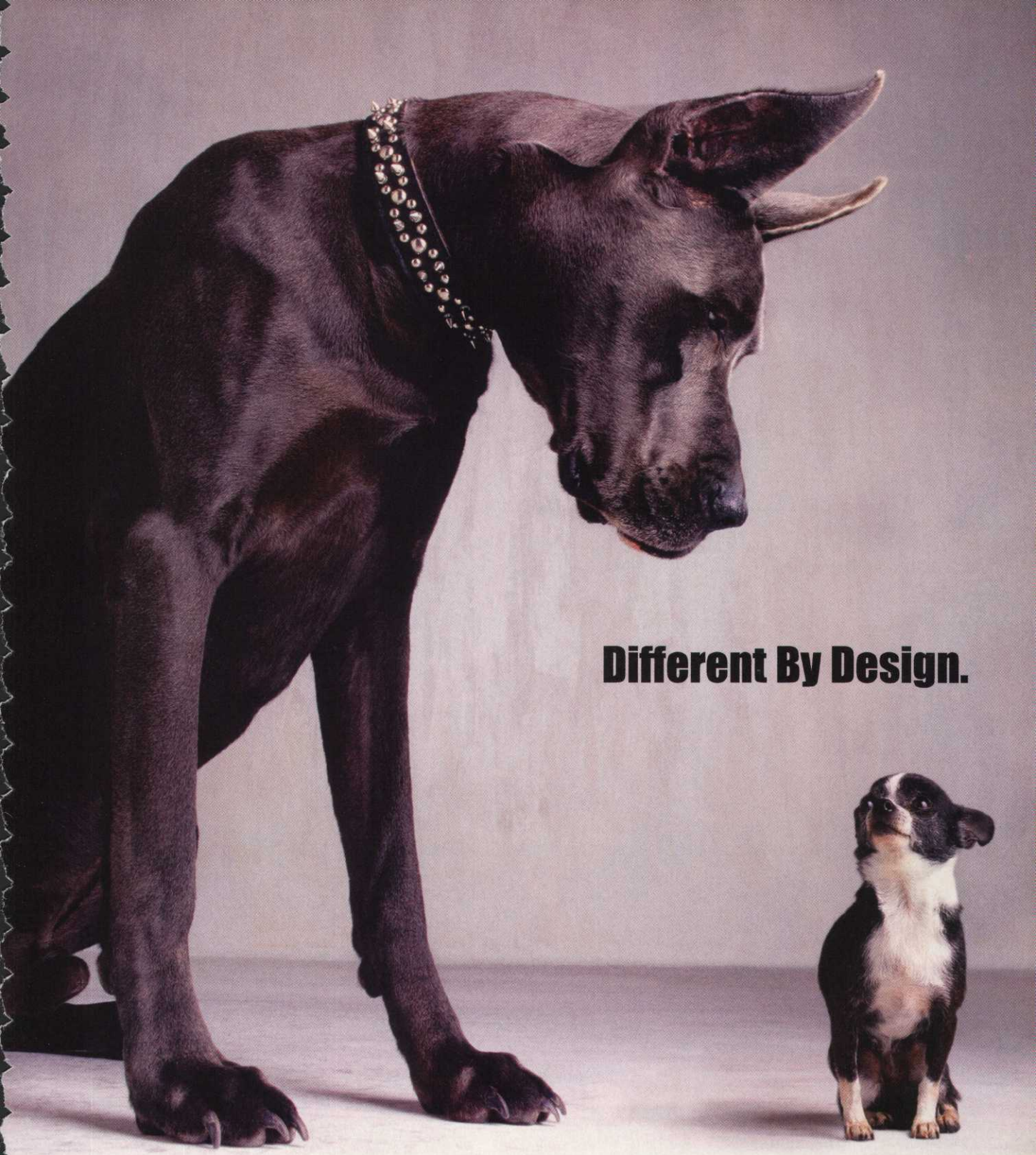

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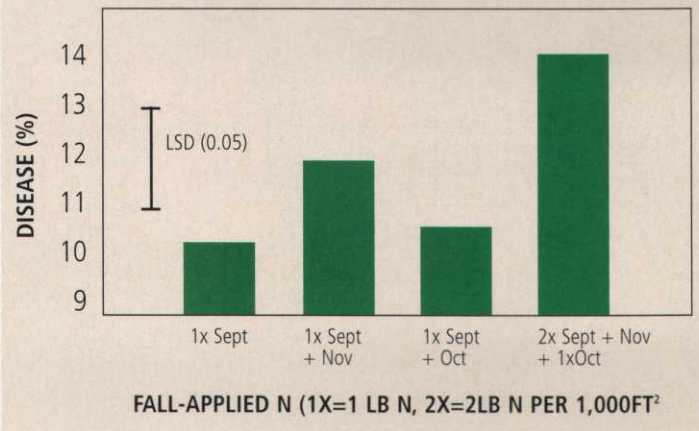
FIGURE 3



Effects of fall-applied N on gray snow mold severity (Typhula incarnata) in perennial ryegrass.

