Super Science

//**IN THE FIELD**

NMSU STUDY ON N

By Clark Throssell, Ph.D.

A multi-year New Mexico State University study determined how N fertilization impacts the amount of water certain grasses need to have acceptable quality — specifically Kentucky bluegrass, tall fescue, buffalograss and bermudagrass. Higher N required less water to maintain the same level of quality, but N source had only moderate influence. Contact Ryan Goss, Ph.D., assistant professor of turfgrass science at ryangoss@nmsu.edu for more information.

Right side of the image is the irrigation source (linear gradient irrigation system). Amount of applied water goes from none on left to 150 percent ET on right. You can see the four turfgrass species as you progress away from the camera.

MAIN PHOTO BY: RYAN GOSS / PHOTO COURTESY: OREGON STATE UNIVERSITY

Golfdom suggests...

- **10 a.m., Feb. 4th** — Steps to improving your irrigation water quality, Golf Industry Show, San Diego
- **8 a.m., Feb. 5th** — Expanding the boundaries of ultradwarf bermudagrasses in the upper South and the transition zone, Golf Industry Show, San Diego
- **1 p.m., Feb. 5th** — Management of fine fescues for "native" rough areas of golf courses, Golf Industry Show, San Diego

NEWS UPDATES

GEORGIA TURF EXPERT HEADS TO OREGON STATE

Alec Kowalewski, formerly an assistant professor of turf management at Abraham Baldwin Agricultural College in Georgia, began work at Oregon State University as the school's new turf specialist on Dec. 31st. He replaces Rob Golembiewski, who took a job at Bayer Environmental Science in March 2012.

He'll divide his time between teaching, researching and working as a specialist with OSU's Extension Service to help the industry. He'll carry out his research on the plots and putting greens at OSU's Lewis-Brown Farm and the Trysting Tree Golf Club near campus. He'll be aided by OSU's Brian McDonald, a research assistant who maintained the turf program after Golembiewski's departure.

> "I THOUGHT THIS WAS A RARE, UNIQUE PROBLEM WHEN I FIRST WITNESSED IT IN HAWAII. BUT NOW I'VE SEEN THIS IRON LAYER IN TEXAS, MISSOURI, VIRGINIA, PENNSYLVANIA, WEST VIRGINIA, CALIFORNIA..."

Glen R. Obear on iron layering in two-tiered putting greens *(see full story on page 55)*

//**PRE-EMERGENT HERBICIDES**

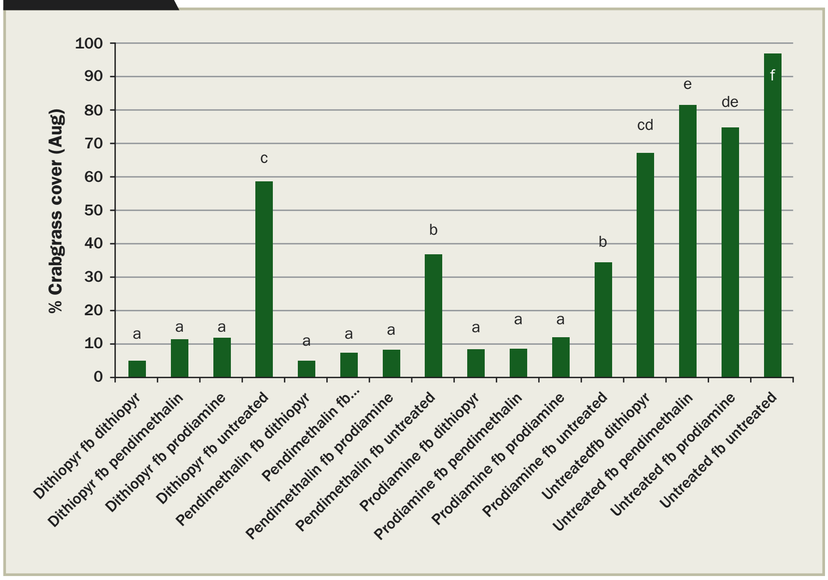
Pre-emergent herbicides for golf turf

By Zac Reicher, Ph.D.

