A PRACTICAL RESEARCH DIGEST FOR TURF MANAGERS

TURFGRASS TRENDS

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TURFGRASS SEED RESEARCH

Major Developments
In Turfgrass Breeding

By Doug Brede, Ph.D.

Turfgrass breeding is a rapidly evolving technology, not unlike computers in how fast it's changing. Over the past ten years, plant breeders have been pumping out an array of advanced turfgrass varieties that make older varieties pale by comparison. Substantial improvements in endurance, playability, appearance, and stress and pest tolerance have been incorporated into each successive generation. Superintendents are confronted with the paradox of when to climb on board: "Do I invest in this year's best grasses or hold out for next year's model?"

In this article I'd like to update you on all the latest advancements in turfgrass breeding so you'll be an informed buyer, able to pick the right moment to take the plunge into the latest grasses. Secondly, I'll give you a glimpse of what the future holds, so you'll know whether it's better to buy now or hold out for something else.

Bentgrasses

Getting golf course superintendents to agree on the single most important feature in a creeping bentgrass variety is nearly impossible. Everybody has their own views of what traits are admirable to have in a bent.

Here ia a sampling of possibilities (4):

- **True putting** - It should produce a clean, smooth putting surface, free of bobbling as the ball rolls.
- **Uniformity** - The grass shouldn't segregate into patches over time.
- **Complete ground coverage** - Nothing fouls the game of golf faster than bare spots on a putting green.
- **Pest resistance** - No grass gets spared as pest pressures become heavy enough. What's

MAJOR DEVELOPMENTS IN TURFGRASS BREEDING

- Bentgrasses for greens
- *Poa annua* var. reptans for greens and fairways
- Kentucky bluegrasses below one inch for fairways
- Endophyte pest resistance
- Bioengineering

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TURFGRASS TRENDS

Editor
Terry McIver
440-891-2709; 440-891-2675 (fax)
turfgrasstrends@advanstar.com

Production Manager
Karen Lenzen
218-723-9129; 218-723-9576 (fax)
klenzen@advanstar.com

Circulation Manager
Frank Christopherson
218-723-9271

Layout & Production
Bruce F. Shank, BioCOM
805-274-0321

Group Editor
Vern Henry

Group Publisher
John D. Payne
440-891-2786; 440-891-2675 (fax)
jpayne@advanstar.com

Corporate Office
7500 Old Oak Blvd.
Cleveland, OH 44130-3369

Editorial Office
7500 Old Oak Blvd.
Cleveland, OH 44130

Abstracts: 800-466-8443
Reprint: 440-891-2744
Permission: 440-891-2742
Single copy or back issues:
Subscription/Customer Service
218-723-9477; 218-723-9437 (fax)

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important here, is the freedom from major "holes" in a variety's disease and insect spectrum.

- **Competitiveness with Poa** - A bent must stand up to Poa.
- **Close-cut tolerance** - Grasses with the ability to withstand close cutting heights have their own set of tradeoffs.
- **Summer stress tolerance** - In many areas, mid-summer is the make-or-break period for creeping bent. Varieties concocted out of southern strains tend to outperform northern varieties through this period.
- **Fairway adaptation** - More and more bentgrass seed is going into fairways. A good bentgrass should be able to handle the higher cut without becoming puffy and thatchy.

This discussion of desirable bentgrass attributes wouldn't have been possible 15 years ago, when all there was to choose from were 'Penncross' and 'Seaside' (7). Penncross was the hands-down favorite, save a few mavericks.

But today's superintendents are bombarded with over 20 different bentgrass varieties (11), all vying for a position on their putting greens. Each new bent has its own set of plusses and minuses. While these added varieties do satisfy our natural human desire for choice, it creates confusion about which one to select.

Judge for yourself. The avenue most superintendents follow when choosing a bentgrass is word of mouth. Grasses like fescue and ryegrass, on the other hand, are introduced to the trade by magazine ads alone. Not so with bentgrass. Superintendents need to hear about it from friends, they need to see it, touch it, bond with it - before they're ready to commit. After all, a lot is at stake in selecting a bentgrass, including your career.