Continued from page 50

snow mold severity by as much as 40 percent as K rates increased from one to 9 pounds per 1,000 square feet per year. Although soil exchangeable K indicated optimum levels, K was growth limiting at this moderately high N rate.

In contrast, with a single application at 1 pound N per 1,000 square feet applied in September, cold hardiness increased with K fertilization (Figure 4), possibly due to luxury consumption of K. Luxury consumption of K is an accumulation of K in tissues beyond those levels needed to sustain normal growth.

At the rate of 1 pound N per 1,000 square feet, no increase in the rate of shoot growth (and crown hydration) was observed with K, although significant uptake (and accumulation) of K was detected. Potassium acting to either increase solute concentrations and to bind water and/or to increase energy reserves are possible physiological explanations to the role of K in enhancing cold hardiness.

Conclusions

Late fall-applied N had no effect on winter kill. Nitrogen applied after shoot growth had ceased had no significant effect on either cold hardiness or winter disease.

Applications of 3 pounds WSN during periods of active shoot growth (in September and October) caused significant increases in crown hydration and winter kill from low temperature stress and disease.

Winter kill from fall-applied K was dependent on the rate of N. Applications of 1 pound of WSN with high levels of K approaching 5 pounds per 1,000 square feet per year and higher decreased the potential for low-temperature kill, possibly due to luxury consumption of K. These K rates are above those levels typically recommended. No detrimental effects on winter survival were ever observed with relatively high levels of K so long as WSN rates in the fall did not exceed 1 pound per 1,000 square feet per growing month.

J. Scott Ebdon is an associate professor of turfgrass management in the department of plant, soil and insect sciences at the University of Massachusetts Amherst. ... David E. Webster is a former graduate research assistant.

ACKNOWLEDGMENT

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Excess Phosphorus from Golf Courses Can Taint Surface Water

By Kevin W. King and James C. Balogh

Environmentally sound management of golf course turf provides both public and private facilities with environmental, cultural and economic benefits. According to the National Golf Foundation (2003), there are approximately 16,000 golf courses operating in the United States. Public demand is increasing for golf course managers to maintain high-quality turf on golf courses but also to protect water and soil resources in the vicinity of these facilities (Balogh et al. 1992; Beard and Greene, 1994).

The perception (Kohler et al. 2004; Shuman, 2002; Peacock et al. 1996; Smith and Bridges, 1996; and Pratt, 1985) and potential (Balogh and Walker, 1992) for nutrients and pesticides to be transported in surface water is well documented. Management of existing golf courses and construction of new facilities is often a lightning rod of environmental and water quality concern (Balogh et al., 1992).

Whether or not that concern is warranted is often debated because of limited information on water quality exiting golf courses. High-quality watershed scale data are needed to adequately address this issue.

Previous studies (Easton and Petrovic, 2005; Gaudreau et al. 2002; Cole et al. 1997; Linde and Watschke, 1997; and Morton et al. 1998) have addressed runoff volume and nutrient loss from turf. However, these studies focused on small areas from plots up to individual greens or fairways (Cohen et al., 1999; Kenna, 1995). The data collected from plot studies is also limited with regard to the temporal domain.

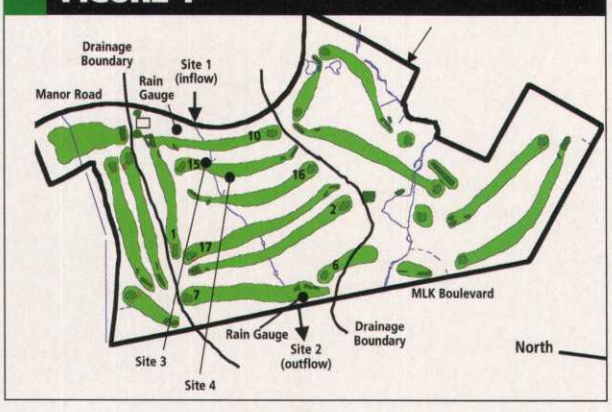
Studies on small scales are valuable, but they may not represent the diversity and connectivity associated with a complete turf system. Cohen et al. (1999) emphasizes the need for field-scale water quality studies on golf courses. The objective of this research effort was to quantify nutrient transport in surface water runoff from golf courses.

