ly. I add wood three times a day in cold weather, two times a day if it is in the 30s and sunny. You do get smoke and water vapor when you add wood, but in an hour the combustion chamber is hot and chimney smoke is barely detectable. If you keep the fire hot the stove and chimney stay amazingly clean. In a burning season there is less than 1/4" of creosote build-up, so I don't routinely clean the chimney. In August the heating season's creosote sloughs from the chimney tile and can be removed from the clean-out door.

You can visualize the amount of wood burned in a season different ways. Annually it is three ranks 16' X 5" X 18 inches, or five trees with a 16" stump. Weekly the amount is a heaped 4'X 3' X 32" wood box.

Store wood in two areas: one area for seasoned and ready to burn wood, and one area for storing newly cut wood. It's handy to switch the areas each year.

For their wood supply, old timers sought out hardwoods, but their houses generally had poor insulation and their stoves were not too efficient. Hickory does not burn and soon fills my stove with charcoal, and oak is too hot for all but the coldest weather. My favorite woods are boxelder and popular as both produce a clean, hot fire. Generally, trees cut after the leaves emerge in the spring make a hot burning fire, and the wood is clean because the bark comes off when the wood is split.

With lightweight chain saws and hydraulic splitters, the physical labor of cutting firewood is not as hard as it used to be. And with modern stoves, larger pieces of wood burn cleaner and more efficiently. I split wood to 4 – 6 inches, and an occasional crooked or knotty piece is burned at 8 – 10 inches.

Testing for Micronutrients in Sand Putting Greens

By P.D. Blumke and Dr. W.R. Kussow, *Department of Soil Science, University of Wisconsin-Madison*

INTRODUCTION

In 1992, Turner and Hummel identified three areas of soil fertility research on turfgrass that warranted additional investigation. One was the need to develop better calibrations of soil tests. The second was micronutrient studies focused on determination of potential conditions where micronutrient applications may be beneficial on sand putting greens. Sand putting greens were singled out because of the assumption that such greens are prone to micronutrient problems and because of the tendency of turfgrass professionals to indiscriminately apply micronutrients to them.

Soil testing represents the most rapid and cost-effective means for determining when nutrient applications are warranted (CAST, 2000). But in order to serve this purpose, soil tests first have to be proven reliable. The reliability of soil tests derives from two potential sources of error (CAST, 2000). One arises with the soil test method itself. The quantities of nutrients extracted from soils have to directly relate to the amounts of that nutrient that plants can take up from those soils.

The process of relating soil test values to plant uptake of the nutrient is termed soil test correlation. Correlation refers to a statistical value – the correlation coefficient – that tells how reliably the soil test method estimates the soil supply of plant available nutrient. Correlation coefficients range from 0 (no relationship) to 1, a perfect relationship. As a general rule, soil tests that have correlation coefficients of 0.8 or higher are judged sufficiently reliable to serve as criteria for determining when it is beneficial to apply fertilizer.

The second potential source of error in soil testing is in the calibration of the test. Calibration is the process whereby different soil test values are related to crop

TABLE 1
Creeping Bentgrass Tissue Nutrient Sufficiency Ranges and Deficiency Symptoms

Element	Tissue sufficiency range	Deficiency symptoms
N	3.50 to 4.50%	General yellow-green or chlorotic color. Older leaves initially go off color and dieback from tip. Shoot density and tillering decrease.
P	0.30 to 0.55%	Leaves progress from dark green to purplish to reddish purple color. Stand may appear wilted and exhibit poor spring green-up and growth.
K	1.75 to 2.50%	Older leaves exhibit yellowing first, followed by dieback at top and then along leaf margin. Early spring chlorosis observed.
Ca	0.25 to 0.50%	Younger leaves exhibit symptoms first, with reddish brown color along leaf margins.
Mg	0.20 to 0.40%	Older leaves turn red to cherry red along margins.
S	2.0 to 4.5%	Similar to N deficiency although mid-vein may remain green.
Fe	35 to 100 ppm	Younger leaves exhibit symptoms first, typically an interveinal chlorosis — leaves may appear almost white under severe deficiency.
Mn	25 to 150 ppm	Interveinal chlorosis of younger leaves. Necrotic spots may develop on leaves.
Zn	20 to 55 ppm	Stunted leaves. Some chlorosis. Puckered leaf margins.
Cu	5 to 20 ppm	Tips of younger leaves dieback. May get white-tip. Growth may be stunted.
B	1 to 5 ppm	Reduced growth and stunting. Leaves narrow and turn dark green.
Mo	Not known	Similar to N deficiency. May get some interveinal chlorosis.
Cl	Not known	Not commonly observed in turf.

