Stomatal action. Annual Review Plant Physiology 26:309-340.

Woodward, F.I. 1998. Do plants really need stomata? Journal Experimental Botany 49:471-480.

Herbicide Resistant Turfgrasses — Panacea or Problem?

Will herbicide resistant turfgrasses solve your problems or add to them? This author offers his opinion

By Dr. Joseph C. Neal

Just about every turfgrass manager (and home gardener) would love to have a product they could spray over the top of their lawn or golf turf to kill all weeds, as well as not injure the turfgrass, be environmentally friendly and be essentially non-toxic.

Not many years ago, this would be dismissed as a dream; however, with recent advances in genetic engineering and plant breeding, that dream is now quite possible and very close to becoming a reality.

Researchers at Rutgers University demonstrated the potential by genetically engineering creeping bentgrass for resistance to the herbicide glufosinate (Finale, by AgrEvo).

Selectively controlling perennial grasses like this velvetgrass (Holcus lanatus) in a Kentucky bluegrass lawn may be possible if herbicide resistant turfgrasses become a reality. But at what cost? (Photo by J. Neal)

Researchers at The Scotts Company are currently engineering and breeding turfgrasses for resistance to glyphosate (Glyphosate, by Monsanto).

Imagine if you will, that you could spray glyphosate over your bluegrass lawn without injuring the bluegrass; finally, there would be a way to remove all the unwanted grass species like tall fescue, colonial bentgrass and even bermudagrass.

Similarly, would not golf course superintendents' battles with annual bluegrass become a thing of the past if a glufosinate-resistant bentgrass variety were available?

Listing the positives

The list of positive attributes for herbicide-resistant, particularly glyphosate-resistant, turfgrass is long. Weed control would be simple and complete. No more wondering about which product will control a particular weed. No more worries about overseeding bare spots in herbicide treated turf.

We could reduce the environmental load of herbicides used in turfgrass management; and, since herbicides account for the majority of pesticides used in turf maintenance, the overall environmental load of pesticides used in the turfgrass industry would be reduced.

However, there are serious negative impacts which must be considered with the implementation of this new technology. Foremost among these negative impacts are the evolution of herbicide-resistant weeds, escape of the herbicide-resistant grass into surrounding areas and transferal of herbicide resistance to closely related grass species.

Would they fit?

Not long ago, most weed scientists (I among them) did not believe that resistance to glyphosate would naturally occur, and if this unthinkable event did happen, that the glyphosate-resistant weeds would not be ecologically "fit" (in other words, a glyphosate-resistant weed would not be able grow and reproduce efficiently).

After all, it took over a decade of intense research in laboratories and genetic engineering to create the first glyphosate-resistant crop species.

Boy, were we wrong!

In 1996, researchers in Australia reported a population of rigid ryegrass (Lolium rigidum) had developed resistance to glyphosate following 15 years of treatment with that herbicide. More recently, similar resistance has been reported in California.

Okay, rigid ryegrass is not a major turf weed, so why should we care? Rigid ryegrass is a genetically diverse grass that is considered by many to be one of the species most prone to developing herbicide resistance. Broad genetic diversity and selection pressure of continued use of a single herbicide mode of action is a recipe for herbicide resistance development.

The mechanism of the development of a resistant is fairly straightforward. In a genetically diverse population, there can be several to many population members that have naturally evolved characteristics that allow these individuals to survive a specific herbicide application. If these individuals can successfully reproduce, they can rapidly become the dominant portion of a population, particularly if repeated applications of the same herbicide puts the resistant members at a competitive advantage.

Kentucky bluegrass encroaches into landscape beds via rhizomes. (Photo by J. Neal)

Do we have similarly genetically diverse weed species in turf? Yes! Annual bluegrass.

One resistant species

Annual bluegrass is a genetically diverse species with many biotypes and it is prone to herbicide resistance. Following continuous use of a single herbicide for several years, annual bluegrass has been reported to have developed resistance to the triazine herbicides (simazine and atrazine) and the dinitroanaline preemergent herbicides (benefin, oryzalin, pendimethalin, prodiamine, and trifluralin), as well as the general vegetation control materials amitrole and paraquat.

Broad genetic diversity and selection pressure of continued use of a single herbicide mode of action is a recipe for herbicide resistance development.

