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Continued from page 60

canopies do not become excessively puffy or unsmooth and also possess moderate to high levels of dollar spot resistance. If dollar spot resistance is your primary focus in cultivar selection and you plan to use few fungicides for disease prevention, I would generally avoid Crenshaw, Penn A-4, Independence, Providence and Backspin, all of which have shown poor resistance relative to the other cultivars (Table 2).

It is important to keep in mind that these aforementioned categories are based on my personal observations during the past three years. In some cases, some statistical overlap among cultivars might exist. For example, T-1 is not statistically different than A-4. Additionally these categories are most appropriate for the cool-humid region where the trial has been conducted and differences in other climates such as the Southeast or arid Southwest might yield different results. Do not forget that management practices such as mowing height, intended use (putting green versus a tee or fairway) will result in different recommendations. I personally still think Penncross is an excellent fairway grass due to its aggressive nature and moderate disease resistance.

The last thing to consider in this era of niche cultivars is the concept of cultivar blends. Blending improves the genetic diversity of the turf stand. But when considering the components of a blend, it is important to only combine cultivars with similar genetic color, leaf textures and growth habits. Otherwise a patchy turf can result.

More information on this study and cultivar performance information for other regions can be accessed at the National Turfgrass Evaluation Program's Web site located at http://www.ntep.org. Another option is to visit some of these cultivars at their test locations during turfgrass field days, or better yet put out your own test plots on your course where you can evaluate these cultivars under your management programs in your unique growing environment.

Most importantly, do not be afraid to be the guinea pig when it comes to these new cultivars. There really does seem to be a difference.

TABLE 2

Dollar spot severity of 26 creeping bentgrass cultivars grown on a native soil research putting green at Purdue University, West Lafayette, Ind.

Cultivar	27 Oct. 2005	12 Aug. 2006
	----- infection centers per plot ------	
CY-2	0	0
Memorial	0	1
Declaration	1	1
Shark	9	1
Kingpin	2	1
13-M	0	2
Pennlinks	0	3
Benchmark	0	3
IS-AP9	0	3
L93	1	4
Pennlinks II	2	4
Penn A1	2	4
Bengal	12	4
Authority	8	5
007	2	6
LS44	1	7
Tyee	8	7
Mackenzie	5	10
Alpha	4	10
Backspin	28	11
Penncross	7	13
Providence	18	13
T-1	9	14
Penn A4	22	22
Independence	18	27
Crenshaw	47	40
LSD (0.05)	17	19

Dollar spot was rated as the number of infection centers in each plot.

To determine statistical differences among cultivars, subtract one cultivar's mean from another cultivar. Statistical differences occur when this value is larger than the corresponding LSD value (LSD 0.05).

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Part 1 of 2

See August's TurfGrass Trends for Part 2.

Recognizing the Nitrate Effect on Root Growth and Development

NO_3- presence in the leaves directs plant resources toward leaf and shoot growth at some expense of root expansion

By Richard J. Hull and John T. Bushoven

Recent evidence might cast the nitrate problem in a somewhat different light and may offer a few solutions.

A vigorous and healthy root system is critical to maintaining high quality turf. Without sound roots, turfgrasses cannot acquire the mineral nutrients and water necessary to support good leaf growth and color and withstand the rigors of heavy use.

In an earlier article, we discussed turf-management strategies that should insure optimum root growth and efficient resource utilization (Hull, 1996; visit turfgrasstrends.com and search "Hull" to see previous articles on fertility, nutrient availability and more). In that article, the negative impact of nitrate-nitrogen ($N0_3$-N) on root growth and its promotion of excess shoot growth were discussed (Fig. 1) along with some ideas of why this occurs. Because $N0_3$-N is the most abundant source of nitrogen available to roots in most soils, its potential for depressing root growth is all but inevitable and there is little the turf manager can do about it. At least, that was the impression you logically would get from that 1996 article. Here we are not refuting that conclusion, but we are suggesting that recent evidence might cast the nitrate problem in a somewhat different light and may even offer a few solutions.

