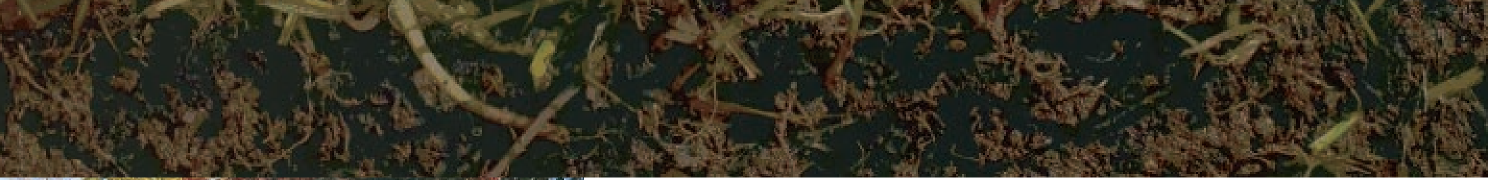

PHOTO BY: MIKE KLEMME

is summer heat and moisture stress.

Given that it's impossible to develop a fertilization program that fits all situations because of changes in climate, soil type, individual management programs, duration of the summer stress period and budget, it's still possible to develop a general program. For creeping bentgrass, developing a fertilization program is based on its growth habit.

The start of the fertilization season in the northern U.S. begins in the fall after the summer stress period. As average soil temperatures drop below 70 degrees Fahrenheit, creeping bentgrass root growth occurs. The period of root growth actually peaks a little later in the fall for bentgrass than the other cool-season turfgrasses (Koski, 1983). At the same time, shoot growth moderates and slows. It's at this time that applications of nitrogen become extremely beneficial to creeping bentgrass recovery and health going into the next year. An important application during the fall is known as late-season fertilization (LSF). Defined here as applying nitrogen in late fall when the turf is still green but no shoot growth is occurring, LSF is the most important nitrogen application of the year.

» The fall application should carry into to mid- to late spring, just in time for the start of the summer stress period.

Historically, light and frequent fertilization was practiced during the fall. The rationale was to apply nitrogen to match the shoot growth rate potential of the turf. That changed with the first research studies that reported the benefits of LSF (Powell et al., 1967). Given that the common LSF application rate is normally between 1 pound and 1.5 pounds of nitrogen per 1,000 square feet, the benefits associated with LSF could not be matched with light, frequent fall applications.

The major reported advantages of late-season nitrogen fertilization include:

- extending the greening period later into fall;
- initiating spring greenup as much as a month sooner;
- increasing stand density late into the fall and thus reducing weed pressure; and
- increasing root growth.

Metabolically, LSF is associated with increased carbohydrate levels. Normally, carbohydrate levels increase in stems and roots during the winter months, with decreasing levels occurring in shoots. The real benefit of LSF in carbohydrate metabolism is the lack of excessive carbohydrate use in response to early-spring fertilization.

Increased shoot density and root growth is demonstrated indirectly from one of the by-

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products of LSF — thatch. Although increased thatch layers are detrimental to turf health, thatch accumulation does provide insight into the dynamics of LSF. Thatch is composed of dead and living stems (rhizomes, stolons), crowns, leaves and roots between the zone of green vegetation and the soil surface. Living and dead roots comprise the greatest percentage.

A drawback to late-season fertilization is the increased threat of pink snow mold.

PHOTO BY: JOE RIMELSPACH, THE OHIO STATE UNIVERSITY

For example, 61 percent of a Baron Kentucky bluegrass thatch layer was comprised of roots (Koski, 1986). Most likely, LSF favors root growth during the spring and early summer, while early-spring nitrogen applications discourage root development. In Koski's study, the relative percentages of roots, stems and tillers didn't vary between treatments. Thus, the associated increase in thatch also meant an increase in tiller and rhizome development.

In relation to a biological stress, a previous study found that nitrogen programs containing a late-season application had less anthracnose than a program where late-season fertilization was excluded (Danneberger, et al.,1984). The desirable amount of nitrogen applied for the season was 3 pounds of nitrogen per 1,000 square feet.