Annual bluegrass resistance to the triazine herbicides is widespread in golf course turf in the United States and several other countries. Recently, researchers at North Carolina State University reported an annual bluegrass population in golf course turf that had developed resistance to the pre-emergent dinitroanaline herbicides following just seven years of dinitroanaline use. Even goosegrass, a species not known for its genetic diversity, has developed resistance to the dinitroanaline herbicides in the southeastern U.S., and in Malaysia, goosegrass has developed resistance to glyphosate.

Would glyphosate-resistant weeds develop in a glyphosate-resistant turf? The answer is simple — yes!

In a glyphosate-resistant turfgrass, we could expect to see several applications of glyphosate during the growing season — fall and spring for annual bluegrass and perennial broadleaf weed control, early summer for crabgrass and nutsedge control and other spot treatments for escaped weeds.

Annual bluegrass in a creeping bentgrass green. Is herbicide resistant turf the answer? (Photo by R. Uva)

Multiple applications per season over several years would increase the selection pressure for herbicide resistance in several weed species. We do not know how long it would take for these resistant populations to develop, but a fair estimate is between 7 and 15 years.

Quite a weed

Glyphosate-resistant turf could be quite a weed. Glyphosate, in any one of its many formulations or trade names, is clearly the herbicide of choice for controlling perennial grass weeds that encroach into landscape beds or adjacent properties.

One survey of grounds maintenance operations suggests that glyphosate may account for up to 90% of their pesticide applications in landscape beds. Although there are several postemergence grass herbicides (such as sethoxydim [Vantage], fluazifop [Fusilade or Ornamec], and clethodim [Envoy]) that can be used to control perennial grasses in landscape beds, none control perennial grasses as well as glyphosate does, particularly late in the season.

Our research has also shown that glufosinate (Finale) does not control perennial grasses as well as glyphosate. In short, if a glyphosate-resistant turf were to creep into landscape beds or sand traps, it would be difficult to control because we don't have other tools that are as effective as glyphosate.

Glyphosate is also our number-one tool in turfgrass renovation. Should renovation of the glyphosate-resistant turf be necessary, or if you wish to kill the turf to prepare the site for a landscape bed, how will you get rid of that glyphosate-resistant turf?

Neither the postemergence selective grass herbicides nor Finale are effective alternatives for turfgrass renovation. Other herbicides effective on perennial grasses would leave a soil residual that would prohibit reseeding or planting.

Fumigation would, in my opinion, be the only effective alternative.

With the impending loss of methyl bromide in 2005, we will lose one of our most versatile fumigants and possibly the only rational control material for glyphosate-resistant turf.

Transmission of resistance

It is generally accepted that glyphosate resistance can be transferred when pollen from glyphosate-resistant plants move to the flowers of nearby plants of the same species. Under these circumstances, can glyphosate-resistant offspring be produced? Yes!

One survey of grounds maintenance operations suggests that glyphosate may account for up to 90% of their pesticide applications in landscape beds.

Realistically, most of these new offspring would probably not be ecologically fit and would not survive.

In particular, if these newly resistant offspring were to emerge in a turfgrass area, as with any newly emerged seedling, the likelihood that they will be able to successfully compete with established vegetation is very small. However, if they were to emerge in landscape beds where other competing vegetation has been controlled, they will have the potential to establish, grow and reproduce. The subsequent movement of these resistant species off-site would be inevitable.

Conclusion

I personally believe that glyphosate-resistant turfgrass is a bad idea and, for the reasons I have expressed above, hope it never becomes a commercial reality.

That is not to say that I am completely against the concept of herbicide-resistant turfgrasses. For example, a glufosinate-resistant (Finale resistant) turfgrass could be controlled with glyphosate if it escaped cultivation or if renovation became desirable.

Annual bluegrass has developed resistance to many herbicides. (Photo by R. Uva)

I believe genetic engineering of turfgrass species offers great promise for overall quality enhancement, insect and disease resistance and stress tolerance.

However, researchers engaged in improvement of turfgrasses through genetic engineering must be particularly vigilant and careful not to release a turf type with the potential to become a significant weed or to otherwise negatively impact the environment surrounding our turf. It is always helpful to remember that the law of unintended consequences is in play here.

—The author is professor of weed science at North Carolina State University.

Four Zoysia Varieties Promise Shade Tolerance, but at a Price

By Mary M. Porter

The name zoysia may not roll off the tongues of many people outside the industry, but those same people may soon be rolling out this new grass for golf courses, parks, and home landscapes, according to Texas A&M turfgrass breeder Dr. Milt Engelke.