Experimental sites

Two golf courses with differing characteristics (Table 1) were selected for this research effort:

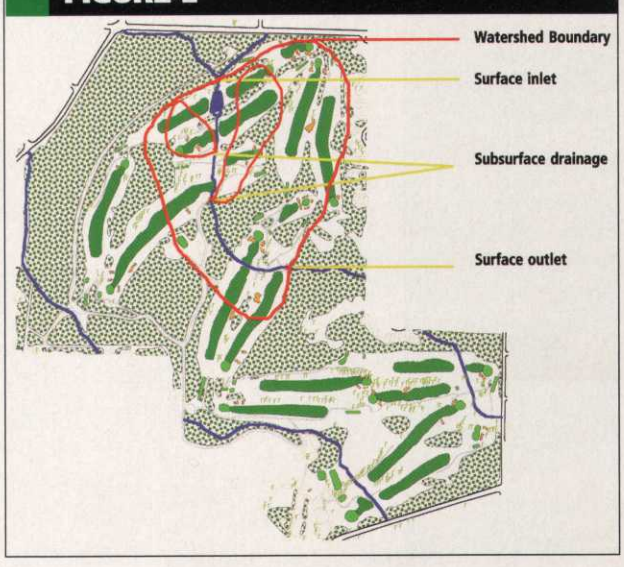
Continued on page 55

FIGURE 1



Above: Layout of Morris Williams Municipal Golf Course and study area.

FIGURE 2



Right: Layout of Northland Country Club Golf Course and study area.

TABLE 1

Site characteristics from two golf course watersheds:

	Morris Williams Municipal	Northland Country Club
GRASS	tifdwarf bermudagrass (Cynodon dactylon L. Pers.)	creeping bentgrass (Agrostis palustris Huds. A. stolonifera L.)
CLIMATE		
temperature	avg. min (4 °C); avg. max (35 °C)	avg. min (-9 °C); avg. max (25 °C)
precipitation	810 mm	1000 mm
growing season	273 days	220 days
MANAGEMENT	moderate	moderate to intense
SOILS	gravelly, silt clay to clay	clay
AREA	29.0 hectares	21.8 hectares
greens	0.7 ha (10 greens)	0.3 ha (8 greens)
tees	0.3 ha (7 tees)	0.5 ha (8 tees)
fairways	8.2 ha (7 fairways)	4.0 ha (8.5 fairways)
SLOPES	4-8%	3-25%
elevation change	19 m	37 m

TABLE 2

Statistical analysis† of nutrient concentrations (milligrams L-1) in storm flow and baseflow at Morris Williams Municipal Golf Course:

	Storm Flow Concentrations (mg L-1) (n = 1049 for inflow and n = 1063 for outflow)					
	NO3+NO2-N		NH4-N		DRP	
	Site 1	Site 2	Site 1	Site 2	Site 1	Site 2
Mean	0.30	0.44	0.10	0.09	0.12	0.15
Median	0.23 a	0.35 b	0.05 a	0.04 b	0.10 a	0.13 b
Maximum	2.25	3.52	4.04	3.23	0.90	0.99
	Baseflow Concentrations (mg L-1) (n = 239)					
	NO3+NO2-N		NH4-N		DRP	
	Site 1	Site 2	Site 1	Site 2	Site 1	Site 2
Mean	0.30	0.79	0.10	0.03	0.11	0.10
Median	0.27 a	0.73 b	0.08 a	0.02 b	0.10 a	0.10 a
Maximum	1.84	2.35	0.69	0.17	0.37	0.27

† — Medians were evaluated with the Mann-Whitney non-parametric test. Medians for each constituent followed by the same letter are not significantly different ($p<0.05$).

Continued from page 53

Morris Williams Municipal Golf Course (MWMGC) in Austin, Texas, and Northland Country Club (NCC) in Duluth, Minn.

A sub-area of each course was instrumented with ISCO 6700-automated collection systems. Discharge and nutrient concentrations were recorded for five years (1998-2003) on MWMGC and 2.5 years (2002-2004) at NCC.