In 1997, the golf industry took a giant step forward in selecting bentgrasses. The USGA, GCSAA, and the National Turfgrass Evaluation Program (NTEP) teamed up to create the world's first series of controlled, on-course variety trials (2). Unlike earlier bentgrass trials that were run under the rather cushy conditions of a college back lot, these trials will be maintained by actual superintendents, using real world chemicals, daily mowing, and wear and tear from golfers. Thirteen courses have been chosen from New York to California, spanning several climatic zones (Table 1). The greens were constructed in summer 1997 to USGA specs, with the entries planted in the fall.

NTEP will produce annual reports from these trials from the data collected by the university evaluators. But my advice to you is to travel to the course nearby and examine the grasses firsthand. Getting a personal impression is a far better way to pick a bentgrass than reading numbers from a list. Don't sell yourself short: Your impression of these grasses is every bit as important and relevant as the university profs who do the rating. Incidentally, the host superintendents at these courses have agreed to allow your visits to the sites, as long as you make an advanced appointment.

Poa annua and *Poa reptans*

When I was at Penn State University taking my first plant breeding course, the teacher had us write an essay proposing a new breeding project on some unusual species. For mine, I picked *Poa annua*. In the essay, I proposed to launch a breeding program on annual bluegrass for golf courses. As part of the class assignment, we were required to have the essay reviewed by someone in our specialty. I asked my major professor, Joe Duich, to look it over. Joe's reaction was, "This is the dumbest idea I've ever read, pal."

The irony is that 20 years later, David Huff, Joe's successor is doing just that: He's launched a breeding program on *Poa annua* for golf courses! (I wonder if Dave had Joe review his proposal?) "I haven't encountered much of a stigma in the industry as far as the superintendents are concerned," says Huff about his fledgling Poa breeding effort. "As a matter of fact, most of the resistance I've encountered has come from the scientists."

Huff's project was made easier this spring by the release of 'DW-184,' a new

TABLE 1. GOLF COURSES INVOLVED IN THE USGA/GCSAA/NTEP ON-COURSE BENTGRASS TESTING PROGRAM

Sites of the USGA/GCSAA/NTEP on-course bentgrass testing program launched last fall across the US (2). The USGA Green Section constructed an additional practice green at each course. NTEP is providing coordination for testing and reporting. GCSAA has offered sponsorship. These trials are open for your inspection, with appropriate notice given to the cooperating superintendent.

Golf course	University evaluator
Boon Links GC, Florence, KY	A.J. Powell, Univ. of Kentucky
Crystal Springs GC, Burlingame, CA	Ali Harivandi, Univ. of California
Fox Hollow at Lakewood, Lakewood, CO	Tony Koski, Colorado State Univ.
Golf Club at Newcastle, Bellevue, WA	Gwen Stahnke, Washington State Univ.
North Shore CC, Glenview, IL	Tom Voigt, Univ. of Illinois
Purdue Univ. North Course, W. Lafayette, IN	Clark Throssell, Purdue Univ.
Westchester CC, Rye, NY	Jim Murphy, Rutgers Univ.
Westwood GC, Vienna, VA	Dave Chalmers, Virginia Tech
Bent Tree CC, Dallas, TX	Milt Engelke, Texas A&M Univ.
SCGA Members Club, Murietta, CA	Robert Green, Univ. of California-Riverside
CC of Birmingham, Birmingham, AL	Elizabeth Guertal, Jeffrey Higgins, Auburn Univ.
CC of Green Valley, Green Valley, AZ	Dave Kopec, Univ. of Arizona
The Missouri Bluffs, St. Charles, MO	John Dunn, Univ. of Missouri

variety from Donald White at the University of Minnesota (17). DW-184 has broken down a lot of barriers in peoples' minds about the concept of an intentionally planted Poa.

Peterson Seed, the producer of this new variety, is calling DW-184 a "creeping bluegrass," or *Poa reptans*. From a true botanical standpoint, DW-184 is actually *Poa annua var. reptans* (Hausskn.) Timm. - the perennial subform of annual Poa (14,17). But promoting it as *Poa reptans* has helped overcome some political barriers, since *Poa annua* is classed as a noxious weed by the seed laws of several states, making its sale prohibited.

