Nothing minor about **micronutrients**

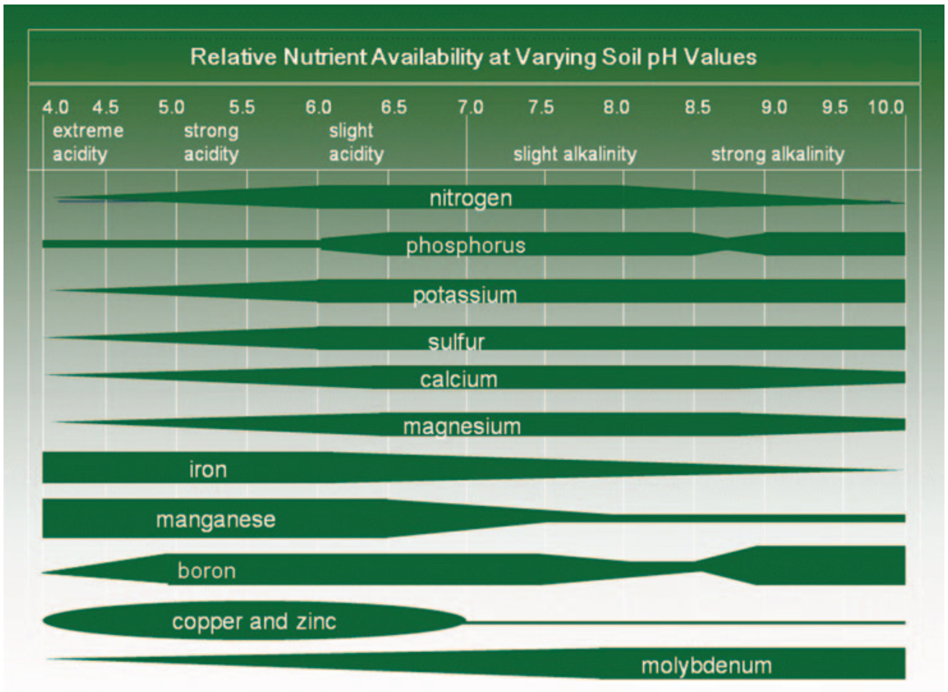
ALTHOUGH TURFGRASSES CONTAIN ONLY TRACE AMOUNTS OF BORON (B), chlorine (Cl), copper (Cu), iron (Fe), manganese (Mn), molybdenum (Mo), nickel (Ni) and zinc (Zn), these eight micronutrients are essential for plant growth and survival. When it comes to turfgrass nutrition, essential micronutrients deserve attention and should not be overlooked.

In order for a nutrient to be considered 'essential', it must 1) be required for a turfgrass plant to complete its growth cycle; 2) perform a plant function that cannot take place without it; or 3) be directly involved in photosynthesis, respiration, or the production or breakdown of organic materials within the plant, or necessary for a critical chemical reaction.

Of the essential nutrients, carbon, hydrogen and oxygen are supplied to turfgrasses by carbon dioxide and water. The majority of carbon dioxide is taken up through minute pores, or stomates, on the surface of leaves and stems. In addition to moving nutrients from one plant part to another, water also provides turfgrasses with hydrogen and oxygen.

Turfgrasses primarily absorb the remaining essential nutrients from soil. The fibrous nature of the root system and the massive number of root hairs contribute to a turfgrass plants ability to extract these mineral nutrients from a soil solution. Due to the amount turfgrasses require, nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg) and sulfur (S) are categorized as macronutrients. The macronutrients are often further sub-divided according to the amount required by turfgrasses. Nitrogen, P and K are primary macronutrients, while Ca, Mg and S are secondary macronutrients. Results of analyses of macronutrients in tissue are often reported as percent on a dry-weight-basis. For example, bermudagrass turf is often considered nutrient deficient if shoot tissue contains less than 2% N, 0.3% P, 1% K, 0.5% Ca, 0.3% Mg and 0.2 % S on a dry-weight-basis.

Figure 1. Soil pH chart.



EFFECT OF SOIL PH ON UPTAKE OF MICRONUTRIENTS

Micronutrients, also referred to as trace or minor nutrients, are usually found in dry turfgrass shoot tissue at levels less than 1,000 ppm. Micronutrient applications are seldom beneficial to turfgrasses growing in fertile, mineral soils with a slightly acid pH (for example, 6.0 to 6.9). However, when turfgrasses are managed in high-sand-content soils, organic soils or soils with high- or low pH, the application of a micronutrient may be very beneficial. The availability of micronutrients in soil for uptake by turfgrasses is influenced by the level of soil acidity or alkalinity. Plant availability of Fe, Mn, Cu and Zn decreases as the soil pH rises above neutral (7.0), while that of Mo increases with increasing soil pH (Figure 1).