A disadvantage to LSF is the potential for increased winter disease injury. The primary winter disease associated with LSF is microdochium patch, also known as pink snow mold and fusarium patch. Its threat is highest when the fall nitrogen applications are made while shoot growth is still occurring. Succulent, rapidly growing turfgrass plants going into the winter would be more susceptible. But correctly timed LSF actually reduces the severity of other spring and summertime diseases.

Although the benefits of LSF are primarily associated with nitrogen, potassium is an element commonly applied during late season. Fall applications of potassium are associated with winter hardening. Conflicting reports exist, but potassium is associated with winter hardening of warm-season turfgrasses, including bermudagrass. On cool-season turfgrasses, the benefits of exogenous applications of potassium when soil levels are adequate have not been reported.

With any turfgrass-management practices, the advantages need to be weighed against the disadvantages. In the case of LSF, especially on cool-season turfgrasses, the positives often greatly outweigh the negatives.

With the arrival of spring, creeping bentgrass is much slower to start top growth than Poa annua and most cool-season turfgrasses (Koski, 1983). It's this time that care needs to be taken in fertilizing creeping bentgrass. Given that while the other turf species, especially Poa annua, are actively growing and the creeping bentgrass is not, the first inclination is to jump start the creeping bentgrass with a heavy dose of nitrogen. This is a major mistake in that the creeping bentgrass will not respond with top growth. In addition, the nitrogen may actually be detrimental to root growth during a time when root growth is most active.

The LSF application should carry into mid- to late spring, just in time for the start of the summer stress period. At this point, the most popular and maybe the most effective method of reducing stress, in this case basal rot anthracnose, is light, frequent applications of nitrogen (Inguagiato, et al., 2008). The rate most cited is one-tenth of a pound of nitrogen per 1,000 square feet per week.

As the seasonal circle is completed and we're back to the beginning of fall, the combination of LSF and light, frequent applications of nitrogen through the summer stress period with a total seasonal application of 3 pounds per 1,000 square feet is a good base line to start developing a strong nitrogen fertility program based on your conditions. ■

Danneberger, Ph.D., is Golfdom's science editor and a turfgrass professor from The Ohio State University.

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TURFGRASS TRENDS

DOLLAR SPOT CONTROL

Rock and Rolling

This well-studied practice can help reduce dollar spot on greens, among other things *By Thomas A. Nikolai*

In the 1970s, several rock bands gained fame with the release of live albums. Kiss gained the national spotlight when Gene Simmons yelled to the crowd, "I want to rock and roll all night and party every day," prior to initiating the song on the 1975 "Alive" album. Cheap Trick gained stardom with the release of "At Budokan" in 1978 primarily based upon the distinctive manner in which singer Robin Zander states, "I want you to want me."

But my favorite catch phrase from a live concert album can be heard on the regionally successful concert album, "Live Bullet," which was recorded in Detroit's Cobo Arena in 1976. Bob Seger and the Silver Bullet Band weren't well known but they knew how to excite the hometown crowd. Seger tells his audience, "I was reading in Rolling Stone where they said Detroit audiences are the greatest rock-n-roll audiences in the world." The crowd erupts and Bob bellows, "I thought to myself, I've known that for 10 years!"

That line came to my mind when *TurfGrass Trends* asked me if I knew enough about lightweight rolling and dollar spot to write an article on the subject. Personally, I've performed more lightweight rolling research than everyone else combined. I'm not bragging; heck, maybe I'm even conceding my limitations. But in any event, it's a fact. I initiated lightweight rolling research at Michigan State University in 1993 and haven't missed a year performing research on the mechanical practice ever since.

Early on

In the 1990s, the initial objective of lightweight roller research was to gather data to determine if the mechanical practice was safe. Concerns included the limitation of rolling frequency due to the increased possibility of compaction and the more prevalent movement of diseases that are spread by mechanical means.