Huff views DW-184 as a valuable fairway grass. He says, though, that it may be too tall growing for putting greens. "I view it, relative to what I'm working on, as a bigger, taller grass," he says. Huff's work has centered on what he calls "greens type" Poa's - shorter, denser plant forms.

Of course, the tradeoff toward a smaller plant has been an even scantier seed yield. Reportedly, DW-184 is no tiger when it comes to yield (14). Seed supplies are expected to be tight, with demand far outstripping supply. Huff's diminutive putting green types are skimpier still on seed. "We're focused right now on seed production. Quality doesn't seem to be a hard thing to get. We've got a lot of good types. So we're really looking hard at seed production," he says.

Future trends. Huff's groundbreaking work has opened new avenues in *Poa annua* research and breeding. "It seems we're learning something totally new about *Poa annua* every month or two - things we never knew before," he says. In addition to seed production, Huff is studying Poa's cold tolerance and resistance to two primary pests, annual bluegrass weevil and anthracnose.

A recent discovery of a truly blue-gray Poa strain has sent his research into a brand new vein. "In the past we were thinking of pure Poa greens. But we've recently gotten a selection that has an identical color match to bent. So, now we're thinking of the possibility of mixing Poa with bent when seeding a green. It would add the strength of *Poa annua* to the green, and it wouldn't stick out like a sore thumb," says Huff.

Don't expect to purchase seed of Huff's new invention next year, or for a few years to come. Plant breeding takes time, especially when you're dealing with a species that has never been commercially exploited before.

Fairway Kentucky bluegrasses

Fairway adaptation for early turf breeders was truly an afterthought. Varieties were bred and developed with home lawns in mind. Breeding plots received the same weekly tending your average homeowner might give his yard. Later, after a variety was released, if it showed a particular aptitude toward close mowing, it would be selectively marketed in that direction.

As time passed, golf courses turned their backs on Kentucky bluegrass for fairways. Ryegrass and bentgrass became the favored species - not because they were easier to manage, but because they could handle the sub-inch mowing. Bluegrasses prospered at 2 to 3 inches. As the cutting height of early bluegrasses was lowered below 1 inch, they quickly faded from disease and stress.

When I began breeding bluegrasses 12 years ago, I took a different path from my predecessors. Having been a golf superintendent, I decided to make the golf course a prime consideration in my breeding. Rather than make close mowing an afterthought, I made it a primary screening tool. Instead of waiting until a variety was released before testing it for fairway adaptation, I screened tens of thousands of early-generation hybrids using a cutting height below one inch. Under these grueling conditions, most hybrids quickly gave way to moss or bare ground. Only a handful of varieties out of thousands prospered under this intensity of mowing. I selected these for release (6).

By 1995, just as my new generation of fairway bluegrasses were making their debut, the NTEP initiated bluegrass testing at under an inch (12). Earlier NTEP bluegrass trials screened varieties at 1 to 3 inches, home lawn height. The latest trial evaluates sub-inch mowing at several locations, including in the tough, transition-zone cor-

ORIGINS OF MODERN BENTGRASSES

Experiment station selections - Back in the 1960's, nearly every state university worth its salt had its own bentgrass variety in the works. Many of these bents never got off the farm and into the industry. As early turf specialists - Bill Kneebone, Wayne Huffine, and others - traveled their state visiting golf courses, they'd extract a plug or two from attractive patches they observed. These plants would end up on the experiment station's putting green, where they would be compared endlessly against Penncross and Seaside. The University of Arizona experiment station was one of the few to actually release their selections to the public. 'SR 1020,' released in 1987, consists of 5 clones selected from attractive spots on golf courses (1).

University germplasm exchanges - Back in the late 1960's and early '70's, in an effort orchestrated by the US Golf Association, numerous colleges across the country agreed to an informal swap of their collected bentgrasses. This provided two opportunities for researchers: (a) Small colleges could share their collections with bigger programs in hopes that at least something good would become of their valued finds, and (b) colleges that wished to augment their breeding programs could do so without added cost. 'Putter' bentgrass, bred by Stan Brauen of Washington State University, traces its parentage in part to this early exchange of bent germplasm (5).