The new zoysias will be seen first in parks and on golf courses before they are adapted to existing home lawns. "It's

TABLE 1 CURRENT PRODUCERS OF ZOYSIAGRASSES

"Diamond"			
Producer	**State**	**Contact**	**Phone Number**
Southwest Turf	TX	Terry Jungman	972/474-2821
West Coast Turf	AZ, CA	John Foster	800/447-1840
"Cavalier"			
Producer	**State**	**Contact**	**Phone Number**
Gardner Turfgrass	TX	Sam Peterson	888/221-0422
Horizon Turfgrass	TX	Willy Gavronovic	409/532-8599
Quail Valley Farms	AR, LA, MS, MO, OK, TN	Roger Gravis	800/666-0007
Rod Farms	TX	Glenn Rod	409/543-0121
Triangle Turf Inc.	TX	Buzzy Romine	800/753-5182
Trinity Turf Nursery	TX	Doug O'Connor	800/290-8873
Wharton Turfgrass	TX	Charles Davis	409/532-4340
Wittig Grass Farm	TX	Allan Wittig	409/657-4496
"Palisades"			
Gardner Turfgrass	TX	Sam Peterson	888/221-0422
Horizon Turfgrass	TX	Willy Gavronovic	409/532-8599
Rod Farms	TX	Glenn Rod	409/543-0121
Trinity Turf Nursery	TX	Doug O'Connor	800/290-8873
Wharton Turfgrass	TX	Charles Davis	409/532-4340
Wittig Grass Farm	TX	Allan Wittig	409/657-4496
"Crowne"			
Gardner Turfgrass	TX	Sam Peterson	888/221-0422
Horizon Turfgrass	TX	Willy Gavronovic	409/532-8599
Triangle Turf Inc.	TX	Buzzy Romine	800/753-5182
Wharton Turfgrass	TX	Charles Davis	409/532-4340
Wittig Grass Farm	TX	Allan Wittig	409/657-4496

TABLE 2 NEW ZOYSIA VARIETIES' CHARACTERISTICS

	Crowne	Cavalier	Diamond	Palisades
Agronomics	coarse textured stolons/rhizomes excellent establishment rapid regrowth highly competitive against weeds low nutritional needs traffic tolerant	fine leaf texture high shoot density long slender leaves spreads by stolons recovery from injury resistant to pythium blight resistant to tropical sod webworm, fall armyworm, tawny mole cricket	fine leaf texture high shoot density high rhizome production rapid recovery excellent sod strength early green-up good genetic color good fall color retention	medium-coarse texture uniform density stolons/rhizomes excellent establishment rapid regrowth few seed heads low thatch tendency tolerates close (1/2-in.) mowing vertical growth — less trimming
Environmental	low water use shade tolerant cold hardy heat tolerant salt tolerant	cold hardy good shade tolerance good salt tolerance moderate/low water use	excellent shade tolerance excellent salt tolerance low water requirements	low water use shade tolerant cold hardy heat tolerant salt tolerant
Limitations	Rhizoctonia susceptible tends to scalp flowers produces seed heads	tends to thatch under high fertility, moderately susceptible to brown patch, susceptible to zoysiagrass mite	limited winter hardiness, thatch/scalp tendency, susceptible to tropical sod webworm, susceptible to zoysiagrass mite	susceptible to fall armyworm
Mowing	1 to 2.5-in. with rotary mower	1.5 to 2.0-in. with rotary mower	from 1/8-in. up	from 0.5 to 2.5-in.
Uses	industrial parks home lawns low maintenance areas	golf tee boxes fairways home lawns	putting greens tee boxes high-maintenance turf areas	fairways — especially dry areas sports fields industrial parks and highway medians

expensive to start over with a completely new lawn," says Engelke. "A totally new lawn using zoysia sod would cost three to four times more than common bermuda and twice that of hybrid bermudagrass (Tifway) or St. Augustine. However, the savings in maintenance afterward in reduced water and fertilizer would soon balance out the difference."

He expects these zoysia grasses to become a viable alternative to St. Augustinegrass, noting, "They have good shade tolerance, lower water demands and are cold hardy." Engelke has introduced four varieties of zoysia that have patents pending.

Pressure to perform

"In urban areas, pleasing landscapes are considered a necessity by homeowners and businesses alike," Engelke explained. He noted that as cities grow, the demand on water resources and the need to monitor water supplies as a result of widespread use of chemicals has encouraged researchers to look for solutions in the genetics of plants.

Engelke's research based in Dallas is aimed at finding hardy turfgrasses, especially for southern climates, that demand less fertilizer, pesticides and water.