In 1995, I began to make a peculiar observation that, when research greens had been rolled three times a week (every Monday, Wednesday and Friday following mowing), they had less dollar spot compared to plots that were not rolled. I believed this observation to be an oddity, and I was relatively certain I'd never make similar observations in the future. However, in 1996 I made four dollar spot counts, and on every outbreak the rolled plots had less dollar spot than non-rolled plots.

This probably would've been the end of the story but, because of generous funding by the United States Golf Association, the study continued through the summer of 2000. Every time a dollar spot outbreak occurred over the six-year period, rolled research greens had less dollar spot compared to nonrolled plots. It's certainly noteworthy the study took place on three different root zones (two primarily sand

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We've heard about insects that have become resistant to common insecticides. But how many people know that weeds can become resistant to certain herbicides in? What causes resistance to develop and why should anyone in the turfgrass industry care? 58

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greens meeting USGA specifications and the third on a native sandy clay loam).

Conclusions from rolling three times per week (or every other day) after mowing include:

- **Noticeably increased green speeds every day.** From studies performed after 2000, we learned that if the thatch/mat layer on a putting surface is greater than 0.5 inches there is a noticeable drop-off in green speed the following day.
- **No increases in compaction** given the plots were on a sand topdressing program. If the plots were not on a sand topdressing program, I don't know what the results would be, but it's certainly worthy of consideration.

John Fulling, certified golf course superintendent of Kalamazoo Country Club, rocks with his band the Bronk Brothers every night. Fulling also rolls his course's greens every day.

- **No decreases in water infiltration** — again, given the plots were on a sand topdressing program.
- **Significant decreases in dollar spot.** This takes several months to a year to become incredibly noticeable on research plots.
- Additionally, the more sand in the root zone, the greater the reduction in the amount of dollar spot.

I originally published the results in a scientific journal in 2001 and, understandably, many of my peers seemed skeptical. In 2002, I gave a presentation on the subject at the Golf Course Superintendents Association of America's annual convention in Orlando, and several roller companies were so delighted that they have continued to fund lightweight rolling research to date. Support from those companies (and the Michigan Turfgrass Foundation) has allowed us to study the effects of various rolling/mowing frequency programs over the years, including:

PHOTO COURTESY: JOHN FULLING

■ **Alternating mowing and rolling on a daily basis.** This mowing/rolling frequency results in daily green-speed measurements equivalent to just mowing every day and improved turfgrass wear tolerance. Obviously, this program can also save money. However, there's no reduction in the amount of dollar spot observed with this program compared to mowing alone. This can be a very nice economic option, especially during times of the year with the greatest heat stress.

■ **Mow and roll every day.** We certainly aren't considering saving money with this option. However, results indicate consistent green speeds from day to day, the possibility to raise mowing heights for better turfgrass health and wear tolerance, and significantly more dollar spot control than mowing every day and rolling every other day.

■ **Roll every day and mow every other day.** That's right, rolling every day and mowing every other day. Of all the mowing/rolling frequencies I've researched, this one results in the most consistent green speeds from day to day — very good wear tolerance compared to mowing alone, and better dollar spot control than mowing every day and rolling every other day. Obviously, there could also be some economic saving with this program as well.

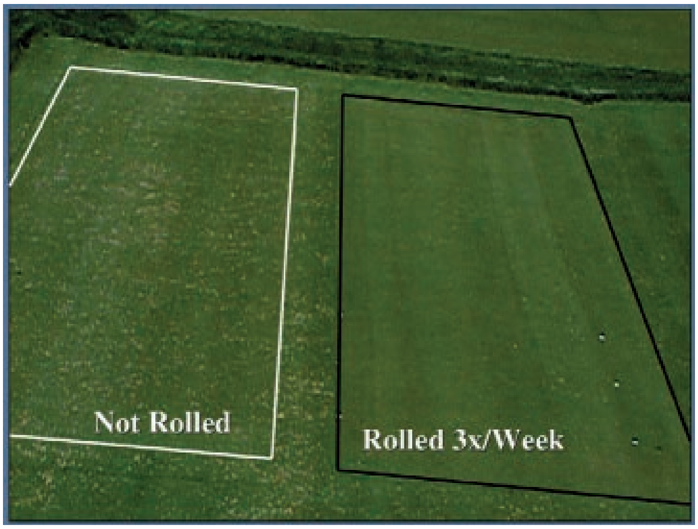
With all the programs listed above, I've never observed an increase in compaction. However, all my research plots have been on frequent sand topdressing programs (every two to three weeks).