response in the field to increasing levels of nutrient (CAST, 2000). As pointed out by Turner and Hummel (1992), turfgrass poses a unique problem in soil test calibration. With agronomic and horticultural crops, the measure of crop response is yield of harvested product. Picking an appropriate measure of turfgrass response is problematic.

While several methods have been developed for extraction of plant-available micronutrients from soils, the one in widest use today and for turfgrass in particular is the DTPA test. This test was developed in Colorado by Lindsay and Norvell (1978) for identifying calcareous soils with insufficient levels of Zn for soybean production. One of the reasons for the popularity of the DTPA test is that it measures Cu, Fe, and Mn as well as Zn.

Micronutrient applications are being recommended for Wisconsin golf putting greens based upon DTPA soil test results. Yet, our search of turfgrass literature failed to turn up any research reports on the reliability of the DTPA test itself or on calibrations of the test results for turfgrass and sand putting greens.

The purpose of the present study was to gather preliminary information on the reliability of the DTPA test as a basis for recommending micronutrient applications on sand putting greens. This was approached as a two-stage process: (1) Testing the reliability of the DTPA method and (2) Testing the DTPA test interpretations used by a commercial soil testing laboratory.

METHODS

The study began with the assembly of a data base. Data came from two sources. One source was three research putting greens at the O.J. Noer Turfgrass Research and Education Facility. These were constructed with 11 different root zone mixes and have been subjected to differing fertilization programs for 4 years or more. The second source of data was putting greens at two Wisconsin golf courses. The two golf courses were selected for the contrast in root zone mix sand – one is highly calcareous and the other acidic – and because both had recent sets of soil tests from the same commercial laboratory.

A single set of bentgrass clippings was collected from each site, cleaned, ground, digested and analyzed by the Soil and Plant Analysis Laboratory (SPAL) in Madison, WI along with DTPA soil extracts from the Noer Facility putting greens. The total data base consisted of 61 soil and plant analyses for Cu, Fe, Mn, and Zn. Clipping weights were also determined for the Noer Facility greens.

RESULTS

A key decision in this study was what to use as a measure of bentgrass response to different soil test levels of Cu, Fe, Mn, and Zn. Given the type of information gathered, the only option for the entire data set was to use clipping concentrations of the nutrients and critical levels reported in the literature. The critical levels employed are those given in Table 1. These values are a composite of those reported by Jones (1980) and analyses done in conjunction with various research projects conducted at the University of Wisconsin-Madison during the past 15 years.

The standard procedure in testing the reliability of a soil test method is to correlate the test results with plant uptake of the nutrient (CAST, 2000). To do this, one must know plant dry matter yield as well as tissue nutrient concentration. Such information was available only for the Noer Facility putting greens. Our first task was to determine if correlations of soil test results with nutrient uptake and plant tissue nutrient concentration are sufficiently similar such that we could include data from the two golf courses in our study.

The correlation coefficients (r) for the relationship between DTPA extractable soil Mn and Mn uptake was 0.847. For clipping Mn concentration, $r = 0.793$. These two values are not significantly different, which justifies use of clipping Mn concentrations and our complete data set. However, future studies should consider soil test correlations with nutrient uptake as well as clipping concentration.

Soil Test Reliability

The relationship and correlation between DTPA extractable Cu and bentgrass clipping Cu concentration is shown in Figure 1. Two problems are identified in the figure. First, the correlation coefficient is too low to consider this a reliable soil test. Second, the indication is that at a zero level of DTPA extractable Cu, the clippings would have averaged about 12.3 ppm Cu. This is a strong indication that the test does not measure all forms of plant available Cu.