Little has changed in pre-emergent herbicides (PREs) for use on cool-season turfgrasses over the last 20 years. The primary products for golf turf are still dithiopyr (Dimension, Dithiopyr), prodiamine (Barricade and others) and pendimethalin (Pendulum, PRE-M and others). Oxadiazon (Ronstar, Oxadiazon) is often used specifically for goosegrass control, while bensulide (Betasan, Bensumec) is still a standard for annual bluegrass control in greens-height creeping bentgrass.

Though formulations are always improving, some relatively recent changes include introduction of post-patent PREs as well as some pre-packaged mixes of active ingredients. Though the availability of PREs and application technology has changed very little in the last 20 years, effective and efficient use of PREs is still critical for golf courses across the country.

FIGURE 1



Crabgrass cover in response to changing the active ingredient between the initial and sequential application of pre-emergent herbicides, averaged over four locations in Indiana and Nebraska. This research clearly shows that the active ingredient can be changed between applications with no negative effect on crabgrass control, contrary to previous recommendations. All PREs were applied at one-half the high use rate, and "fob" indicates followed by.

CRABGRASS CONTROL

Most PREs are targeted for crabgrass, and the weather the last three summers has certainly tested efficacy of PREs for crabgrass control. Preemergent herbicides are most effective on dense, competitive turf stands that limit crabgrass. Tough summers not only thin cool-season turf, but warm soils and increased sunlight penetration into thin turf increases microbial and UV degradation of PREs.

Furthermore, staff and golfers can easily see the difference between 100 percent and 90 percent crabgrass control, so there is little room for marginal control. By their nature, PREs provide variable crabgrass control from year to year and among locations. The product and rate that worked really well last year may perform poorly this year, or vice versa. Or the product and rate that worked really well for the course down the street did not perform well for you.

The bottom line is that the PREs available today are all very effective, but efficacy can be affected by a multitude of factors, many of which we cannot predict or understand. Following are a few suggestions to maximize PRE efficacy on crabgrass and goosegrass.

Application timing: Many studies, including ours at Purdue University and the University of Nebraska-Lincoln (UNL), show that timing of PRE application can be in late fall (October-November in the north central states) or very early spring (February-March in the north central states) and still achieve season-long crabgrass control comparable to the traditional timing of mid-spring.

The benefit of late fall or very early spring applications is, they can be made well before spring's mad dash of cleanup, constant mowing, and course opening. Though the data show

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it works, the traditional application timing of mid-spring still usually trends higher for crabgrass control than very early spring or late fall application. Therefore, higher PRE rates must be used for late fall and very early spring to maximize control.

Sequential applications: After working with PREs for 25 years, I am convinced that it is best to maximize crabgrass and goosegrass control with sequential applications. Depending on your location, two applications at one-half plus one-half the high use rate will usually suffice and will almost always improve crabgrass and goosegrass control over a single application at the high use rate. The second application is usually made 4-6 weeks after the first expected crabgrass germination, but the first application can be made at the traditional timing, late fall or very early spring.

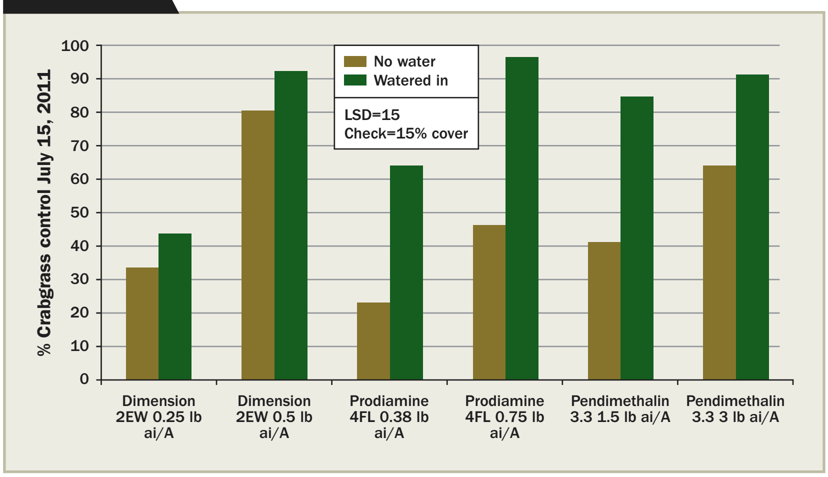
Up until the last few years, we recommended using the same active ingredient for the initial and sequential applications. However, our recent research shows that when using one-half the high use rate for the initial and sequential application, it does not matter which active ingredient is used for the initial or sequential applications (Figure 1; we tested only dithiopyr, pendimethalin and prodiamine). This increases flexibility in product selection, allows use of remaining product from previous years/applications and could increase post-emergent herbicide (POST) control of breakthrough crabgrass if dithiopyr is used for the sequential application(s).