For some time, we have been studying the efficiency of nitrogen utilization by turfgrasses at both the ecological level ($N0_3$-leaching & N budgets in turf) and the physiological level ($N0_3$- uptake efficiency and the partitioning of its assimilation within turfgrasses). These latter investigations led us to the realization that perennial ryegrass (*Lolium perenne L.*) and creeping bentgrass (*Agrostis stolonifera L.*), like many grasses, transport most of the $N0_3$- absorbed by their roots to the leaves where it is reduced to ammonia (NH_3) and assimilated into amino acids (Bushoven and Hull, 2001). These amino acids can then be transported from the leaves to all parts of the plant, including the roots, where they support cell division and growth.

Already we can see a problem because NO_3- in the leaves functions as a "signal molecule" that diverts sugars, made by photosynthesis, from transport to the roots to the synthesis of amino acids in the leaves.

As we shall see below, NO_3- metabolism requires much energy. If photosynthetic energy in the form of sugars is used to assimilate nitrogen, there will be less sugar available for transport to roots. Given the anatomy of a grass plant, the transport of sugars and amino acids from leaves must pass through the crown at the soil surface, where leaves are initiated and their growth supported, before they can reach the root tips where root growth occurs. In short, NO_3- present in the leaves directs plant resources toward leaf and shoot growth at some expense from root growth. That scenario alone explains how NO_3- favors turf leaf production and retards root growth.

There are other factors involved, however.

At this point, we need to clarify what we mean by NO_3- metabolism in leaves or roots. The process of NO_3- reduction and assimilation into amino acids is not a simple operation. It involves four chemical reactions catalyzed by four different enzymes. Nitrate reduction to NH_3 (NH_4+ is its ionic form) requires two reactions occurring in different compartments of leaf or root cells. In the cytosol (liquid phase of a cell's cytoplasm), NO_3- is initially reduced to nitrite (NO2-) by acquiring two electrons from the universal biochemical reducing agent: NADH. The enzyme catalyzing this reaction is Nitrate Reductase (NR).

The resulting NO2- is then transported into a plastid (chloroplasts in leaf cells, leucoplasts in roots) where it acquires six additional electrons from the reduced form of Ferredoxin (Fdred) and emerges as the fully reduced form of N: ammonium (NH_4+). The plastid enzyme Nitrite Reductase (NiR) catalyzes this reaction.

Ammonium is the only form of nitrogen that can be used by a plant to make amino acids and subsequently proteins, nucleic acids and all other nitrogen-containing compounds. These two reactions constitute NO_3- reduction.

The assimilation of NH_4+ into an organic molecule (amino acid) also generally occurs via two reactions. The first reaction involves the binding of NH_4+ to the #5 carbon atom of the 5-carbon amino acid, glutamic acid (ionic form is glutamate), to form the amide-containing amino acid: glutamine.

Ammonium is the only form of nitrogen that can be used by a plant to make amino acids and subsequently proteins, nucleic acids and all other nitrogen-containing compounds.

Glutamine Synthetase (GS) is the enzyme that catalyses this pivotal reaction by which inorganic nitrogen (NH_4+) enters the world of organic biochemistry. Glutamine is an amide amino acid that functions as a universal nitrogen donor for the synthesis of many N-compounds in plants,