The study area (Figure 1) on MWMGC is characterized by a series of grassed waterways, culverts and casual water detention areas that cross the center of the course. The topography is such that the contributing area (29 hectares [ha]) contains 10 greens (0.73 ha), seven fairways (8.23 ha) and seven tees (0.30 ha). The managed areas (greens, fairways and tees) represent 32 percent of the total area. The contributing area also contains approximately 6.5 ha of reduced-managed rough, with the remainder comprised of unmanaged trees and shrubs.

NCC has several sub-watersheds or drainage areas with unnamed streams draining into Lake Superior. The study area is located along a stream on the northeastern part of the golf course (Figure 2). This area forms a discrete drainage area composed of six complete holes, three partial holes and unmanaged areas of mixed northern hardwoods and bedrock outcroppings.

The 21.8 ha drainage area is comprised of eight greens (0.3 ha), 8.5 fairways (4.0 ha), eight tees (0.5 ha) and 17 ha of unmanaged trees and grass. The managed turf area accounts for 21.7 percent of the measured drainage area. The drainage stream enters a natural pond located at the top of the small watershed. This stream then bisects the proposed study area.

Nutrient concentrations and loadings

Nutrient concentrations were measured at various magnitudes from each course (Tables 2 and 3).

Median concentrations of NO3-N were below 1 milligram (mg) per liter and the maximum recorded concentration was well below the EPA drinking water standard of 10 mg per liter. Median outflow concentrations of NO3-N were significantly greater than the inflow concentrations at MWMGC.

No statistical differences in median NO3-N concentrations were measured at NCC. Similarly, dissolved reactive phosphorus (DRP) concentrations were significantly greater in the outflow compared to the inflow at both courses. The measured phosphorus concentrations were consistent with concentrations shown to cause eutrophic conditions in lakes, ponds and streams.

Nutrient loadings (the mass of nutrient transported in surface flow) from MWMGC and NCC were calculated from the concentration data and the measured runoff from each course. The loadings from these two golf courses are generally greater than similar loadings reported for native prairies and forested catchments but less than loadings reported for agriculture, the exception being phosphorus. Despite the relative immobility of phosphorus in soil (Walker and Branham 1992), the results of this study suggest that these courses may have the potential for small but

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TABLE 3

Statistical analysis† of nutrient concentrations (milligrams L-1) in surface flow at Northland Country Club in Duluth, Minn.

	Surface flow concentration (mg L-1) (n = 325 for inflow and n = 508 for outflow)									
	NO3+NO2-N		NH4		DRP		TN		TP	
	Inflow	Outflow	Inflow	Outflow	Inflow	Outflow	Inflow	Outflow	Inflow	Outflow
Mean	0.38	0.37	0.21	0.17	0.05	0.09	0.71	1.00	0.08	0.10
Median	0.25 a	0.26 a	0.02 a	0.03 a	0.01 a	0.04 b	0.62 a	1.01 b	0.09 a	0.10 b
Maximum	2.65	3.16	6.30	6.39	2.42	2.59	2.97	3.93	0.23	0.55

† — Medians were evaluated with the Mann-Whitney non-parametric test. Medians for each constituent followed by the same letter are not significantly different ($p<0.05$).

Continued from page 55

significant contributions of phosphorus to surface water. Both courses have a long history of phosphorus applications. Once the soils become saturated with precipitated phosphorus, any additional phosphorus is more readily available for loss in surface runoff.

Kevin W. King is an agricultural engineer with the USDA-ARS Soil Drainage Research Unit in Columbus, Ohio. His research program focuses on the watershed scale assessment of land management and development of best management practices to reduce and/or eliminate offsite transport of nutrients and pesticides at sites in Texas, Minnesota and Ohio. James C. Balogh is the CEO and soil scientist with Spectrum Research Inc. in Duluth, Minn. His research program focuses on the environmental evaluation of turfgrass systems and development of strategies and management plans to mitigate nonpoint source pollution from turfgrass environments.

