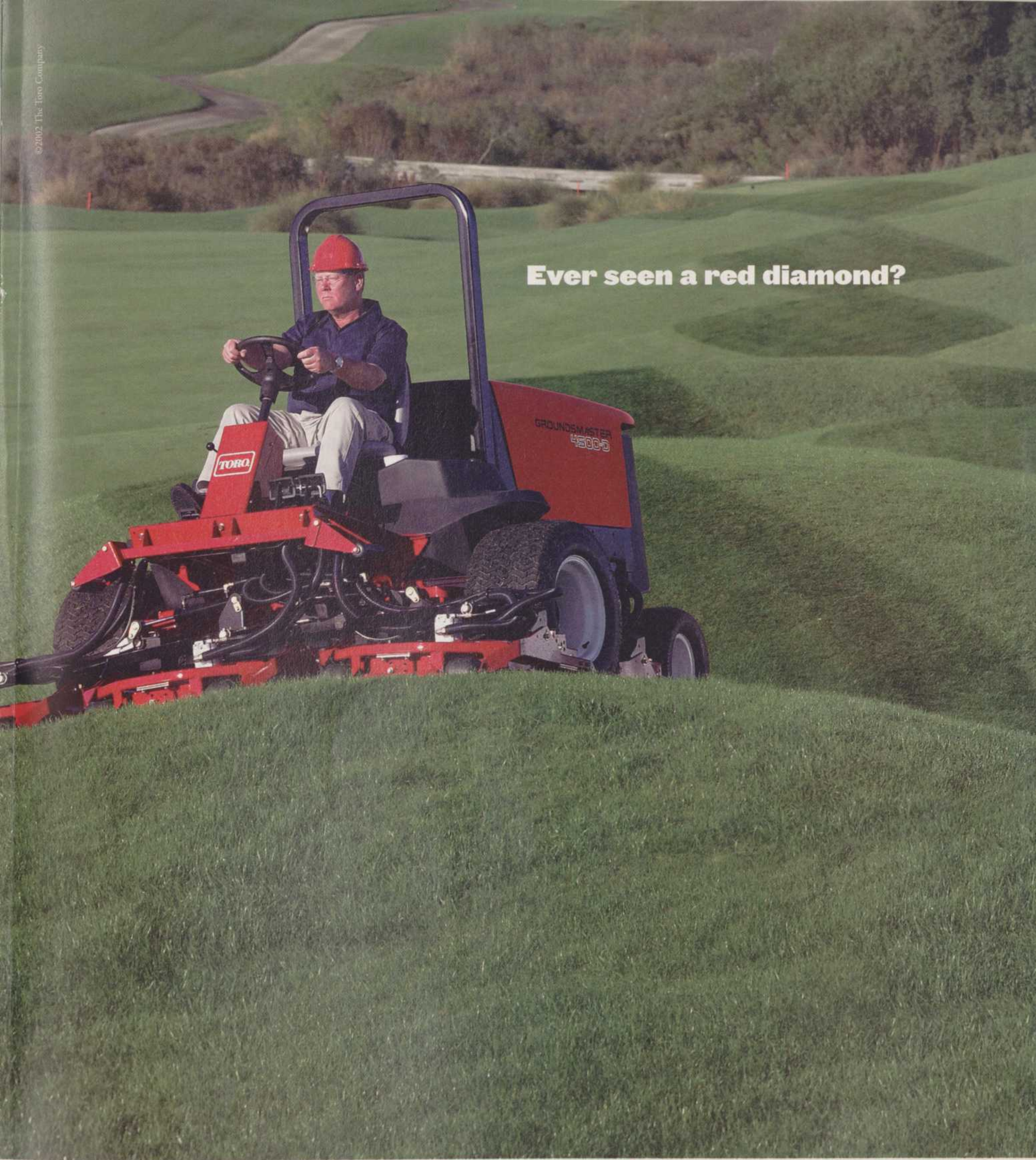

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The Dry Look

Leaf wetness linked directly to several turf diseases

By Curtis E. Swift

Most of the fungal and bacterial turfgrass diseases that superintendents and grounds managers battle are known to be more serious under prolonged periods of leaf wetness.