An additional caution: When I rolled plots every day during the week, I always used the lightest rollers available on the market (Tru-Turf, DMI Speed Roller and True Surface vibratory rollers) mainly because they have been continuous supporters of my research.

I don't mean to imply that rolling seven days per week with a roller heavier than 550 pounds would result in compaction and therefore weaker turf; I'm just cautioning that we don't know if heavier rollers used daily would result in compaction or not. This would include all electric rollers.

Why does this work?

The obvious question is, "Why the reduction in dollar spot?"



In 1995, Thomas Nikolai noticed that when research greens were rolled three times a week and were followed by mowing, they had less dollar spot than greens that weren't rolled.

To be honest, the answer still eludes us. Michigan State University graduate student Paul Giordano, under the guidance of Joe Vargas, Ph.D., a MSU turf professor, is trying to determine the cause of the decrease.

During the late '90s I had several superintendents in my state of Michigan tell me, "I don't care what your data says, there's no way I'm ever going to let one of those machines on my greens." Every one of those individuals has now been rolling his greens for at least three years and all them swear by the practice — and dollar-spot reduction, too.

The question is, as asked by Peter Frampton on "Frampton Comes Alive" in 1976: "Do you feel … like we do?"

Thomas A. Nikolai, Ph.D., a former superintendent, is a turfgrass specialist at Michigan State University. To discuss rolling greens or the history of rock and roll, contact him at nikolait@msu.edu.

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Unyielding to Herbicides

Are weeds the next group to demonstrate resistance?

By Scott J. Nissen

Even with good IPM strategies, herbicide-resistant weeds can still become established.

PHOTO COURTESY: FRED YELVERTON

We've all heard about antibiotic-resistant, flesh-eating bacteria resulting from the overuse of common antibiotics. We've heard about insects, like mosquitoes, that are now resistant to common insecticides. But how many people know that weeds can become resistant to certain herbicides in the same way? What causes resistance to develop, and why should anyone in the turfgrass industry care?

Resistance is caused by selecting for rare individuals (bacteria, insects, plants, rodents, etc.) that carry some kind of genetic mutation that provides a mechanism for that individual to survive and produce resistant offspring. The selection pressure comes from highly effective antibiotics, insecticides, herbicides or rodenticides. As long as the resistance mechanism can be passed from one generation to the next, those resistant individuals will become a major part of the population over time.

The Weed Science Society of America, in conjunction with major herbicide manufacturers, maintains a database on the worldwide occurrence of herbicide-resistant weeds. The Web address is www.weedscience.org/in.asp and there are 11 weed species known to be resistant to one of the most common herbicides used in turf — pendimethalin. Fortunately, there are no reports of pendimethalin-resistant crabgrass, but there are reports of pendimethalin-resistant annual bluegrass, goosegrass and green foxtail in the United States. The Web site is a great resource if you suspect you might be dealing with an herbicide-resistant weed population.

As an extension educator for 30 years, I've found it a challenge to convince applicators they should know something about how herbicides work. Knowing how herbicides work is the first step in managing herbicide resistance. I often start a presentation by showing a long list of herbicide trade names and asking my audience how many modes of action are represented by this long list of familiar products.

There are five to seven major herbicide modes of action, depending on how you group related modes of action. Of course, it's a trick question. From a list of perhaps 15 commonly recognized herbicides, there will only be a single mode of action. So what's the point?