ROLE OF MICRONUTRIENTS IN TURFGRASSES

Boron affects the formation of plant cell walls and the transport of sugars. Chlorine influences photosynthesis, the division and length of plant cells, and the opening and closing of stomates. Copper is necessary for photosynthesis and influences the lignin content and strength of cell walls. Iron is involved in the production of chlorophyll. Several enzymes associated with the transfer of energy, N fixation and the production of lignin contain Fe. Manganese is necessary for photosynthesis and is involved in the formation and breakdown of N-containing compounds. Plants deficient in Mn for an extended period of time are, most often, very low in chlorophyll. Molybdenum is involved in the formation of proteins and the use of N and S by turfgrasses. Molybdenum also affects the production of pollen. Nickel, recently classified as an essential micronutrient, is a component of an enzyme.

Table 1.
Copper recommendations for both new and established turfgrass areas (for organic soils only).[a,b]

Copper, Cu	Application method: Soil broadcast	Application method: Foliar Spray[c]
Soil test level	Amount of Cu to apply/1000 sq. ft.[d]	
ppm	Pound Cu	Ounce Cu
0 to 2.5	0.1 to 0.3	0.4
> 2.5	0.0	0.0

[a] From: Rosen, C.J., P.M. Bierman and R.D. Eliason. 2008. Soil test interpretations and fertilizer management for lawns, turf, gardens, and landscape plants. Department of Soil, Water, and Climate. Regents of the University of Minnesota (http://www.extension.umn.edu/distribution/horticulture/components/1731-complete.pdf)
[b] Applications are suggested on a trial basis only.
[c] Apply foliar sprays at the recommended rate 2 to 3 times per year.
[d] Multiply by 44 to convert the rate from lb./1000 sq. ft. to lb./acre; multiply by 2.7 to convert from oz./1000 sq. ft. to lb./acre.

Table 2.
The chemical symbol, plant available form and general sufficiency range in shoot tissue of eigh essential micronutrients.[a]

Micronutrient, chemical symbol	Form absorbed by plants	General sufficiency range, ppm- dry weight basis
Boron, B	H_3BO_3, BO_3^{-3}	5 - 60
Chlorine, Cl	Cl^-	200 - 400
Copper, Cu	Cu^{+2}, $Cu(OH)^+$, Cu-chelates	5 - 20
Iron, Fe	Fe^{+2}, Fe^{+3}, Fe-chelates	50 - 100
Manganese, Mn	Mn^{+2}, Mn-chelates	20 - 100
Molybdenum, Mo	MoO_4^{-2}, $HMoO_4^-$	1 - 4
Nickel, Ni	Ni^{2+}	< 1
Zinc, Zn	Zn^{2+}, $ZnOH^+$	20 - 55

[a] Summarized from: Carrow, R.N., D.V. Waddington and P.E. Rieke, 2001. *Turfgrass soil fertility and chemical problems: assessment and management.* Hoboken, NJ: John Wiley and Sons, Inc.

Several enzymes active in the production of carbohydrates and proteins contain Zn.

Many soil testing laboratories test for available B, Cu, Fe, Mn, Mo and Zn. More than one method (Mehlich II and III, DTPA) can be used to extract micronutrients from soil and results often vary from one method to the next. After testing soil, very specific recommendations may be made regarding the application of individual micronutrients (Table 1). Interestingly, it is not uncommon for turfgrasses to respond favorably to an application of Fe even though a soil test report indicates that the concentration of the micronutrient is in the High range. An analysis of plant tissue is recommended as a supplement to soil testing. Micronutrient levels in turfgrass tissue are usually reported as ppm on a dry-weight basis. For example, bermudagrass turf is often considered nutrient deficient if shoot tissue contains less than 100 ppm Fe, 30 ppm Zn, 25 ppm Mn and 10 ppm Cu on a dry-weight-basis. Information regarding specific micronutrient sufficiency ranges for individual turfgrass species or varieties is limited, however general or common sufficiency ranges have been published (Table 2).