A serious problem in the analysis of putting green clippings is soil contamination. To check for this, the clippings are analyzed for aluminum, whose concentrations are an index of the amount of soil contamination. The element whose clipping concentration is most strongly influenced by soil contamination is Fe. Despite the care taken in the study to remove soil from the clipping samples, the Al concentrations indicated that all but about 20 of the samples had some soil contamination.

Only those clippings without evidence of soil contamination were used to examine the relationship between DTPA extractable Fe and clipping Fe. There was a high correlation between them (Fig. 2), indicating that the DTPA test was a reliable measure of plant available Fe. But, as in the case of Cu, a zero soil test was associated with clipping Fe concentrations of around 118 ppm, which is above the upper end of the sufficiency range (Table 1). Thus, the indication is that the DTPA test did not measure all forms of plant available soil Fe.

There was no interpretable relationship between DTPA extractable Zn and clipping Zn (Fig. 3). In fact, indications were that clipping Zn concentrations tended to decline with increasing amounts of DTPA extractable soil Zn.

As shown in Figure 4, the correlation coefficient for the relationship between DTPA extractable Mn and clipping Mn was high (r = 0.829). Furthermore, the relationship indicates that clipping Mn concentrations would have been near zero were the DTPA extractable soil Mn zero. These two observations suggest that the DTPA method is a reliable test for soil Mn.

The Soil and Plant Analysis Laboratory employs 0.1N H_3PO_4 as an extractant for plant available Mn (Dahnke, 1980). This test method was selected based upon research where soybean was the test crop. Soil samples from the Noer Facility were analyzed for Mn by SPAL. The correlation coefficient for the relationship between 0.1N H_3PO_4 extractable soil Mn and bentgrass clipping Mn concentration was only 0.189.

Soil Test Interpretation

The interpretation of soil tests for micronutrients seeks only to establish a realistic critical value (CAST, 2000). The critical value is the soil test below which there is high probability of plant response to an application of the nutrient. In the present study, we examined only the interpretation of the DTPA test for Mn

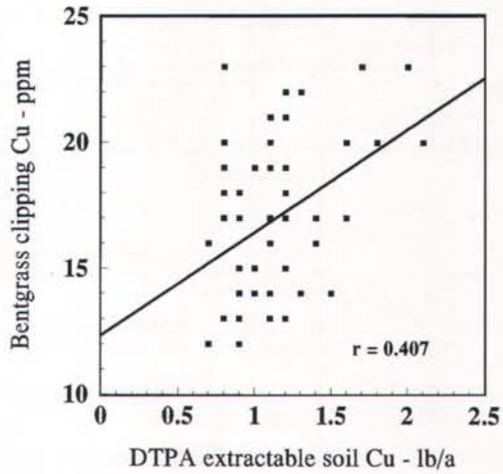


Figure 1. Relationship of DTPA extractable soil Cu to bentgrass clipping Cu concentration.

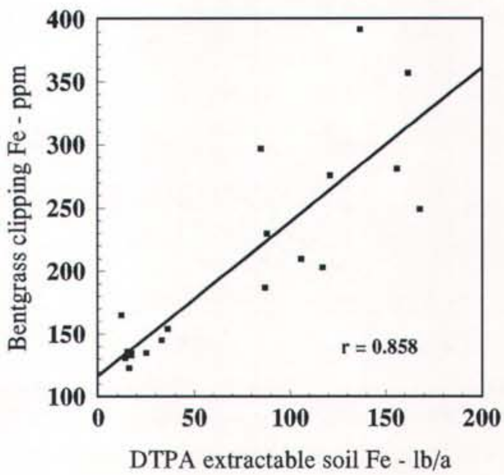


Figure 2. Relationship of DTPA extractable soil Fe and bentgrass clipping Fe concentration.

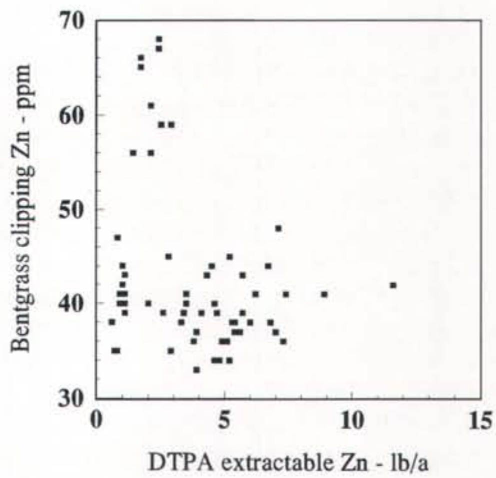


Figure 3. Relationship of DTPA extractable soil Zn and bentgrass clipping Zn concentration.