Bacteria require a moist film on the leaf surface to increase their population and gain entrance to the leaf's interior through wounds and stomata (breathing pores). Fungal spores (most but not all) require this wet leaf surface to germinate and form the structures necessary to locate and enter stomata or otherwise forcibly penetrate the plant tissue. Some fungal-like organisms produce a motile spore that swims in this film of water entering plant tissue through stomata.

Once the pathogen enters the plant, infection and disease can result.

In addition to a wet leaf surface, if an additional energy source is available to the pathogen, the chance for disease increases. The most common energy source available to these pathogens consists of the sugars, starches and amino acids that ooze from glands called hydathodes onto the leaf surface during the evening and night hours. This exudate (guttation fluid) makes up only 25 percent of the dew that forms with the other 75 percent being condensation from the atmosphere. When turfgrass managers reduce the concentration of the guttation fluid, disease problems are lessened.

When turfgrass managers reduce the concentration of the guttation fluid, disease problems are lessened.

Dollar spot was controlled for many years by a hose dragged over golf greens or a bamboo pole used to knock the dew off the grass. Some turfgrass managers use this same technique today. Fiberglass has replaced bamboo as the pole of choice and, when done early in the morning, diseases can be prevented or at least reduced in severity. This procedure knocks guttation fluid off the leaf blade, thereby reducing the energy available to the disease pathogen.

Knocking the dew off the grass also hastens the drying of the grass, reducing the amount of time the pathogen has available for infection to take place.

Bacterial diseases increase in severity in direct relationship to the length of time the leaves are wet. Infection by bacterial pathogens is more severe under shade conditions than in nonshaded areas because of an increase in humidity within the turf canopy and the increase in the length of time the leaves remain wet.

Rusts (*Puccinia* spp.) and leaf spot fungi (*Bipolaris* and *Drechsler* spp.) are more severe in heavily shaded grasses than in areas

Patch diseases become more severe as duration of leaf wetness increases.

with full sun exposure. This is again because of the duration of leaf wetness.

Moisture on the foliage determines the production and survival of most fungal spores. As early as 1930, the incidence of brown patch, caused by *Rhizoctonia solani*, was shown to coincide with irrigation in the afternoon. The severity of this disease is known to increase when the length of leaf wetness extends beyond nine hours.

The longer the leaf surface is wet, the greater the risk of infection and the greater the number of infections per leaf. Minimal infection by this disease pathogen occurs when the duration of leaf wetness is below six hours; severe infections occur beyond eight to 10 hours.

Irrigation in the afternoon is directly associated with an increase in infection, especially when warm day temperatures are followed by cool night temperatures. When the turf does not dry out before nightfall, normal dew formation during the night hours extends the time the grass is wet. This increase in infection also may be because of an increase in guttation fluids that feed the pathogens.

Watering in late afternoon causes an increase in water pressure within the plant tissue resulting in more guttation fluid being exuded onto the leaf surface. More guttation fluid means a higher concentration of sugars, starches and amino acids available to the pathogen.

Gray leaf spot of perennial ryegrass and tall fescue caused by *Pyricularia grisea* is known to become more severe as the duration of wetness increases. Even patch diseases have been reported to increase in severity with prolonged periods of leaf wetness. The take-all patch organism (*Gaeumannomyces graminis*) is particularly sensitive to moisture fluctuations. Necrotic ring spot (*Leptosphaeria korrae*) also increases in severity with excessive moisture and frequent irrigations.

Curvularia (one of the Helminthosporiums) and the leaf blighting and crown rot phases of *Dreschlera*-caused diseases are encouraged by extended periods of leaf wetness. Dollar spot requires an extended period of leaf wetness for its cobwebby structure to develop while Ascochyta leaf blight is controlled in part by diluting the concentration of sugars, starches and amino acids in the guttation fluid by irrigating turf in the early morning hours (prior to sunrise) when dew is present.

The powdery mildew fungi are exceptions to the leaf wetness requirement, as they prefer high humidity without the film of moisture on the leaf surface for germination of spores and infection to occur.

While some turf diseases can become severe when the leaf surface is wet for as little as six hours, most of our turf diseases require 12 or more hours of moist foliage for a major disease outbreak to occur. The shorter the time the grass is wet, the less the disease problem.

If the turf is watered in the early evening hours or in the morning after the sun has risen but before the night dew has dried, the grass is wet for an extended period. This often results in infection.