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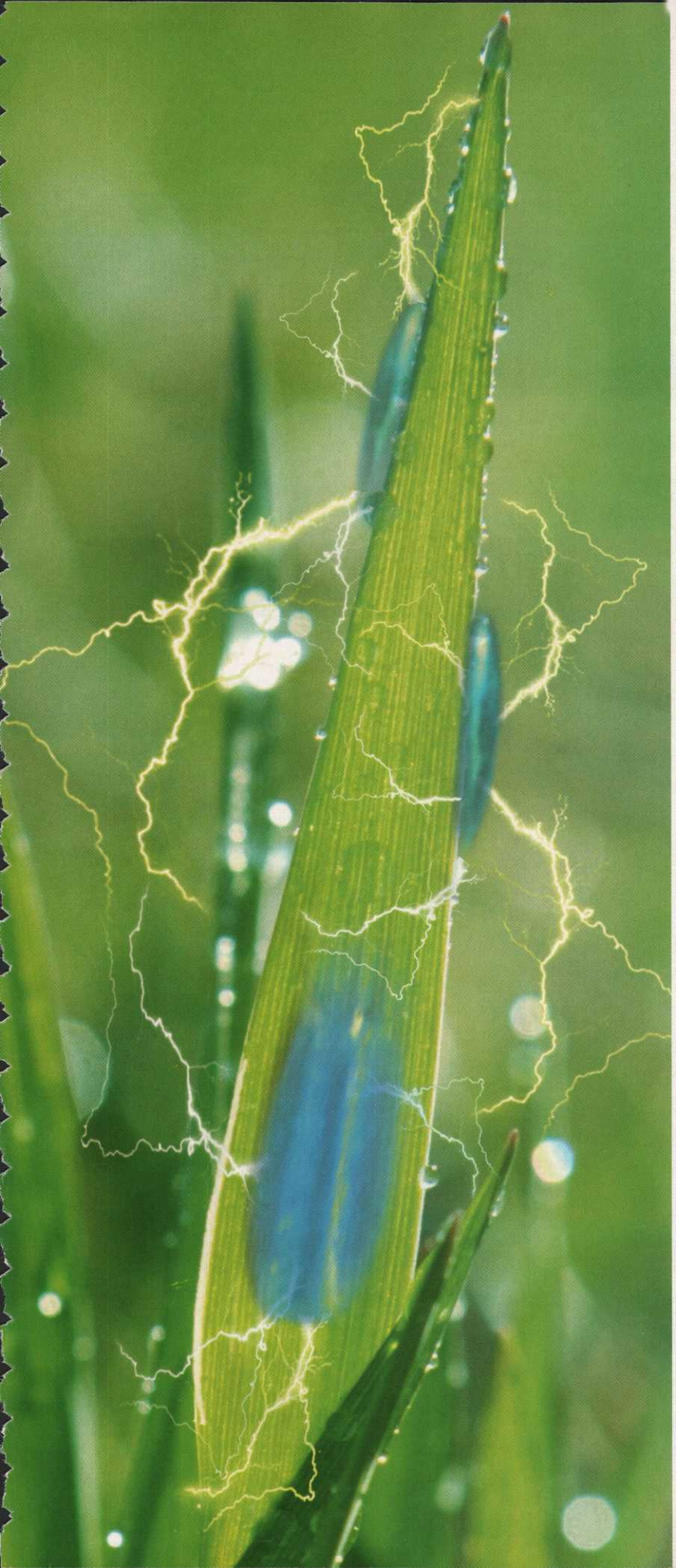

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THE SEQUEL

Butting Heads Over Bio

It's time to revisit the biological and organic fertilizer category to see what's happened since 1999

By Larry Aylward, Editor in Chief

Nearly seven years ago, *Golfdom* published a cover story that discussed biological and organic fertilizers. The headline on the magazine's cover read "Butting Heads Over Bio," and the accompanying stories in the April 1999 issue debated whether biological and organic were viewed as "scientific miracles" or "snake oil."

We've decided it's time to revisit the issue. While seven years is not a long time when it comes to the Chicago Cubs winning a World Series (97 years and counting), it is a prolonged spell for change to occur in this product category. And it has. While the category, which includes products ranging from biostimulants to foliars, has grown with new players, it has also lost a few participants. It's also safe to say — and manufacturers will attest to it — that sales of biological and organic fertilizers have increased because more superintendents are using them. Manufacturers say their products can help reduce turf stress and help superintendents slash their nitrogen use.

Bill Middleton, a senior technical advisor for Milliken Turf Products and founder of Emerald Isle True Foliars, says biological and organic products have nearly a 60 percent market penetration today. "That's pretty decent," he notes.

Bill Byrnes, president of Floratine Products, which celebrates its 15th anniversary in February, says "biostimulant use has become a widespread mainstream management practice on golf courses," says Byrnes, who also cites a dramatic evolution in product diversity and sophistication as a factor contributing to increased use.

While the debate raged on whether the products were viewed as a "scientific miracle" or "snake oil" in 1999, it may be waning. But while those partisan opinions still linger, it seems that biological and organic fertilizers are viewed by more superintendents today as products that work best when used as part of sound turf management programs.