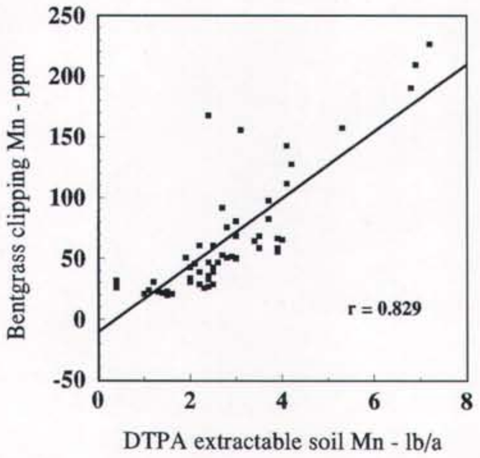


Figure 4. Relationship of DTPA extractable soil Mn and bentgrass clipping Mn concentration.

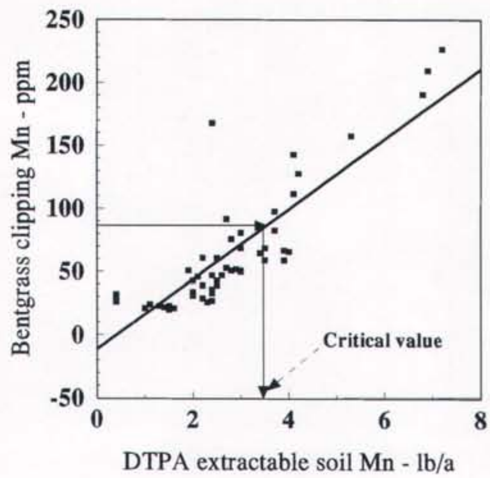


Figure 5. Identification of a critical value for DTPA extractable soil Mn.

because this is the only micronutrient for which the test appeared to be reliable.

The criteria we chose for establishing the critical value for the DTPA test for Mn was the mid-point of the tissue range for Mn (Table 1). Choosing the mid-point of this range rather than the lower end of the sufficiency range is a conservative approach and one that can result in instances where Mn application is recommended but the probability of plant response may be low.

The mid-point of the Mn sufficiency range for bentgrass clipping is 87.5 ppm (Table 1). Application of this criteria indicated that the critical value for DTPA extractable soil Mn was close to 3.5 lb/acre (Fig. 5). All putting greens analyzed by the commercial laboratory were judged to be low in Mn. By examining the actual soil test values, we concluded that the critical soil Mn value being applied by the laboratory is very near 8 lb Mn/acre. This is eight times higher than the critical value tentatively suggested by the developers of the DTPA test (Lindsay and Norvell, 1978).

CONCLUSIONS

The data used in this study came from the 18 sand putting greens on each of two Wisconsin golf courses and three research greens at the O.J. Noer Turfgrass Research and Education Facility. The number of observations totaled 61 and came from putting greens constructed with 13 different root zone mixes. Some mixes were blended using acid sand and others with low (2%) to high (17%) carbonate content.

The conclusions drawn from the study are:

(1) The DTPA test provides no reliable information on the plant available Cu and Zn content of sand putting greens.

(2) The DTPA test for Fe may have some value, but requires more extensive investigation.

(3) The DTPA test for Mn is judged to be a reliable method of analysis for plant available Mn in sand putting greens.

(4) Further research is required regarding the critical value of the DTPA test for Mn. The commercial laboratory that analyzed the golf course putting greens appears to be using a critical value of 8 lb Mn/acre. Our study identified a critical value of 3.5 lb Mn/acre. The commercial laboratory would have declared all 61 of the putting greens to be Mn deficient. Our criteria would have declared only 36 of the greens to possibly be responsive to application of Mn.

ACKNOWLEDGMENTS

Paul Blumke is a senior in the University of Wisconsin-Madison Turf and Grounds Management Program. Wayne Kussow is his faculty advisor. Appreciation is expressed to Jeff Parks, University Ridge Golf Course, and Scott Sann, Greenwod Hills Country Club, for sharing their soil test reports and providing clippings from their putting greens.