POSSIBILITY OF A MICRONUTRIENT DEFICIENCY

Some micronutrients are more apt to be at low or deficient levels than others. A deficiency of Fe in turfgrasses maintained out of doors is much more common than a deficiency of the other micronutrients. Iron deficiencies are most likely to occur in poorly rooted and thatchy turfs maintained in calcium-rich soils with high P and pH (> 7.5) levels, and very little organic matter. Turfgrasses irrigated with water high in bicarbonates, P, Ca, Cu, Mn or Zn may also be deficient in Fe.

Although less commonly observed than a Fe deficiency, a Mn deficiency in turfgrasses is not unusual. A Mn deficiency, like that of Fe, may occur in plants maintained in soil with a high pH and Ca level. Extended periods of dry, warm weather reduce Mn availability in soil. Boron, Cu, Mo and Zn deficiencies are rare. High levels of Ca in soils can reduce the availability of B. Boron deficiencies are also more likely to occur in turfgrasses growing in porous, sandy soils with a high pH and high level of K. Since Cu can tightly bond with soil organic matter, deficiencies of Cu have been observed in turfgrasses growing in organic soils. Copper deficiencies have also occurred in turfgrasses maintained in sandy and alkaline soils, and soils with high N, P, Fe, Mn, Zn or pH levels. Molybdenum deficiencies are more prevalent in turfgrasses growing in acidic and sandy soils.

High levels of S, Cu, Fe and Mn may limit the amount of Mo turfgrasses absorb from soil. Zinc deficiencies have occurred more often in turfgrasses in shade, in alkaline or acidic soils, and during cool, wet weather. At present, no Cl or Ni deficiencies have been documented in turfgrasses.

Once inside a turfgrass plant, some micronutrients are much more mobile than others. Iron and Mn are immobile and Cl is mobile in turfgrass plants. Boron, Cu, Mo and Zn are somewhat mobile. The location of a deficiency symptom on a turfgrass plant is influenced by nutrient mobility. For example, due to the inability of a turfgrass plant to move the micronutrient from older to younger leaves, symptoms of a Fe and a Mn deficiency occur first on young leaves. Leaf tissue between veins of young leaves of a plant deficient in Fe often turns yellow then white. This condition is commonly referred to as interveinal chlorosis. The youngest leaves of a plant deficient in Mn usually develop small grayish-green spots before the leaf tips and the tissue between veins turn yellow. Turfs deficient in

Several factors deserve consideration when applying micronutrients in water to turfs. They include: the weather; the type, nutrient status and growth rate of turfgrass; leaf wetness; the form of the micronutrient; the product application rate, frequency and interval; the spray volume; and the spray tip.

Mn often appear mottled. Young leaves of a turfgrass plant deficient in B may have yellow or white leaf tips and exhibit interveinal chlorosis long before older leaves. The margins of young and middle-aged leaves of plants deficient in Cu often turn yellow, and leaf tips may have a bluish cast. Symptoms of a Mo deficiency are much like that of an N deficiency. The older leaves of plants deficient in Mo 'fire' when the micronutrient is mobilized and moves to young leaves. Leaves of Zn deficient plants are often mottled and stunted, and may roll or appear 'crinkled'. The symptoms of Zn deficiency may be more apparent on younger leaves.

SELECTING AND APPLYING A PRODUCT

A micronutrient deficiency can be corrected by either a foliar or soil application. Micronutrient-containing fertilizer formulations may be in solid or liquid form (Figure 2), and a micronutrient may be mixed with other nutrients (Figure 3, on page 13). Whether in liquid or solid, organic or inorganic form, a fertilizer must be applied uniformly according to label directions.

>> **Figure 2.** An example of a liquid fertilizer formulated with macronutrients and micronutrients.

Several factors deserve consideration when applying micronutrients in water to turfs. They include: the weather; the type, nutrient status and growth rate of turfgrass; leaf wetness; the form of the micronutrient; the product application rate, frequency and interval; the spray volume; and the spray tip. The rate at which cells of leaves divide and expand is influenced by light, temperature, moisture and fertility level. The length of time between micronutrient applications can be adjusted according to the rate of growth of the aerial shoots. The recommended product application interval may decrease with increasing plant growth rate.

Several sources of an individual micronutrient may be available for use in turf (Table 3, on page 12). For example, iron (ferrous) sulfate and iron chelates are common sources of iron. Iron chelates are most often more effective as soil applications than ferrous sulfate, which can be highly effective when applied as a foliar treatment. In soil, a ferrous ion (Fe^{+2}) from iron sulfate may quickly be converted to a ferric ion (Fe^{3+}), which is much less available for plant uptake.