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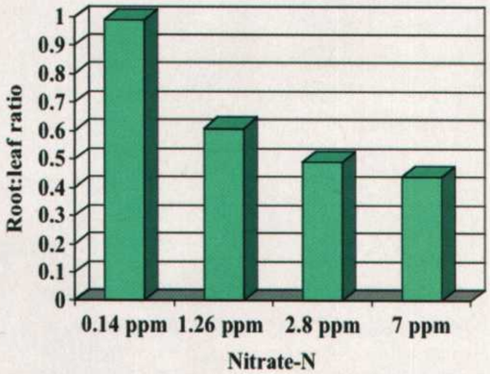
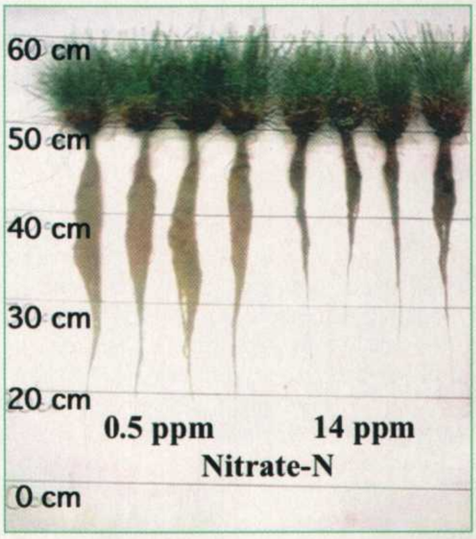
Root Growth and Nitrate Availability

As nitrate availability increases, exceeding root capacity for nitrate reduction, root growth is inhibited.





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animals and micro-organisms. However, to complete this sequence, we need to regenerate glutamate so it will be available to accept another NH_4+ and keep the process going. This process occurs when glutamine donates its amide-N to the No. 2 carbon of a-ketoglutarate (derived from mitochondrial respiration) producing two glutamate molecules.

Glutamate Synthase (GOGAT) is the enzyme that catalyzes this reaction and it also is confined to plastids. Don't ask how you abbreviate Glutamine Synthase to GOGAT; it is actually the abbreviation of a longer more technical name of the enzyme. In this reaction, a-ketoglutarate must first be reduced before it can accept an amide-N and that requires two Fdred molecules as electron donors. One of these glutamates can serve as an NH_4+ acceptor while the other can be used to synthesize other amino acids or become directly incorporated into proteins.

This reaction sequence requires a total of 8 Fdreds, and 2 NADHs (about 5 NADHs) in addition to an ATP for each NO_3- metabolized. That represents a lot of energy, almost equivalent to that required for the photosynthetic fixation of two carbon dioxide (CO_2) molecules. In fact, since most of these reactions occur in chloroplasts (at least in leaf cells) they draw upon the very same photoenergy used to assimilate CO_2. Therefore, NO_3- metabolism can be viewed as a type of photosynthesis. In this analysis, we haven't even considered the energy required to make the 5-carbon compound (a-ketoglutarate) required for the last reaction of the NO_3- metabolism sequence.

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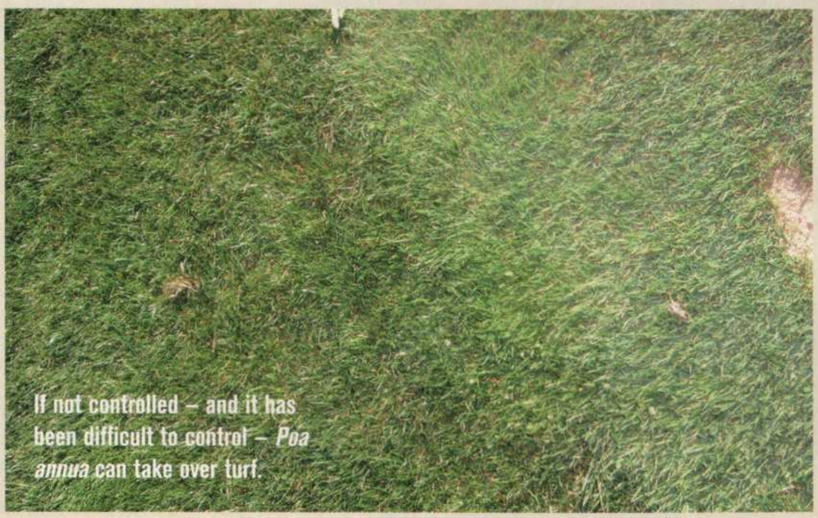
Nipping Poa in the



Problem

The troublesome *Poa annua*, which sticks out on turf with its light-green color, has been the bane of superintendents because it is difficult to manage.