REFERENCES

Council for Agriculture Science and Technology (CAST). 2000. Relevance of soil testing to agriculture and the environment. Issue Paper no. 15, Ames, IA.

Dahnke, W.C. (ed.). 1980. Recommended chemical soil test procedures for the North Central region. North Dakota Agric. Exp. Stn. Bull. no. 499. North Dakota State Univ., Fargo, ND.

Jones, J.R., Jr. 1980. Turfgrass analysis. Golf Course Mgmt. 48(1):29-32.

Lindsay, W.L., and W.A. Norvell. 1978. Development of a DTPA soil test for zinc, iron, manganese, and copper. Soil Sci. Soc. Am. J. 42:421-428.

Turner, T.R., and N.W. Hummel, Jr. 2991. Nutritional requirements and fertilization. p. 385-439. In Waddington et al. (ed.) Turfgrass. Agron. Monogr. no. 32. ASA, Madison, WI.

The Promises, Pitfalls and Ethics of Genetic Transformation of Turfgrasses

By Dr. John C. Stier, Department of Horticulture, University of Wisconsin-Madison

Mankind began genetically transforming plants over 10,000 years ago when two types of a species were planted in close proximity to one another to achieve gene transfer between plants. For the last 300 years we've called this process breeding. Biotechnology offers another means to achieve this end. While not necessarily faster than conventional breeding, laboratory-based genetic transformations become part of the breeding process and allow genes to be introduced into a plant that might normally not be possible (genetic transformation was described in the previous issue of the Grass Roots, Vol. XXX(1).) Once transformed, the genetically altered plants still have to go through field screening trials to ensure the plants grow as expected, seed yield is adequate, and the desired trait(s) is/are passed on to successive generations.

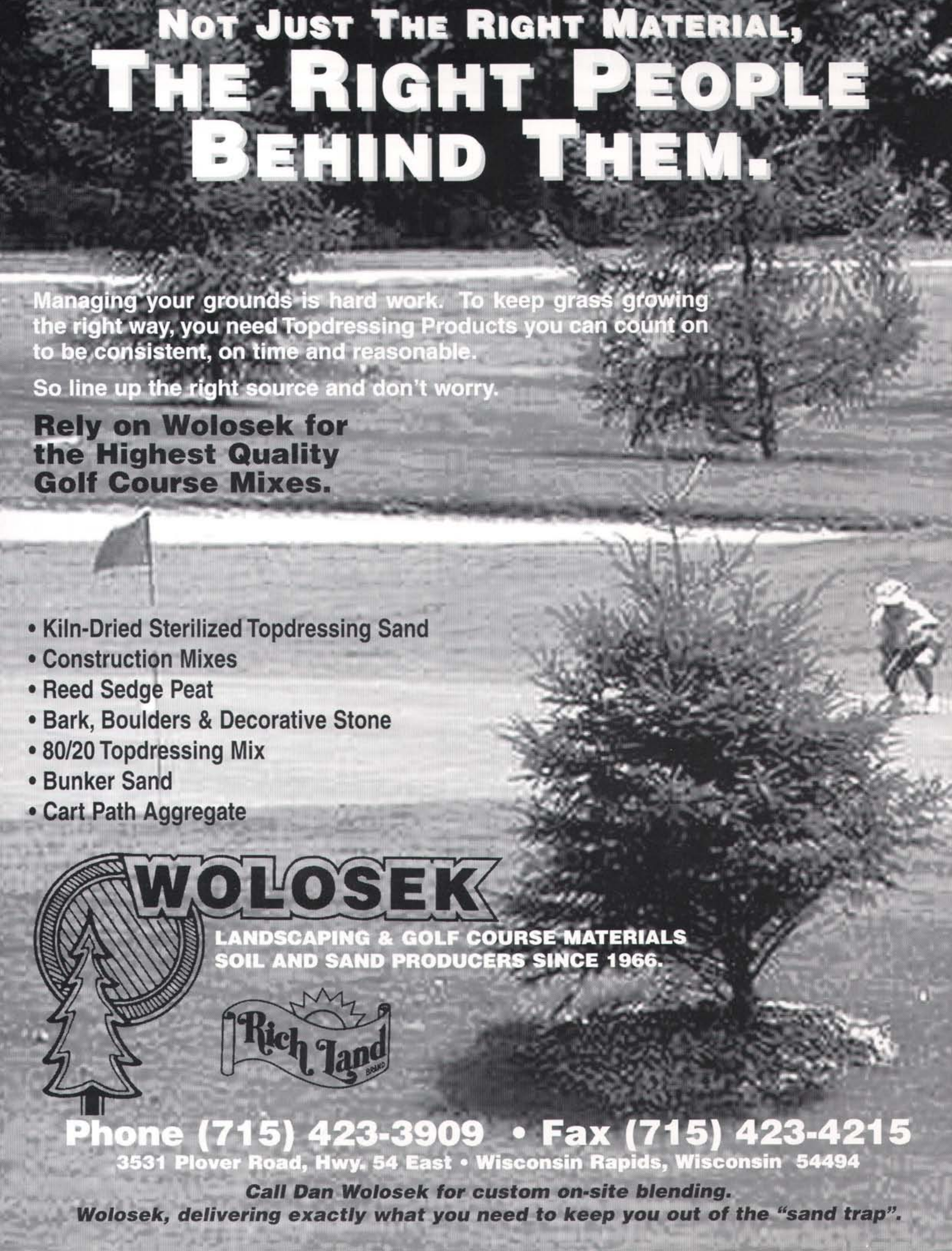
The permitting process.