The development of improved turf

products like the new zoysia varieties are well suited to thrive in the hot Texas sun, in heavy shade, in humid conditions and in arid surroundings, "without the high maintenance we're used to for common bermudas," said Engelke.

More than 2,000 acres of zoysia grasses will be under cultivation in Texas by the end of this year.

The Cavalier variety of zoysia was rated number one overall in national field trials and the coarser-textured varieties, Crowne and Palisades, ranked number one and three, respectively, in their class.

Practical applications

"Golf courses, with their high maintenance costs, are anxious to find better turfgrasses. And the volume they manage gives us a great look at how these varieties perform in practical applications," Engelke noted.

"It will be especially useful on golf tees and shaded areas on golf courses where you can't grow bermuda," according to Scott Parker, superintendent of the Dallas Country Club.

It will be especially useful on golf tees and shaded areas on golf courses where you can grow bermuda — Parker

"I definitely see it being used for home lawns because it doesn't require a lot of mowing — it spreads more than it grows vertically. And for golf courses, it recovers quickly from wear. We can take people off for a short time and it bounces back," he said.

Doug O'Connor of Trinity Turf, one of the licensed growers in Pilot Point, TX, added, "We've had a lot of inquiries from golf courses, cemeteries and parks. Our initial results have shown it's a fast grower. It won't completely replace St. Augustine, but it offers a good alternative, especially in cities where St. Augustine has been banned because of drought."

Commercial release

Texas A&M released four zoysias to commercial sod producers in 1996 and 1997. The Texas Sod Producers Association (TSPA) signed licenses on Crowne, Palisades and Cavalier in April 1997.

They, in turn, have sublicensed 10 growers for production across the state. Their license permits them to produce the grasses in Texas under the Texas Department of Agriculture sod certification program. This requires them to protect the genetic integrity of the specific variety, maintain genetic purity and provide the highest quality control possible. That protects it from contamination.

Crowne or Cavalier zoysia have exhibited distinct and stable properties, said Engelke. "For example, some varieties have special drought-resistant properties we don't want to lose, or resistance to certain diseases or insects. That's what the breeding process is all about — breeding good properties in and bad ones out," he noted. He conducted field trials on the zoysia grasses across the Midwest. "(The zoysias) should be hardy about as far north as Kansas City."

All of these varieties are propagated vegetatively, not from seed, so sod producers will not have seed for sale. Engelke predicts more than 2,000 acres of zoysia grasses will be under cultivation in Texas by the end of this year.

— The author is a communications specialist at Texas A&M University in Dallas.

Management Forum: Turf Experts Respond to Your Questions

This month's topics cover spring fertilization and summer bentgrass decline, unseasonably dry weather in the Southeast and its effect on insects and two kinds of snow mold. If you have difficult problems in the turf you manage, send your questions to the Forum

***Editor's note:** Management Forum is a new feature of TurfGrass Trends. We've assembled a team of five well known and respected turf experts to answer your questions on turfgrass-related problems. Our team includes:*

- *Dr. Richard Hull*
Plant Physiology, University of Rhode Island

- *Dr. Karl Danneberger,*
Agronomy, The Ohio State University

- *Dr. Noel Jackson*
Plant Pathology, University of Rhode Island

- *Dr. Joe Neal*
Weed Science, North Carolina State University

- *Dr. Rick Brandenburg*
Insects, North Carolina State University

The format for each Management Forum will include one or two questions and the appropriate expert's response. Each of our Forum members has a special area of expertise: insects, disease, weeds, general agronomy or plant physiology. We forward questions to them for a speedy response.

If you have specific concerns or problems relating to the turf you manage, don't hesitate to send your question along to Curt Harler, managing editor at curt@curt-harler.com, call 440/238-4556 or fax 440/238-4116. We'll publish our experts' suggestions as promptly as possible

Spring fertilization and bentgrass summer decline

Q: Can spring fertilization practices exacerbate summer bentgrass decline problems and if so, what are the ways to avoid increasing decline problems?

A: Dr. Dick Hull, University of Rhode Island, responds: Yes, fertilization, especially in the spring, can contribute to summer decline of bentgrass turf. Exactly why and how to avoid this problem is not so easy to answer. The problem is knowing exactly what causes summer decline in cool-season grasses and if it is always the same thing (see TGT vol. 8, no. 10, pgs. 1 to 7). Current research at several universities is addressing this problem and more useful information will be available soon.

Turf needs adequate nitrogen supplies in order to respond positively to summer stress and repair injury resulting from play. Balancing these requirements is the challenge of sound management.