Solution

A herbicide, although not a panacea to rid turf of *Poa annua*, proves promising in controlling it.

Herbicide proves promising for control of troublesome variety

BY LARRY AYLWARD, EDITOR IN CHIEF

They picked and plucked the pecks of pesky *Poa* persistently.

For years, superintendent Randy Boudinot and his crew at the Country Club of the North in Beavercreek, Ohio, were able to keep *Poa annua* (annual bluegrass) from invading the course's bentgrass greens by removing it manually.

But that tide began to turn in 2000, 2001 and 2002. That's when Boudinot, who began at the club in 1991 when it was constructed, was forced to lay off several of his crew members because of budget cuts. Alas, there weren't as many workers to pick and pluck the *Poa* by hand.

"We just didn't have the manpower," Boudinot says.

Slowly, the *Poa* began taking over the bentgrass. By the 2005 season, the *Poa* dominated many of the course's greens.

"We had greens that were 50 percent to 70 percent *Poa*," Boudinot says.

But help may arrive in the form of a new herbicide named Velocity. Manufactured by Walnut Creek, Calif.-based Valent Professional Products, Velocity was registered for tees and fairways by the Environmental Protection Agency (EPA) in late 2004. "This new herbicide strongly suppresses production of *Poa annua* and *Poa trivialis* seedheads and can be used to gradually reduce *Poa* infestations," Valent stated at the time.

Boudinot began testing Velocity on his course's chipping green as well as a few tees and fairways in 2005.

"We played around with it to see what it could do," he says.

Boudinot and his crew applied the product at 5 grams per acre once a week for seven weeks beginning in early August. He liked what he saw from the experiments.

"It knocked out the *Poa* hard," he says.

Boudinot knew he had to do something to rid the *Poa* from the greens. Seedheads were affecting ball roll and playability. Most of the club's members supported Boudinot's decision to test with the herbicide, even though it turned the turf a slight shade of yellow.

"We informed the golfers what we wanted to accomplish," Boudinot says. "We explained to them that the turf would

Bud

Michigan State University turf specialist Ron Calhoun discovered that Velocity was effective in controlling the light-green colored ***Poa annua.***

thin [after being treated] and the turf wouldn't be as good as it was the month before. There were a few grumbles, but most of them understood [our goal]."

Boudinot estimates that 40 percent to 50 percent of the *Poa* was killed in the treatment area after the seven-week treatment.

Because the turf was heavily *Poa*-infested, there was noticeable turf thinning after it began dying off. So Boudinot and his crew began "pumping the turf with fertilizer" to get the bentgrass to grow in, which it did in the late summer and fall.

There were still a few bare spots early this spring, but a warm spell in late March and more fertilizer applications spurred most of the bentgrass to fill in within 10 days, Boudinot says.

While there is still *Poa* on the turf, Boudinot says he has it under control now, and the ball roll is noticeably smoother and more consistent.

Certified superintendent Dean Graves is also using Velocity to control *Poa annua* at the Chevy Chase Club in Chevy Chase, Md. Graves worked with Valent to test the herbicide on one-half acre in 2004.

Graves began treating his bentgrass fairways with the product — every two weeks at 15 grams an acre for five weeks — the following year beginning in late May shortly after the product became labeled for fairway use.

"It did quite well," Graves says. "It killed the *Poa.*" He estimates the *Poa* population decreased from 20 percent to 5 percent on fairways after the treatment. The product did damage some ryegrass, so Graves stopped using it on that variety. "But it did not hurt the bentgrass," he stresses.

Graves learned that while Velocity eradicated turf of *Poa,* it would germinate and return a few months later to the voided areas that hadn't grown back with bentgrass. Hence, he incorporated a few other products into the *Poa*-control program.

"I realized we had to go out with a pre-emergent to help prevent the *Poa annua* from filling in those voids that had been created by the *Poa* dying," Graves says, noting that the measure would allow the bentgrass more time to creep over.