Weed control in dormant or spring seedings is critical to limit crabgrass pressure in spring and summer. Most PREs cannot be used prior to seeding, and their use is delayed afterward.

Watering-in: Though the label on all PREs (especially the sprayable formulations) clearly state that they should be watered-in within 24 to 48 hours after application, this recommendation is often ignored.

However, watering-in PREs immediately after application with 0.1 to 0.2 inches of water resulted in up to 50 percent improved crabgrass control in one of our studies on fairway-height Kentucky bluegrass in 2011 (Figure 2). Watering-in the PREs moves the active ingredient to the soil, where it can be effective and reduces loss through volatilization and UV degradation.

FIGURE 2



Effect of watering-in vs. not watering-in the pre-emergent herbicide on crabgrass control in low-mowed Kentucky bluegrass. Applications were watered-in immediately with 0.25 inches of water or left un-irrigated for three days. Watering-in pre-emergent herbicides will help improve control and consistency in control of crabgrass.

USE IN NEW SEEDINGS

Hot, dry summers like 2012's, followed by a dry fall, mandate either dormant seeding this winter or seeding next spring. Weed control in dormant or spring seedings is critical to limit crabgrass pressure in spring and summer. Most PREs cannot be used prior to seeding, and their use is delayed following seeding to limit damage to seedlings.

Dithiopyr has the most flexible label and can be applied after the second mowing of the seedlings. Tenacity (mesotrione) is especially useful over new seedlings of many cool-season turfgrass species (other than creeping bentgrass) because it provides excellent PRE control of crabgrass, annual bluegrass and many broadleaf weeds when applied immediately prior to seeding on bare soils.

However, Tenacity is not an effective PRE on turfed soils. Our research indicates aggressive use of herbicides after seeding may cause some short-term injury to the desired turf but is more than compensated in decreased weed pressure over the long term.

ANNUAL BLUEGRASS CONTROL

POST and growth regulators for annual bluegrass control have improved with new strategies and products, but annual bluegrass is best controlled with a multi-pronged approach. This is at least partly due to variability in annual bluegrass biotypes, where one biotype may be susceptible to a specific herbicide or growth regulator while the neighboring biotype is unaffected. As a winter annual, most annual bluegrass seed will germinate in fall. Thus, PREs applied for annual bluegrass control should be applied in late summer.

Previous research at Cornell University and our current research on creeping bentgrass, Kentucky bluegrass and/or perennial ryegrass fairways clearly show that including a late summer application of a PRE in combination with a program of POST herbicides improves annual bluegrass control over the POST program alone. If the PRE is not included, the tremendous bank of annual bluegrass seed in the soil will germinate all fall and quickly reoccupy any of the openings left by annual bluegrass controlled by the POST applications.

Using multiple modes of action in an annual bluegrass control program also can minimize the chances of developing a population resistant to a single mode of action approach.

During summers like 2011 or 2012, turf stands of desired turf and/or annual bluegrass thin and die. The immediate response is to interseed the desired turf, but annual bluegrass germinates at the same time and starts to out-compete the desired turf again (Figure 3).

Options for using PREs in overseeding are limited to applications after the seedlings have matured. Initial research results at UNL investigating the use of PREs applied prior to seeding to control the annual bluegrass between the overseeder slits and preliminary results are surprisingly positive. Our other research, partly funded by the USGA, is evaluating POSTs applied shortly after emergence of the desired turf to help minimize annual bluegrass. Simply overseeding into thin turf without aggressive annual bluegrass control will continue the cycle of annual bluegrass infesting the stand.