Cool-season grasses are placed under considerable stress by the high temperatures of mid-summer. This is further aggravated by management stresses such as close mowing, foot traffic and possibly aerification.

Much of this cannot be avoided so spring management should be directed toward preparing the turf to enter the summer season in the best physiological condition possible. That includes a deep root system, generous carbohydrate (energy) reserves and freedom from disease.

Unseasonably dry weather like that experienced in the Southeast can encourage certain insects like chinch bugs. Treated and untreated plots show how much damage they can cause.

Nitrogen can influence all three of these physiological conditions. High levels of available nitrogen will stimulate shoot growth but decrease root growth. Also, high nitrogen levels will decrease carbohydrate reserves and, if the climate is suitable, will tend to encourage 'high fertility' diseases.

However, turf needs adequate nitrogen supplies in order to respond positively to summer stress and repair injury resulting from play. Balancing these two sets of requirements is the challenge of sound management.

No two situations are exactly the same so it is dangerous to make blanket recommendations. What follows are my best suggestions:

1. Apply nitrogen early in the spring before it will stimulate rapid shoot growth. The nitrogen will be absorbed by the grass but more will be diverted to stimulating root growth and some will be stored as protein. This nitrogen will have little negative impact on carbohydrate reserves and may even increase their storage capacity. If an early nitrogen application was missed or the grass shows signs of limited nitrogen, an application of a slow-release material later in the spring should be helpful and cause little harm.

2. A modest application of potassium and calcium will also be beneficial. These nutrients will make the grass more responsive to stress conditions including the assault by pathogenic fungi. Because summer decline is partially due to the damaging action of toxic oxygen radicals, those nutrients required to detoxify these radicals must be available.

3. Iron is the most important such nutrient but copper, manganese and zinc are also involved. A light foliar application of these micronutrients just prior to the onset of hot weather and periodically throughout the summer will insure their availability.

These nutrients are likely to be limiting if bentgrass is growing on a sand-based green to which no micronutrients have been added. Even a soil-based green from which clippings have been removed for many years will likely be limiting in some micronutrients. Topdressing materials can be supplemented with these nutrients and that is an effective means of application.

Other management variables can be adjusted to minimize summer decline. These include raising the mowing height, maintaining a well watered soil/sand profile to promote deep root growth, maintaining good air movement over the green and minimizing the time when there is free water on the grass. Summer stress cannot be prevented but careful fertility management can help minimize turfgrass decline.

Unseasonably dry Southeast and its effect on insect damage

Q: How much of a role do unseasonably dry soil conditions in spring — like those that are occurring this year in the Southeast — play later in turf-damaging insect activity?

A: Dr. Rick Brandenburg, North Carolina State University, replies: Dry weather in the spring can affect turfgrass insect damage in several ways. There can be a short-term effect in which the dry conditions enhance the effects of the insect feeding, simply due to the fact that the drought is providing an additional stress to the plant.

Turfgrass damaged by white grubs will show much more serious symptoms of injury if the grass is under drought conditions. Dry weather will usually slow turfgrass recovery once the pests have been controlled.

This can be true for surface feeding pests such as armyworms as well. Dry weather may increase the chance of seeing armyworms on highly managed turfgrass since the armyworms will "move" from areas where the grass is dry from the drought into lush, green irrigated areas.

Some pests, such as bermudagrass mites and southern chinch bugs, usually are more severe during hot dry conditions. The rapid increase of their populations is enhanced under such conditions and the interaction of the pest and the weather often has devastating effects on the turfgrass.

In a few instances, dry weather may reduce the likelihood of a pest problem. This would be true in the case of black cutworms.

Long-term effects of dry weather may result in a reduction in certain pests such as mole crickets or white grubs. This is because the adults prefer to lay eggs in areas with adequate soil moisture to ensure egg viability and hatch. Dry soils often result in eggs that desiccate and, as a result, potential insect problems never materialize.

These are general observations and such trends, while valuable in planning, are not a substitute for a good monitoring program of the turfgrass.

Both gray snow mold and pink snow mold can severely disfigure turf stands of cool-season grasses.

Gray snow mold vs. pink snow mold

Q: How can I differentiate between gray snow mold (GSM) and pink snow mold (PSM) damage and what should I do to help the turf recover if I have either disease?