Early to late evening is the worse time to irrigate as it wets the turfgrass plant and debris (thatch and mat), extending the normal leaf wetness period thus allowing foliar disease organisms to germinate and infect. Watering early in the evening also cools the grass, increasing guttation, which provides fungal organisms additional nutrients for growth. Watering early in the morning (prior to sunrise) dilutes the nutritional benefits of the dew, thereby reducing turf disease problems. It has also been suggested that wetting agents used to reduce leaf wetness may be of some benefit in the war against turf diseases.

Increasing airflow and improving site drainage, especially in humid or wet climates, may help shorten periods of leaf wetness, thereby reducing disease problems. Maintaining the turf at a reasonable height increases the opportunity for the grass to dry properly. Proper fertilization helps avoid succulent, disease susceptible tissue.

While all these factors are critical to disease management and usually well-understood, we often overlook the importance of managing the length of time the turf is wet. In addition, we frequently overlook the need to reduce the concentration of guttation fluid on the leaf surface. Turfgrass managers need to be very flexible when scheduling their irrigation to take advantage of reduced leaf wetness and the dilution of the energy sources found in guttation fluid.

Curtis Swift is an area extension agent at Colorado State University. His responsibilities include assisting owners of sod farms, superintendents and lawn care professionals with turf disease identification and management. He can be reached at Curtis.Swift@ColoState.edu.

Watering early in the morning dilutes the nutritional benefits of the dew, thereby reducing turf disease problems.

Inorganic Soil Amendments in New Sand-Based Rootzones Can Reduce Nitrogen Loss

By Cale A. Bigelow

Most modern golf course putting green root zones are constructed using high sand contents, sometimes 90 percent or more by volume. Sand is an excellent rootzone material for heavily trafficked areas such as putting greens because it resists compaction and maintains air-filled porosity and drainage. Furthermore, it is a relatively inexpensive material and is readily available most anywhere.

Although sands provide favorable soil physical properties, nutrient retention is generally poor and water-soluble nutrients like nitrogen are prone to leaching.

Young putting greens may receive 6 pounds to 8 pounds of actual nitrogen per 1,000 square feet annually, and applications of 10 pounds to 12 pounds during the first year of establishment are not uncommon.

Often nitrogen is supplied using highly soluble sources like ammonium sulfate or urea. Given all of the following conditions — porous rootzone media, water-soluble nitrogen applications, and regular irrigation — it is easy to see why nitrogen loss is a concern.

It is well-documented that a dense mature turfgrass system, even on sandy soils, is very effective in capturing nitrogen because of its extensive root system. Although the potential for nitrogen leaching from mature turfgrass systems may be rather low, the same is not true for young turfgrass plants on newly built sand rootzones. In these situations, turfgrasses are either planted as seed or sod that is frequently irrigated because there is little or no root system to absorb water from the rootzone.

Light, frequent irrigation is required to ensure survival. Not only is the shallow root system unable to explore the rootzone for water, it is also less efficient at nitrogen absorption, which further increases the leaching potential.

Historically, the most popular method for sand-based golf green construction has suggested amending sand with a stabilized organic matter, such as peat moss (USGA, 1993). This amendment is added to improve water and nutrient retention. In the past, many inorganic soil amendments, such as porous ceramics, diatomaceous earth and clinoptilolite zeolites, have been investigated and marketed as alternatives to peat moss (Davis et al., 1970; Waddington et al., 1974). These inorganic products may be better suited to sand rootzones because they are not susceptible to biological degradation and may sustain the original rootzone physical properties longer than peat moss.

Several researchers have documented the benefits of various porous ceramics and zeolites on turf establishment and growth when incorporated into sandy growing media. These results are not surprising since the base mineral for most porous ceramics is clay and many clays and zeolites have cation exchange capacities ranging from 50 centimoles of charge per kilogram (cmolc/kg) to 220 cmolc/kg compared to sand, which often is less than 1 cmolc/kg.

While a wealth of research information exists for several zeolites, comparable data for other commercially available inorganic amendments or experiments directly comparing the amendments to peat moss has been lacking. Thus, the objective of these laboratory studies was to evaluate how a variety of inorganic soil amendments compared to a sphagnum peat moss for reducing nitrogen leaching in simulated quartz sand putting green rootzones. Specif-

Most surprising was that by incorporating either of these amendments to even a rather shallow depth of 1 inch, ammonium losses could be decreased by almost 25 percent.

ically, the effects of amendment type, incorporation rate and depth were documented.