Composites from golf courses - One recent trend in bentgrasses has been toward varieties concocted from mass collections of plugs from golf courses. In some cases, 100 or more plugs have been grouped together from courses in several states to produce a new variety. The advantage of this strategy is a broader genetic base and fewer concerns with quirky disease susceptibilities, resulting from too narrow a germplasm. Some skeptics question whether the genetic base of these composite varieties is really that broad, since most plugs undoubtedly trace from old Penncross greens. Nonetheless, the performance of these broad-based varieties has been unmistakable. Varieties such as 'Southshore,' and 'L-93' which was selected from within Southshore, have been advancements in the state of the art (10,11).

ridor, long a nemesis of Kentucky bluegrass. Without a doubt, this new generation of Kentucky bluegrass has opened the eyes of many skeptics.

Some turf scientists like Bill Torello, University of Massachusetts, are once again promoting bluegrass for fairways as a lower maintenance alternative to ryegrass and bentgrass.

Endophyte

Endophytes are those microscopic fungal creatures that live inside the veins of grass leaves, giving off protective insecticides in exchange for their cozy homes. Endophytes are an inexpensive insurance policy that guards many of today's top ryegrass and fescue varieties from pests. Insects are repelled or killed by these natural pesticides, reducing the turf managers' need for artificial insecticides.

Endophytes have been protecting turf varieties long before their presence was even detected. Turf historians speculate that even the earliest ryegrasses, Manhattan and Pennfine, contained 20 to 30 percent endophyte. Although, curious as it may sound, the breeders never intentionally put it there in the first place (9). The parents of Pennfine and Manhattan were selected for their relative fitness - a trait that may have been induced partly by the endophyte.

Today, pioneering turf breeders are taking the concept of endophytes several steps further. "We're developing populations of tall fescue and perennial ryegrass that utilize diverse sources of endophyte. We don't want to rely on one particular biotype of endophyte," says Don Floyd, turf breeder for Pickseed West in Tangent, OR. Incorporating multiple strains of endophytes into one variety reduces the possibility of failure of a given fungal strain, while broadening its insect and stress spectrum.

Some turf scientists are again promoting bluegrass for fairways as a lower maintenance alternative to ryegrass and bentgrass.

A common concern in pest management is chemical pest resistance (16). Over time, insects and fungi have mutated into forms resistant to many of today's popular ag chemicals. Benomyl fungicide, for example, has become nearly useless as more and more dollar spot-resistant strains have emerged. Although this has never happened with the chemicals in endophytes, it never hurts to be too careful.

Another modern innovation in endophyte technology involves breeding the endophyte itself. Some adventuresome scientists are breeding and selecting endophyte strains just as they would breed and select grass varieties.

There might even come a day when a sticker on your turf seed bag identifies the strain of a popular endophyte inside - just as many of today's computers come with a sticker promoting "Intel Inside."

NOTES ON MANAGING A NEW BENTGRASS

Paul Jett, superintendent at Pinehurst Resort, Pinehurst, NC, recently presented a seminar on his experience maintaining Penn G-2, a new creeping bentgrass, during the 1998 GCSAA conference, Anaheim, CA. Pinehurst No. 2 puts an incredible amount of maintenance into their greens. In the past, they spent a lot of money on their old bentgrasses, but they have doubled their maintenance input after planting 'Penn G-2.'

G-2 has a number of unique management requirements. Jett says it must be topdressed regularly with a very fine sand. The grass was so dense that regular topdressing sand will not work through the turf canopy. Consequently, very fine "sugar" sand must be applied on a regular basis.

Pinehurst topdresses 40 times a year. Of course, all that sand wreaks havoc on the mowers. The mowers must be sharpened every day, in comparison to sharpening once every two weeks with normal bentgrass management. Ball marks must be filled every day. They use a green-dyed sand because it takes two to three weeks for a ball mark to heal on a G-2 green. This is compared to less than one week on a Penncross green.

In practice, superintendents may find that these modern ultra-dense bentgrasses have a place for only the top 5 percent of the golf courses in America - the ones who can afford to maintain this level of grass.

Tinkering with the actual genes of plants is the ultimate tool for making grasses do our bidding.