A: Dr. Noel Jackson, University of Rhode Island, recommends: Both GSM and PSM can severely disfigure turf stands of cool-season grasses. Symptoms of the diseases are apparent at snow melt especially after long periods of persistent, deep snow cover. Snow accumulating over unfrozen ground offers ideal conditions for these psychrophilic (cold tolerant) fungi to take advantage of the dormant turf and generate the typical symptoms. Yellow to bleached, collapsed grass plants in patches from 1 to 2 inches up to 1 to 2 feet mark the infection sites. Patches may coalesce to involve large areas of turf.

Close mown stands of bentgrasses, bluegrasses, fescues and perennial ryegrasses on greens tees and fairways are particularly vulnerable, but all kinds of sports turf and lawns can support infections by these fungi.

The names imply that color differences (in mycelium and/or colonized plant tissues) may be used to differentiate between these snow molds but often such visual distinctions are hard to assess. Positive identification of the causal agents, Typhula spp. (GSM) and Microdochium nivale (PSM), is reliably determined by examination for the resting structures of GSM (visible with a hand lens or naked eye) and for the asexual fruiting structures and spores of PSM (visible with a hand lens and microscope respectively).

GSM resting structures (sclerotia) are rounded, reddish brown to black masses of densely compacted mycelium ranging in size commonly between 0.5-2 mm diameter. They form on or in the collapsed plant tissues and serve to carry these fungi through the season into the late fall when active growth resumes.

Pink snow mold has the capacity to continue activity without snow cover — provided weather conditions remain cool and wet. Existing patches may continue to increase in size and spore inoculum from these sites may spread.

Collapsed plant tissues of PSM often have a pinkish coloration. Examination of such material with a hand lens may reveal the cream to orange-colored slimy pustules (sporodochia) of M. nivale. Transfer of a small sample from the sporodochium to a water drop on a glass slide and viewed through a compound microscope will readily demonstrate a profusion of the characteristically small, banana-shaped spores.

By snow melt, GSM activity ceases. No fun-gicide treatment is necessary at this time but the dormant sclerotia remain in the thatch layer. Generally, GSM damage is confined to the leaf blades and sheaths, the crowns remaining viable so natural but delayed recovery of the turf will occur. Light scarifying to remove crusted leaf debris followed by judicious topdressing and/or fertilizer application will enhance the recovery process.

In contrast, PSM has the capacity to continue activity without snow cover — provided weather conditions remain cool and wet. Existing patches may continue to increase in size and spore inoculum from these sites will be tracked to initiate new infections.

The spring phase of the disease, commonly referred to as Microdochium (Fusarium) Patch (M/FP), can reach epidemic proportions and, depending on location and weather conditions, continue activity as late as June.

Cool, wet weather in late summer and fall is also very conducive to M/FP outbreaks, particularly on Poa annua and bentgrass turf that is lush and succulent from excessive nitrogen fertilization. If not treated at that time, existing MF/P patch symptoms may then be subject to early snow cover, setting the stage for severe PSM damage over the winter.

Microdochium nivale is usually a much more damaging pathogen resulting in death of most crowns and allowing little recovery growth. Thus, treatment with a fungicide at snow melt for PSM infected turf is strongly recommended to prevent any extended spring activity in the MFP phase. Depending on weather conditions, repeat fungicide applications may be necessary.

Dicarboximide, benzimidazole, DMI or strobilurin fungicides all offer good control. Quintozene, a common fall-applied preventive material, should not be used in spring if temperatures of 65-70 degrees Fahrenheit are anticipated since phytotoxicity to bentgrass turf is possible with this material.

Meet Curt Harler

TurfGrass Trends is pleased to introduce Curt Harler to our readers — many of whom probably already know him from his work in Landscape Management, Golfdom, Athletic Turf and other leading industry publications.

When it comes to the Green Industry, Curt is anything but green. He has a B.S. in agriculture from Pennsylvania State University and a Master's degree from Ohio State.

Curt has been covering the farm, lawn and turfgrass industry — both agronomics and equipment — for over 25 years.

He comes to TGT at a good time: We're busy adding new features and elements to TurfGrass Trends, like the new Management Forum which debuts this month. In upcoming issues, we hope to include more practical, in-the-field material and ideas. Also, watch for our upcoming Reader Survey.

We'd like to get your opinions and ideas. We are looking for articles of interest to turf managers.

If you have an idea for a submission, have a question for the experts in our Management Forum, or know of someone else who has completed an impressive project or done some interesting research, get in touch with Curt.

He can be reached electronically at curt@curtharler.com or by phone in his Ohio office at 440-238-4556.

It's easy to contact us —

We appreciate your comments, ideas and questions, and we're easy to reach:

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