Graves also learned it was best to spot-treat *Poa* that germinated in divots and other wear areas with Trimmit 2SC, a plant growth regulator manufactured by Syngenta Professional Products, that Graves says is "very effective in killing *Poa* at the seedling stage."

Graves says he plans to treat his fairways for *Poa* every three years. "When the *Poa* population begins going back up, we'll

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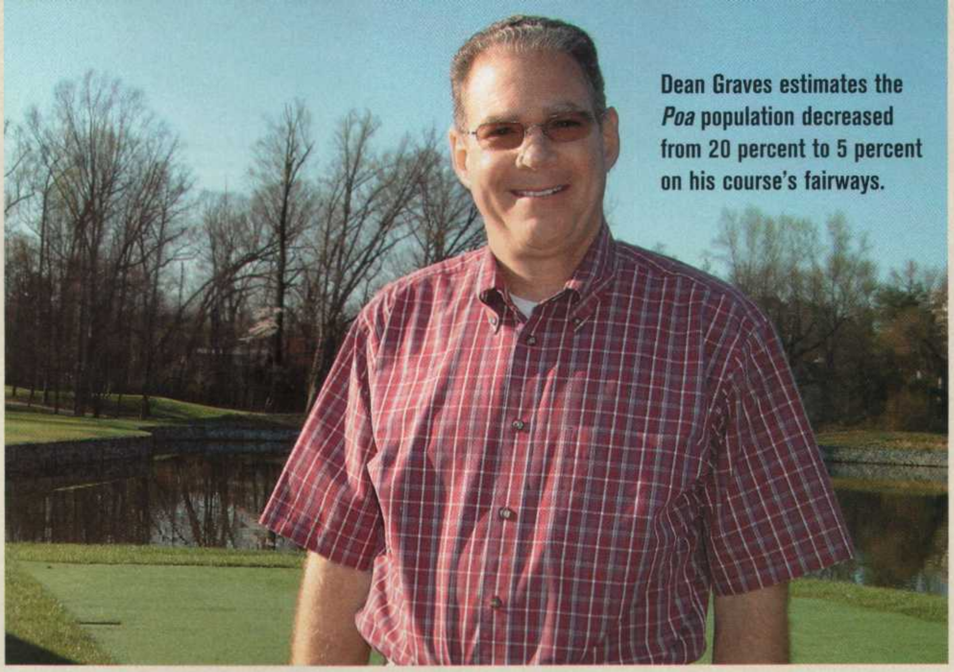
The treated areas greened up quickly after being treated with iron.



Dean Graves estimates the *Poa* population decreased from 20 percent to 5 percent on his course's fairways.

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spray it again," he says.

Like Boudinot, Graves noticed a slight yellowing or "yellow flash" of the turf after it was sprayed with Velocity.

When he tested it in 2004, Graves says he noticed a distinct difference between treated and untreated turf areas. But the treated areas greened up quickly after being treated with iron, Graves notes, downplaying the issue.

"When we sprayed all of our fairways in 2005, I took our green committee out to the middle of the first fairway," he says. "They said, 'The fairways are beautiful.' I said, 'Remember me talking about the yellow flash? Well, we're standing in the middle of it.' They said, 'The fairways look fine to us.' "

Graves says he and his crew also sprayed the club's tees with Velocity.

"It knocked the *Poa* out completely," he says. "We won't have to spray our tees again for a couple of years because it was so effective the first time out."

Before Velocity, Graves relied mostly on plant growth regulators to battle *Poa*. He says Velocity is not a panacea for superintendents in their battle to rid turf of *Poa*, but it's a good weapon to go in the arsenal.

"It's a product that does what it says it's going to do," Graves says.

Jason Fausey, research and development specialist for Valent, credits Michigan State University turf specialist Ron Calhoun for discovering that Velocity was effective in controlling *Poa*.

"Since the summer of 1999, when Ron tested it in the field and saw the activity, we knew it was something that could battle *Poa*," Fausey says.

Fausey says researchers continue to evaluate the potential for using Velocity on greens. ■