PHOTO COURTESY: ZAC REICHER

FIGURE 3

After summer thinning of fairways containing annual bluegrass, overseeding desired turf (the dark green lines of perennial ryegrass in this case) is done to improve playability. However, annual bluegrass germinates quickly in the fall, re-occupying bare areas and likely out-competing the desired turf over the winter. Current research is evaluating the aggressive use of pre- and/or post-emergent herbicides to limit annual bluegrass reinfestation. Preliminary results are promising.

YELLOW NUTSEDGE CONTROL

Yellow nutsedge has long been controlled with POST applications, but PRE control has been documented from both Echelon (prodiamine plus sulfentrazone) and Tenacity. Applications of Echelon to established turf need to be at the typical PRE application timing for crabgrass of mid-spring and are most effective with sequential applications.

Tenacity can control yellow nutsedge PRE in a new seeding on bare soils. Though neither of these products provide 100 percent control of yellow nutsedge every time, their typical 70 to 90 percent control is far better than we ever expected from previous PRE applications.

Though few major changes have occurred in pre-emergent herbicides over the last 20 years, researchers continue to advance our understanding of these products, resulting in improved weed control and expanded uses in golf turf.

Zac Reicher, Ph.D., is a professor in the Department of Agronomy and Horticulture at the University of Nebraska-Lincoln. He can be reached at zreicher2@unl.edu.

//IRON OXIDE

Iron layering in two-tiered putting greens

By Glen R. Obear, M.S. Candidate, University of Wisconsin-Madison

When was the last time you sampled the full profile of your sand-based putting greens? Many people rarely, if ever, sample the profile all the way down to the pea gravel layer. It's inconvenient, out of sight, and therefore out of mind. However, USGA-funded research from the University of Wisconsin-Madison suggests we might be missing the full picture when we fail to sample to the depth of the pea gravel.

Iron-oxide layering has been observed at the sand-gravel interface of two-tiered putting greens of many golf courses across the United States. This layer, which only forms in greens with a pea gravel layer, is detrimental to water infiltration and leads to anaerobic soil conditions and decline of turfgrass quality.

FIGURE 1

Black layer in the low area of a putting green, indicating poor drainage and anaerobic soil conditions. Sand-filled holes from recent aerification are visibly lighter.

PHOTOGRAPHY BY: GLEN OBEAR

FIRST OBSERVATIONS

In the summer of 2008, I had the opportunity to work as an intern at a golf course on the Big Island of Hawaii. During this experience, the superintendent of the course exposed me to a very interesting and troubling soil layering problem.

We first noticed thinning turf on the putting greens, especially in low areas where water collected. We found black layer in the top 6 inches of the profile (Fig. 1), but this didn't make much sense. The course was only five years old, core aerification was done twice each year, and greens were topdressed weekly. We decided to dig deeper, thinking that maybe something was blocking water infiltration deeper in the profile.

Soluble iron moves downward through the profile until it reaches the pea gravel layer, where the water is perched.

At the sand/gravel interface of the first putting green we sampled, there was a thin layer of what looked like oxidized iron (i.e., rust) that was cementing sand and pea gravel together (Fig. 2). This cemented layer was almost impenetrable to water, which created anaerobic conditions in the root zone. As we continued investigating, we found this layer in every green we sampled, and anaerobic soil conditions were most prevalent in the low areas of the greens.

That summer, we experimented with physical removal of the layer. We used a sod cutter to cut two passes on the lowest edge of the green, where water was collecting. We dug down

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FIGURE 2

Iron layer at sand/gravel interface (12-inch depth) of Hawaii putting green. The layer reduced water infiltration, resulting in anaerobic soil conditions and thin turf density at the surface.

FIGURE 3

Iron layer in a Wisconsin putting green. The oxygenated pea gravel layer causes reduced iron in the root zone to oxidize at the textural interface. The darker black color is older, strongly oxidized iron; the light orange color is recent, weakly oxidized iron.

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to the pea gravel layer, removed the oxidized iron layer with a shovel and replaced the root zone with fresh sand. In the short-term, we were successful in improving water infiltration in these low areas. However, our fix was only temporary; the factors that caused the layer to form in the first place were still active, and the layer will likely form in these areas again over time.