Genetic transformation of crops is highly regulated by federal groups including the United States Department of Agriculture (USDA), the Environmental Protection Agency (EPA), and in some cases the Food and Drug Administration (FDA). Applications for field testing of genetically modified organisms (GMOs) must be submitted to the Animal and Plant Health Inspection Service (APHIS), a division of the USDA. APHIS conducts an environmental assessment (EA) to determine the potential environmental impact of a GMO. Permits are issued when a Finding Of No Significant Impact (FONSI) is determined. Field tests of certain organisms (e.g, tomato, corn, soybean, etc.) are subject to lesser standards known as "notifications". As of 7 February 2001, there were 6931 notifications and release permits for field tests. This is more than twice as many as existed in 1997 (Johnson and Riordan, 1999).

Sponsors (owners of the GM products) may petition APHIS for deregulation following appropriate field test results. This is a necessary step towards commercialization of the product. To date, fourteen organisms have been deregulated, primarily edible commodities. No turfgrasses have yet been deregulated.

The Promises.

Over 100 permits have been issued for genetic transformation of turfgrass species. Creeping bentgrass was the first species to get a permit (1993) and has the largest number of permits listed (Table 1). Most of the permits were issued for genes involved in drought and salt stress tolerance. As the availability of high water quality and quantity decrease both drought and salt stress issues will become extremely important to turf managers. Heat tolerance genes will allow bentgrasses to be grown across the South and should improve performance in the North during periods of high temperatures. Even more exciting in the short term is the potential for development of dollar spot and brown patch-resistant turfgrasses. As the Food Quality Protection Act and other regulations such as the proposed NR151 rules in Wisconsin (see the President's article in this issue) increasingly restrict fungicide applications, development of disease-resistant grasses will become essential for golf course maintenance. Such an


NOT JUST THE RIGHT MATERIAL,
THE RIGHT PEOPLE BEHIND THEM.
Managing your grounds is hard work. To keep grass growing the right way, you need Topdressing Products you can count on to be consistent, on time and reasonable.
So line up the right source and don't worry.
Rely on Wolosek for the Highest Quality Golf Course Mixes.
• Kiln-Dried Sterilized Topdressing Sand
• Construction Mixes
• Reed Sedge Peat
• Bark, Boulders & Decorative Stone
• 80/20 Topdressing Mix
• Bunker Sand
• Cart Path Aggregate
WOLOSEK
LANDSCAPING & GOLF COURSE MATERIALS
SOIL AND SAND PRODUCERS SINCE 1966.
Rich Land
Phone (715) 423-3909 • Fax (715) 423-4215
3531 Plover Road, Hwy. 54 East • Wisconsin Rapids, Wisconsin 54494
Call Dan Wolosek for custom on-site blending.
Wolosek, delivering exactly what you need to keep you out of the "sand trap".

advance will also reduce budget allocations for fungicides.