Experimental procedures

A locally available washed quartz sand conforming to USGA size guidelines was amended with the following amendments: Irish sphagnum peat moss; a clinoptilolite zeolite (Ecolite); an extruded diatomaceous earth containing 5 percent of a clay binder (Isolite); and two porous ceramic products (Greenschoice and Profile).

The cation exchange capacity (CEC) of each of the inorganic amendments was:

- 185 cmolc/kg to 220 cmolc/kg for zeolite;
- 1.0 cmolc/kg for shale-based porous ceramic;
- 0.8 cmolc/kg for diatomaceous earth;
- 33.6 cmolc/kg for clay-based porous ceramic; and
- 75 cmolc/kg to 100 cmolc/kg for sphagnum peat.

Values were taken from the manufacturer's product literature. A complete description of all experimental procedures can be found in Bigelow et al., 2001.

Briefly, however, sand or amended sand mixtures were installed into 3-inch-diameter by 12-inch-tall acrylic columns, placed over a 4-inch-tall gravel sub-layer.

After 24 hours at saturation, each column was placed on a screen and allowed to drain for 24 hours to reach field capacity. A liquid ammonium nitrate solution containing nitrogen equivalent to 1 pound nitrogen per 1,000 square feet was applied to the surface of each rootzone and leached with twice-distilled water.

The leachate was collected in small aliquots and analyzed for the presence of ammonium (NH_4 +-N) and nitrate (NO_3-N).

Amendment effects

When incorporated at 20 percent by volume, all amendments significantly decreased ammonium loss, which ranged from 8 percent to 69 percent (Table 1).

In this experiment the two most effective amendments were Ecolite and Profile, which decreased ammonium losses to only 8 percent and 21 percent, respectively, compared to unamended sand. Since no amendment had a significant effect on nitrate leaching — meaning that more than 90 percent of applied nitrate was recovered (data not presented) — this aspect will not be discussed.

TABLE 1

Peak concentration and percentage loss of ammonium in the effluent of sand amended at 20 percent by volume with four inorganic soil amendments and sphagnum peat:

	AMMONIUM (NH4-N) NITROGEN	
Soil amendment	Peak concn. (ppm)	Total loss (percent)
Nonamended sand	59.3 a[z]	96.2 a
Ecolite	3.3 c	7.8 e
Isolite	23.9 b	63.9 b
Profile	8.4 c	21.3 d
Greenschoice	26.9 b	69.4 b
Sphagnum peat	11.0 c	37.7 c

[z] Mean separation within columns by Fisher's protected LSD (P=.05).

As the incorporation rate for the two most effective amendments, Profile and Ecolite, increased from 1 percent to 20 percent by volume, ammonium nitrogen losses decreased in a stepwise manner, with the 20 percent rate resulting in the least losses for both amendments (Table 2).

No difference in nitrogen retention between the two products was observed, except at the 20-percent rate, where significantly less ammonium leached from the Ecolite-amended sand, probably because of the slightly higher CEC soil — 9.6 cmolc/kg vs. 4.6 cmolc/kg — for the 20 percent Ecolite- and Profile-amended sand mixtures, respectively.

Incorporating either of these amendments at 20 percent by volume throughout the entire rootzone depth could be extremely expensive. Thus, it was determined that a 10-percent-by-volume rate would be most cost effective for most situations with only modest decreases in ammonium losses compared to the 20 percent incorporation rate (Table 2).

Based on the results obtained in the amendment rate experiment, the effect of incorporation depth was studied with Ecolite and Profile mixed at 10 percent by volume to 1 inch, 6 inches and 12 inches. Again, as expected, a step-wise decrease in leaching

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losses was observed as incorporation depth increased from 1 inch to 12 inches (Table 3).

What was most surprising was that by incorporating either of these amendments to even a rather shallow depth of 1 inch, ammonium losses could be decreased by almost 25 percent, compared to the unamended sand.