Terry Hogan, the long-time superintendent of Big Run Golf Club in Lockport, Ill., has experienced successes and failures with

Continued on page 60

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NAME	MEAN
Benchmark DSR	**6.9**
Penn A-1	6.8
Pennlinks II	6.8
Memorial (AO3-EDI)	6.4
007 (DSB)	6.3
Vesper	6.3
LSD Value	1.5

2003 NATIONAL BENTGRASS (GREENS) TEST AT **DALLAS, TX.** - 2004 DATA - 1-9; 9=BEST

NAME	GENETIC COLOR	LEAF TEXTURE	DOLLAR SPOT
Benchmark DSR	**7.3**	**8.0**	**8.0**
T-1	7.3	6.3	7.3
Penn A-1	6.3	6.0	7.0
LS-44	6.3	6.7	6.3
Pennlinks II	6.3	4.3	7.3
Penncross	6.3	4.3	7.0
LSD	0.8	1.6	1.1

TURFGRASS QUALITY

RATINGS OF BENTGRASS CULTIVARS IN THE 2003 NATIONAL BENTGRASS (GREENS) TEST AT **MEAD, NE**
2004 DATA - 1-9; 9= BEST

NAME	MEAN
Benchmark DSR	**7.6**
Declaration	6.6
Penn A-1	6.3
Pennlinks II	6.3
LS-44	5.7
Vesper	3.4
LSD Value	0.6

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biological and organic fertilizers. Last summer Hogan worked with Novozymes Roots Plant Care Group to use the company's products on his course's greens. Hogan, who has been at the course for 27 years, says Big Run's regular golfers say the course is the best they've ever seen it.

"They ask me, 'What are you doing differently?' " Hogan says, noting the color of the greens was great, their density was good and their consistency of growth was uniform.

The cover of our April 1999 issue had a touchy tone.

Hogan, who's aware of the snake oil factor, says he's more confident in using biological and organic products than ever.

John Sedivy, director of business development for Roots, says suppliers are still battling the snake oil claim. Sedivy says Roots conducted several focus groups recently and discovered the snake oil stereotype still exists.

"The situation has gotten better over time, but it still persists," says Sedivy, who adds that superintendents haven't forgotten the poor experiences they've had with products whose performances were exaggerated by manufacturers.

Roots decided to attack the perception problem head on in its advertising. Its print ad addresses the perception and reality of biological products and even features a photograph of a snake.

The snake oil label persists because it's still true in some instances. Joe Lara, the product manager for horticulture and specialties at Becker Underwood, says his company has studied competitors' products and found them not to be as advertised.

"We've encountered competitive products that claim plant stimulatory effects only to uncover that they also contain small amounts of nitrogen fertility that create a false impression of how the products really work," Lara says. "Similarly, other product labels do not fully disclose what is in the formulations, leaving end-users to guess what is working or not working. Too often, turf managers end up paying a lot of money for not knowing what they are really applying to the turf."

Joel Simmons, president of Earthworks, which began in 1988, says opportunities unfortunately still exist for quasi-turf scientists to create shady concoctions and enter them as products in the category. All someone needs is a garage, a few 500-gallon tanks and a natural mixture that he refers to as a miracle product. "But there's nothing miraculous about it," Simmons adds.

The bottom line is that superintendents will try biological and organic fertilizers if they trust them, Middleton says. That said, there are several reasons today why superintendents are using the products when compared to 1999.

For instance, more younger superintendents are using the products because they weren't subject to a lot of the debate that had occurred about them in the late '90s and before.

Brent Palich, superintendent of Sand Ridge Golf Club in Chardon, Ohio, uses several products in his turf maintenance program, and the 28-year-old believes more "new generation" superintendents like himself are less skeptical of the products than other veteran superintendents.

"I was brought up around these new fertilizers," Palich says. "I feel more comfortable with them than I do with synthetics because I've worked with them more. More superintendents are using these products than they were even three or four years ago. They are much more common."

Another reason for increased use is that superintendents today are smarter and know more about the products, says Mike Archer, market development manager for Milorganite.

"The overall level of agronomic education of superintendents goes up every year," he says. "If a superintendent had a bachelor's degree 20 years ago, he stuck out from the crowd. Today we have superintendents with master's degrees in agronomy. They're better able to look at products and their specifications and decide whether the products will do what they need them to do."

More superintendents are impressed with

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ILLUSTRATION BY: MIKE CAGLE