Glyphosate (Roundup) tolerance is likely to be the first genetically transformed turfgrass product available commercially, perhaps as soon as 2002-2003. Herbicide tolerance has worked well in row crops: in 2000, approximately 60% of the soybean crop in the U.S. carried the gene for glyphosate resistance. Weed control in turf can become a no-brainer: simply spray visible weeds in a glyphosate-resistance turfgrass with glyphosate at any time of the year and the problem can be solved. This allows control of weeds for which there is not a good selective control such as annual bluegrass and quackgrass.

Table 1. Types of permits issued for field testing of genetically-altered turfgrasses as of 7 February, 2001.

	Bermudagrass	Creeping bentgrass	Tall fescue*	Kentucky bluegrass	Perennial ryegrass
	# permits				
Trait	5	82	4	17	2
Aluminium tolerance		X			
Drought tolerance	X	X		X	X
Heat tolerance		X			
Salt tolerance	X	X		X	X
Glyphosate resistance		X		X	
Sod webworm resistance		X			
Rhizoctonia resistance (brown patch)		X		X	
Sclerotinia/Dollar spot resistance		X			
Growth regulation		X		X	
Genetic markers		X	X		

* This was most likely for forage, not turfgrass, cultivars.

The Pitfalls.

The greatest problem facing the use of genetically modified turfgrasses is a common theme in science—lack of public understanding. In order for GMO technology to be useful, the following issues will have to be addressed sooner rather than later.

Public antipathy and legislation. Perception is reality. Advocacy groups lobby hard to prevent the use of GMOs in our society. Extreme groups go so far as to sabotage laboratories and businesses engaged in research with GMOs. One of the most stunning events occurred on a research farm of Pure Seed Testing, Inc. in Oregon last summer. The Anarchist Golfing Association destroyed greenhouses and field plots on June 5, 2000, causing over $300,000 worth of damage because the company was involved in research using GM turfgrasses (RB, 2000). The AGA opposes turfgrasses because they are grown for profit "and the pleasure of the rich and have no social value". The irony of the case was that Pure Seed had been testing GM turfgrasses to determine the biological and environmental impact of GM turfgrasses. Furthermore, the plants the group destroyed were developed by traditional breeding techniques, not through biotechnology. What the group's actions amount to is eco-terrorism. Of all possible GMO problems, terrorism has got to be the scariest aspect of all.

From a turf management perspective herbicide-resistant turfgrasses could lead to increased reliance on herbicides. This could make turf managers "lazy", allowing them to resort to herbicides to control weeds rather than correct underlying causes (compaction, poor drainage, etc.). Since the actions of any facet of the turf industry are reflective upon the industry as a whole this could reduce credibility of the turf industry. For example, if parks and recreation departments increase their herbicide usage because herbicide-resistant turfgrasses are being used, the public may cry "foul", and golf courses will be looked at in the same light. Increased use of specific herbicides such as glyphosate could lead to cancellation of these products because of public perception and laws such as FQPA which reg-

Syngenta Brings You The New Pro Rewards Program

PRO REWARDS

Now You Can Grow Your Own Rewards

Total Turf Managers Team

Buying Syngenta Professional Products Becomes Even More Rewarding!

- The Total Turf Managers Team program is expanding to become part of the new Syngenta Pro Rewards program. Current TTMT member points will automatically roll over to the Pro Rewards program.
- Pro Rewards is our way of thanking you for purchasing Banner MAXX®, Barricade®, Daconil®, Heritage®, Primo MAXX®, Subdue MAXX®, and other Syngenta Professional Products.
- Earn points for Dell™ computers, Makita® leaf blowers, Troy-Bilt® lawn mowers, and Echo® backpack sprayers to help your golf course operation.
- You can also earn points toward rewards for employees—like Super Bowl tickets, Caribbean cruises, sporting goods, and more—or toward donations to charities or associations of your choice.

Call 1-877-375-0824 to contact your local Syngenta sales representative and learn more about Pro Rewards.

syngenta

Important: Always read and follow label instructions before purchasing or using these products.