Kentucky bluegrass endophyte. Unlike ryegrass and fescue, which commonly contain an endophyte, Kentucky bluegrass varieties never do. This unfortunate quirk of nature could change, if Suichang Sun here at Jacklin has anything to say about it. Sun has undertaken an ambitious project to instill an endophyte into this previously endophyte-free species (3). If he's successful, the implications for turf management will be profound.

"Kentucky bluegrass is the major cool-season turf used around the world. Adding an endophyte would help cut pesticide use on a lot of turf acres worldwide," says Sun. To achieve his goal, Sun isolated an endophyte fungus from an obscure Kentucky bluegrass relative in a distant Asian country (15). Later he perfected a way to incorporate the fungus into bluegrass - a process he later patented. Today, Sun has obtained 57 endophyte-infected Kentucky bluegrass plants ready for field testing.

"We've even gotten the endophyte fungus to crawl along through the bluegrass rhizomes into new daughter plants. I know that sounds funny, but no one's ever seen endophyte propagate underground before," he says.

Bioengineering - the final frontier

Tinkering with the actual genes of plants is the ultimate tool for making grasses do our bidding. Plant breeders already do this, but on a much clumsier scale. Plant breeders move thousands of genes at a time by means of hybrid crosses. Bioengineers, on the other hand, can move a single gene from one plant to another - or even a gene from a bacteria into a grass.

Bioengineering opens up a whole realm of possibilities for turf breeders:

• **Varietal improvement** - Bioengineers in California have isolated a drought-tolerance gene from the ice plant and are transferring it into grasses, in hopes it will enhance the grasses' resistance to droughty soils.

• **Pest resistance** - Michigan scientists have cloned an antifungal gene found in an American elm tree that showed resistance to Dutch-elm disease. The gene codes for chitinase, a enzyme that degrades chitin, the backbone protein found in fungi. When inserted into grass, it appears to give resistance to common diseases such as dollar spot.

• **Weed control** - In recent years, herbicide-resistant plant varieties have set the corn and soybean seed markets on their ear (pun intended). New varieties are engineered with a gene that allows a full rate of non-selective herbicide (Roundup® or Finale®) to be applied over-the-top without damage to the crop. Weeds are eliminated, leaving only resistant crop plants alive in the field. Biotechnology giant, Monsanto, estimates that by 2005, the global market for gene-altered plants will soar to an incredible $6.6 billion (8).

• **Varietal fingerprinting** - With 100 perennial ryegrass varieties in the latest NTEP trial alone, breeders are finding it increasingly difficult to identify their new products. As a result they're turning to biotechnology to pinpoint genes present in their variety alone. "We're moving into an era where the breeder has to protect his varieties - an era where biotechnology will become paramount," says Pickseed's Floyd. "There will be molecular techniques applied to protecting our proprietary varieties."

Turf bioengineering. According to *Business Week* magazine (8), last year U.S. farmers sowed more than 16-million acres of genetically-modified seed. Of those acres, how many of them were turf? The answer is zero.

What are the reasons turf is lagging behind its agronomic cousins in bioengineering? Size is one factor. Multinational chemical companies have invested hundreds of millions of dollars in bioengineering over the past decade. Larger crops such as wheat, cotton, and soybeans provide a stronger avenue for recouping their massive

R&D investments. Turf to them is a bit crop - to small to worry about right now.

Another problem with turf is that it's perennial. If you think about it, all of the current bioengineered crops are annuals. And there's a reason why: They all die after one season of use.

Biotech companies like annual crops because new seed must be purchased each spring. They also like the fact that after a set period of months, their products self-destruct, eliminating the possibility of the plants crawling away, as plants sometimes do. Alfalfa will become the world's first bioengineered perennial crop, available beginning in 2005.

Last but not least, turf suffers from one huge complication that makes bioengineers cringe, it has natural relatives. Corn and rapeseed - two popular bioengineered crops - have no natural relatives near where they're grown. Turf on the other hand, has a slug of cousins along roadsides, in abandoned fields, and on virtually every square foot of ground across the land. Bioengineers' biggest fear is that the biotech bentgrass planted on your golf course will hybridize with the native bent plants along your streambank, spreading their valuable genes into the wilds. Though this may sound like a trivial concern, its very possibility has raised the ire of green groups the world over.