One day, we were sampling and thinking about how the layer might be forming. We had many questions: "Where is this iron coming from? What factors are causing the iron to oxidize and precipitate at the sand-gravel interface? How do we remove this layer once it has already formed? How can we prevent it from forming in the future?" Finally, the superintendent suggested: "Go to graduate school, study this for your master's degree." That is exactly what I did.

UNIVERSITY RESEARCH

A few years later, I started graduate school at UW-Madison. The superintendent from Hawaii sent me some samples of this layer, and I confirmed that it was oxidized iron through physical and chemical analyses. I thought it was a rare, unique problem when I first witnessed it in Hawaii. But now that I've studied it more and more, I have seen this iron layer in Texas, Missouri, Virginia, Pennsylvania, West Virginia, California, North Carolina and even Vietnam. The layer seems to occur all over the United States and doesn't seem to be restricted to any specific climate zones.

When we take soil samples, we usually pull several plugs from the top 3-6 inches of the profile. From this, we get a wealth of information.

For my master's research, I am trying to find out exactly what causes this layer to form, how to prevent it and what to do if you already have it. The iron could be coming from fertilizer; high rates of iron fertilizer have become popular for *Poa annua* management programs, and many superintendents apply iron to improve turfgrass color. The iron could also be coming from irrigation water; many golf courses use groundwater that contains dissolved iron, and the amount of iron added through typical irrigation operations is comparable to typical iron fertility rates. Finally, iron could be coming from the dissolution of minerals in the sand used for root zone construction. Most likely, all of these sources

FIGURE 4

Full profile view of sand-based putting green using a PVC pipe sampling method. Note the oxidized iron layer at the sand/gravel interface (15-inch depth).

contribute to the formation of the iron layer to some degree.

Soluble iron moves downward through the profile until it reaches the pea gravel layer, where the water is perched. When reduced iron is exposed to this oxygen-rich pea gravel layer over an extended period of time, the iron oxidizes and precipitates along the interface (Fig. 3). Over time, this iron layer becomes more cemented and water infiltration is severely reduced.

Currently I'm collecting soil samples from a number of courses with the iron layer across the U.S. I am also collecting irrigation water samples and fertility records to see if these factors have a relationship with iron layer formation.

THE IMPORTANCE OF FULL-PROFILE SAMPLING

When we take soil samples, we usually pull several plugs from the top 3 to 6 inches of the profile. From this, we get a wealth of information that can guide the application of fertilizer and soil amendments. We typically focus on the upper portion of the profile because this is where we find roots, thatch and potential organic layers. While this type of soil sampling can be useful, it may not be enough for two-tiered putting greens. When we only sample the top half of the profile, we are only getting half of the picture.

The lower half of the profile can have as many interesting features as the top 3 to 6 inches, and these features can drastically impact the performance of the putting green. If we hadn't sampled the full profile in Hawaii, we never would have found the iron layer. Our conclusion would have been to increase aerification and topdressing frequency, and we would have been unaware of what was really causing the problem.

Why don't we sample the bottom half of the profile? Probably because it is inconvenient. Many t-probes aren't long enough to reach the pea gravel layer, and those that are long enough tend to be difficult to push down to that depth. The soil profile samplers that give you a cross-sectional view (Mascaro, Turf Tec, etc.) can offer a better view of the profile than the t-probe, but even these don't usually sample the full profile down to the pea gravel layer.

Dr. Norm Hummel offers a simple, effective and inexpensive method for collecting full-profile soil samples using PVC pipe (http://www.turfdoctor.com). With a handheld oscillating saw ($40-$100), the PVC pipe can easily be cut open for viewing of the full-profile (Fig. 4).

SEEKING SAMPLES

Are you experiencing this layering on your golf course? Know somebody else who is? We are currently looking for more samples, and we would be thrilled to include your site in our study. Please contact me at obear@wisc.edu for more information.

Glen Obear is a master's degree candidate at the University of Wisconsin-Madison studying with Doug Soldat, Ph.D. Obear can be reached at obear@wisc.edu.