TABLE 2

Peak concentration and percentage loss of ammonium in the effluent of sand amended with Ecolite and Profile at 1 percent, 5 percent, 10 percent and 20 percent by volume:

Soil amendment	Depth (inches)	AMMONIUM (NH4-N) NITROGEN Peak concn. (ppm)	Total loss (percent)
Nonamended sand	0	58.4	95.7
Ecolite	1	49.6 a[y]	75.0 a *[x]
	5	39.1 a ***	52.3 b *
	10	10.3 b ***	17.0 c *
	20	4.3 b ***	7.7 d *
Profile	1	52.3 a	78.7 a *
	5	25.4 b ***	51.6 b *
	10	11.4 c ***	32.6 c *
	20	6.7 c ***	22.4 d *

[x] Means within the same column followed by * or *** are significantly different from nonamended sand at P<.05 or .001, respectively.

[y] Means within columns for the same soil amendment followed by the same letter are not significantly different at P=.05 by Fisher's protected LSD.

TABLE 3

Peak concentration and percentage loss of ammonium in the effluent for sand amended with Ecolite and Profile at 10 percent (v/v) incorporated to 1-, 6- and 12-inch depths:

Soil amendment	Depth (inches)	AMMONIUM (NH4-N) NITROGEN Peak concn.[z] (ppm)	Total loss (percent)
Nonamended sand	0	61.9	97.6
Ecolite	1	30.7 a[y] ***[x]	68.2 a *
	6	20.1 ab ***	38.2 b *
	12	10.4 b ***	17.6 c *
Profile	1	38.1 a ***	76.6 a *
	6	19.9 b ***	49.4 b *
	12	11.4 c ***	32.2 c *

[x] Means within the same column followed by * or *** are significantly different from nonamended sand at P<.05 or .001, respectively.

[y] Means within columns for the same soil amendment followed by the same letter are not significantly different at P=.05 by Fisher's protected LSD.

Conclusions

These experiments support previously published reports regarding ammonium and nitrate movement in newly constructed sand-based rootzones.

As was previously reported by numerous other researchers, nitrogen leaching in unamended quartz sands can be initially very high, exceeding 95 percent of the applied nitrogen especially when turfgrass is not present or mature.

Ammonium losses, however, can be reduced substantially to more than 8 percent by incorporating certain inorganic amendments like Ecolite or perhaps Profile and to a lesser extent sphagnum peat, provided these amendments are providing sufficient CEC to capture the positively charged ammonium nitrogen molecule.

Nitrate leaching will continue to be a concern in any sand-based rootzone, particularly during turfgrass establishment. One potential solution to this problem would be to implement best-management practices to minimize leaching. These would be selecting a properly sized sand that does not allow excessive percolation and amending the sand with one or more of the following amendments: peat moss, zeolite or a relatively high CEC porous ceramic like Profile.

During the grow-in period the young turf should be fertilized with either a controlled-release fertilizer or a water-soluble fertilizer that is predominantly ammonium based so that any nitrogen that bypasses the roots can be retained in the amendments.

Some practical questions remain: Is more amendment really better? Should I use amendments in a new construction?

Although Ecolite and Profile were effective in these experiments for decreasing nitrogen leaching, they cost considerably more (five times greater or more) than peat moss when used at equal incorporation amounts (Moore, 1999). This may limit their widespread adoption as peat moss replacements.

Secondly, how do the inorganic amendments affect the rootzone physical properties? In related experiments it was demonstrated that although the amendments do offer some degree of water retention because of their

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internal porosity, they were not as effective as peat moss in extremely drought-prone sands when combined with three varying sand sizes. (Bigelow, 2004).

Lastly, how best can you use the inorganic amendments in an existing putting green rootzone? This may be the best situation for using these amendments. Because they are packaged as dry products (which means they are flowable), they can easily be incorporated into the core cultivation holes. These smaller amendment quantities could make them cost effective and, when repeatedly applied, would improve fertilizer use efficiency once a critical volume of amendment is achieved.

Cale Bigelow is an assistant professor of agronomy/turfgrass science at Purdue University in West Lafayette, Ind. His research program focuses on practical cultural management practices that affect turfgrass nutrition and soil-related problems in commercial/home-lawns and fine turfgrass areas. He can be reached at cbigelow@purdue.edu.

Acknowledgements

Grateful appreciation is expressed to the U.S. Golf Association, Far Hills, N.J., and the Turfgrass Council of North Carolina, Southern Pines, N.C., for their support of these research experiments.