The point is, even if the name on the jug has changed, the applicator hasn't alternated herbicide modes of action. The most widely recognized strategy to reduce the possibly of selecting herbicide-resistant weeds is to alternate or combine herbicide modes of action. This strategy reduces the intensity of the selection pressure, making it more difficult for resistant weeds to become dominant.

The problem is that even with good IPM (integrated pest management) strategies, herbicide-resistant weeds can still become established and weeds can be resistant to herbicides that you have never used. How is that possible?

The answer is pollen. Pollen from resistant plants miles away can pollinate susceptible weeds and produce resistant seeds. For many types of herbicide resistance, the resistance trait is dominant or semi-dominant, which means

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QUICK TIP

New turf varieties address many common turf issues, offering more resistance to disease, drought and pests. Bear in mind, the fundamental physiological needs of turf do not change dramatically, but it is important to recognize that species and varieties of turf require the need for best management practices for the selected species. Recognizing the limiting factor of turf, regardless of the varietal benefits, is essential in providing optimal growth and performance. Consistently maintained nutrition and environmental management is still the most important step in growing strong, healthy turf. Learn more at www.Floratine.com.

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Annual bluegrass is a weed in many superintendents' eyes that needs to be eradicated.

PHOTO COURTESY: FRED YELVERTON

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that plants only need one copy of the resistance gene to produce highly resistant seed. So even if you're doing all the right things, herbicide resistance can be an issue on your golf course and sod farm. Annual broadleaf weeds can be highly competitive and reduce the quality of new sod, especially during grass establishment. Most often, these annual weeds are likely to be herbicide-resistant.

In much of the western United States, kochia (*Kochia scoparia*) is the poster child for herbicide resistance. Kochia is highly resistant to several major herbicide families and sometimes the same plant is resistant to several different herbicide modes of action.

The 800-pound gorilla in the room, as far as herbicide resistance is concerned, is glyphosate-tolerant crop technology. Glyphosate is the active ingredient in Roundup and many other generic products. Transgenic technology was used to produce a number of important crop plants that are tolerant to this non-selective herbicide. For most major crop plants, there are glyphosate-tolerant varieties, also known as Roundup Ready varieties. Farmers rapidly adapted this technology because weed control was simple and it allowed for significant reductions in tillage, resulting in less soil erosion. Herbicide applications require smaller equipment and they allow growers to farm more acres.

Monsanto and many others (I include myself in this group) didn't feel that glyphosate resistance would be a significant issue with this new technology primarily because of glyphosate's unique mode of action.

What we didn't fully anticipate was that, given enough selection pressure (millions and millions of acres being treated with the same herbicide year after year), weeds would find new resistance mechanisms. So starting as early as 1997, glyphosate-resistant weeds began to appear, and today there are 15 confirmed cases of glyphosate-resistant weeds worldwide. There's little evidence so far that these glyphosate-resistant crop plants have become weedy or have crossed with weedy relatives. So what does all this have to do with the turf industry: Well, can you say glyphosate-tolerant creeping bentgrass?

Glyphosate-tolerant creeping bentgrass is still under regulated status by the U.S. Department of Agriculture's Animal and Plant Health Inspection Service in Oregon. Applying transgenic technology to a wind-pollinated, outcrossing, perennial grass species has raised some concerns. The concerns are primarily about pollen flowing from these genetically engineered plants to naturalized populations, increasing their invasiveness.

Since creeping bentgrass requires significant moisture, it's most likely to be more competitive or invasive in riparian areas, which are high-value sites for biological diversity. The other issue is the potential of creeping bentgrass to hybridize with other closely related species and these hybrids becoming invasive.

This represents one more situation in which selection for glyphosate-resistant weeds can take place. While the regulated status of glyphosate-tolerant creeping bentgrass may soon be resolved, the deregulation of this genetically engineered plant is likely to have some unintended consequences. In all likelihood, these consequences will be minor, but I wonder what's more likely to happen.

Will superintendents find themselves dealing with glyphosate-resistant weeds from nearby cropland, or will farmers and ranchers have to manage weeds selected on the local golf course? Only time will tell.

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