An actual case of gene escape occurred last October in France. Scientists reporting in Nature magazine, showed that herbicide-resistance genes from oilseed rape could transfer to wild radish weeds, conveying herbicide resistance into weed populations. Can you imagine: Weeds that you can't kill with herbicide. That's why the biotech giants are progressing slowly with turfgrass. They don't want a two-bit crop to jeopardize their global moneymakers.

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Plots in this trial were seeded in the fall of 1996 and rated through spring 1997 at a mowing height of _ inch. Rating scale was 1 to 9, with 9 equal to best quality.

I'm not saying that all doors are closed in regard to turf bioengineering. Yes, the avenue of herbicide-resistant varieties has been derailed for five or 10 years. But advancements in drought, pest, and stress tolerance from bioengineering could begin appearing on the market as soon as 2005.

Doug Brede, Ph.D., is research director for Jacklin Seed and Medalist America, the turf seed branch of the J.R. Simplot Company in Idaho. His team of scientists and breeders have released over 40 popular turf cultivars in recent years. Brede has written over 100 articles on turfgrass and related subjects. His latest venture is a book on how to reduce your turf maintenance, due out in the fall. Turfgrass TRENDS subscribers can save $20 off the cover price by ordering early from Ann Arbor Press at (734) 475-8787.

RESEARCH SUMMARIES

Controlling June Beetle Grubs, with surface-applied insecticides. *Research conducted by Dr. Rick Brandenburg, NC State University.*

Several different treatments were evaluated for control of green June beetle grubs (Cotinus nitida L.) on a bermudagrass fairway at the Quali Ridge Golf and Country Club in Sanford, NC.

Turfgrass on the site was mowed at 7/8-inch, with 1/4-inch of thatch present. The soil was classified as "sandy loam" with pH of 5.6 and 0.51 percent humic matter.

Plots 10ft. x 10 ft. were established in an area with a historyof green June beetle infestations and treatments (replicated four times) were randomly assigned to the plots. All liquid insecticides were applied using a CO_2 backpack sprayer delivering approximately 30 gpa, operating at 40 psi.

Granular insecticide formulations were applied using a hand-held Republic EZ Handscpreader. All treatments except for Orthene 75S received approximately 0. inches of water immediately after application of insecticides.

All plots were oversprayed on 29 September with a 5.0 lb. ai/acre rate of Sevin 80 -S, and were evaluated on September 30 by counting all the dead grubs on the surface within two 1m^2 frames randomly placed in each plot. Dead grubs from the Sevin overspray are assumed to have survived the "initial test" treatment. The average number of grubs counted per lm^2 in each plot are reported in Table 1.

All data were transformed (square root of X+ 0.05) prior to ANOVA and DNMRT.

Actual means are presented in tables.

Results and discussion

Sampling showed treatments using Oftanol 5G provided greater control than both treatments using Orthene 75S and treatments using CGA-293343 2SC at the 10- and 20-ox. rates. Only the Oftanol and CGTA-293343 2SC at the 15-oz. rate provided a significant reduction in grubs.

TABLE 1.

Treatment	RATE (LB AI/A)	TARGET	—grubs per 2 m^2 per plot REP 1	REP 2	REP 3	REP 4	AVERAGE
Orthene 75S	3.0	1 st instar	22.00	20.00	18.00	31.00	22.75 bc
Orthene 75S	5.0	1 st instar	32.00	17.00	12.00	35.00	24.00bc
CGA-293343 2SC	10 fl. oz.	1 st instar	42.00	37.00	58.00	10.00	36.76 c
CGA-293343 2SC	15 fl. oz.	1 st instar	3.00	41.00	7.00	16.00	16.75 ab
CGA-293343 2SC	20 fl. oz.	1 st instar	14.00	16.00	26.00	22.00	19.50 bc
Oftanol 5G		1 st instar	6.00	9.00	3.00	2.00	5.00 a
Untreated	———	1 st instar	35.00	41.00	25.00	33.00	33.50 c

Means followed by the same letter are not significantly different (DNMRT, P=0.05)