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TURFGRASS TRENDS

SECTION STAFF

Managing Editor
Curt Harler
440-238-4556; 440-238-4116 (fax)
curt@curtharler.com

Golfdom Staff Contact
Thomas Skernivitz
440-891-2613; 440-891-2675 (fax)
tskernivitz@advanstar.com

Online Editor
Lynne Brakeman
440-826-2869; 440-891-2675 (fax)
lbrakeman@advanstar.com

Chief Science Editor
Dr. Karl Danneberger
614-292-8491; 614-292-3505 (fax)
danneberger.1@osu.edu

Production Manager
Jill Hood
218-723-9129; 218-723-9223 (fax)
jhood@advanstar.com

Art Director
Lisa Lehman
440-891-2785; 440-891-2675 (fax)
llehman@advanstar.com

Publisher
Patrick Jones
440-891-2786; 440-891-2675 (fax)
pjones@advanstar.com

General Manager
Tony D'Avino
440-891-2640; 440-891-2675 (fax)
tdavino@advanstar.com

Corporate & Editorial Offic
7500 Old Oak Blvd.
Cleveland, OH 44130-3369

CONTACT US:
Editorial: 440-238-4556
Web site: *www.turfgrasstrends.com*

Unlikely Source Gives Good Advice

BY JIM BLACK

Being somewhat of a word guy, I've always been intrigued by bumper stickers. I like the way so much can be said in so few words. Bumper stickers are also also quite revealing of the driver's personality and character.

THINK is a bumper sticker to which we all can relate. I know a lot of people who would benefit from some more thinking before they choose to start acting.

Taking the "think" concept a little further, there's another bumper sticker that always catches my eye — THINK GLOBALLY, ACT LOCALLY. That's one that should apply to all of us as members of this unique fraternity who get to locally impact the globe every day. And it really doesn't matter whether you're a public, private or resort superintendent, we all have an obvious duty to perform responsibly to our local community and to the environment.

Somebody's on our side

I got on the Internet recently to see what was out there in regards to golf and the environment. Expecting to see positive search results from RISE and negative results from The Sierra Club, what I did find caught me totally by surprise.

EarthShare.org is the Web address of an organization I assumed would be just another golf course-bashing, tree-hugging club that has nothing better to do with its time than sharpen its fingertips for more accurate pointing results.

What I found there instead was a list of golf course-friendly and superintendent-friendly suggestions for the golfer as to how he or she can be more earth-friendly.

As I read over the list, the floor came closer and closer to my jaw. Surely, I thought, this group must have been founded by a golfer — maybe even a superintendent golfer. I mean, here is an organization that is a federation of America's leading nonprofit environmental and conservation charities, and the first entry on its list of how golf can support the environment is, "Replace all divots."

Of course, you may read that and say, "Big deal. Golfers see that every day and still don't replace their divots or repair their ballmarks." To that I say, "Read on."

WOULD PEOPLE HEED THESE SUGGESTIONS IF THEY HEARD THEM FROM A LEADING ENVIRONMENTAL GROUP INSTEAD OF FROM A SUPERINTENDENT?

How many times does a golfer see, "Accept the natural limitations and variations of turfgrass plants growing in a natural environment (e.g., brown patches, thinning, loss of color)?" Or, "Be willing to play on brown grass during periods of low rainfall?"

These are just two examples from the group's 20-bullet list of things that should be published in a ... *For Dummies* book. You know — *Golf and the Environment for Dummies*.

Also included in the list are topics on golf car usage (less is better), recycling programs, accepting aeration practices and respecting environmental areas as designated. After reading through the list, I couldn't help but think to myself: Would people heed these suggestions if they heard them from a leading environmental group instead of from a superintendent?

In my own personal journeys, I've found that fear is usually based on the unknown. In applying that principle to golf and the environment, the fear of a negative impact is based on the fact that critics just don't know.

They don't know the science. They don't know the professionalism and training that superintendents have received. They don't know the technical research involved in the formulation of chemicals and fertilizers we use. And frankly, they don't want to find out.

But what if they were to find out through an environmental group that can touch on these subjects in a way as to not be a threat to their intellect, but more to address these subjects through their sensibilities?

If the message gets through, then so be it. I encourage you to share *EarthShare.org's* list with your golfers. Maybe it will encourage them to THINK.

Jim Black, a veteran public golf course superintendent, can be reached at greenkeeperjim@yahoo.com.