Chelates are produced by combining a positively (cation) or negatively (anion) charged micronutrient with an organic compound or chelating agent. The reaction results in a 'protected' micronutrient cation or anion bound in a chemical ring structure. The length of time during which a chelated micronutrient remains in plant available form in soil is influenced by the soil pH, the ion that is in protected form, and the chelating agent. Citric (CIT), acetic [DTPA, diethylene triamine pentaacetic acid; EDTA, ethylene diamine tetraacetic acid; EDDHA, ethylene diamine di (o-hydroxy-phenylacetic acid); and HEDTA, hydroxyethyl ethylene diamine triacetic acid] and oxalic (OX) acids are examples of chelating agents used to produce chelated micronutrients.

When foliar feeding, no more than one-half gallon of a micronutrient-containing solution is usually applied per 1,000 sq. ft. The intent of a soil-drench (one gallon of water or more per 1,000 sq. ft.) treatment is to carry the micronutrient through thatch and into the soil. Turfgrasses most often respond more quickly to a foliar feeding than a granular or soil drench application. The addition of a surfactant may, or may not, be recommended.

Thorough and uniform coverage is essential when applying a micronutrient to turf in water. The diameter of spray droplets varies depending on the spraying pressure and the spray tip installed in the nozzle body on the sprayer boom. The diameter of spray droplets may range from very coarse (> 550 microns) to very fine (< 150 microns).

Table 3.
Several fertilizer sources of essential micronutrients and their approximate nutrient content.[a]

Source	Formula	Approximate micronutrient content (%)[b]
Boron, B		
Borax	$Na_2B_4O_7{\cdot}2H_2O$	11
boric acid	H_3BO_3	17
Chlorine, Cl		
Potassium chloride	KCl	45
Copper, Cu		
Copper oxide	CuO, Cu_2O	75, 89
Copper sulfate	$CuSO_4{\cdot}H_2O$, $CuSO_4{\cdot}5H_2O$	25, 35
Copper chelate	Na_2Cu EDTA	13
Iron, Fe		
Ferric oxide	Fe_2O_3	69
Ferrous oxide	FeO	77
Ferric sulfate	$Fe_2(SO_4)_3{\cdot}4H_2O$	23
Ferrous sulfate	$FeSO_4{\cdot}7H_2O$	20
Ferrous ammonium phosphate	$Fe(NH_4)PO_4{\cdot}H_2O$	29
Ferrous ammonium sulfate	$(NH_4)_2SO_4{\cdot}FeSO_4{\cdot}6H_2O$	14
Iron chelates	NaFeDTPA, NaFeEDTA	10, 6
Manganese, Mn		
Manganese oxide	MnO	41 - 68
Manganese sulfate	$MnSO_4{\cdot}4H_2O$	27
Manganese chelate	Na_2Mn EDTA	12
Molybdenum, Mo		
Ammonium molybdate	$(NH4)_6Mo_7O_{24}$	54
Molybdenum trioxide	MoO_3	66
Sodium molybdate	$Na_2MoO_4{\cdot}2H_2O$	40
Zinc, Zn		
Zinc oxide	ZnO	78
Zinc sulfate	$ZnSO_4{\cdot}H_2O$, $ZnSO_4{\cdot}7H_2O$	35, 23
Zinc chelate	Na_2Zn EDTA	14

[a] From: Carrow, R.N., D.V. Waddington and P.E. Rieke. 2001. *Turfgrass soil fertility and chemical problems: assessment and nanagement.* Hoboken, NJ: John Wiley & Sons, Inc.
[b] The actual percentage of the micronutrient may vary depending on the purity and source of the product.

GUARANTEED ANALYSIS

Magnesium (Mg)	1.00%
1.00% Soluble Magnesium	
Sulfur (S)	3.50%
3.50% Combined Sulfur	
Boron (B)	0.02%
Copper (Cu)	0.25%
0.25% Chelated Copper	
Iron (Fe)	4.00%
4.00% Chelated Iron	
Manganese (Mn)	1.00%
1.00% Chelated Manganese	
Molybdenum (Mo)	0.0005%
Zinc (Zn)	0.60%
0.60% Chelated Zinc (Zn)	

Derived from: Magnesium Sulfate, Sodium Borate, Copper Glucoheptonate, Iron Glucoheptonate, Manganese Glucoheptonate, Zinc Glucoheptonate, and Sodium Molybdate

- ***Optimal liquid foliar formulation of essential plant nutrients***
- ***Aids in the prevention and correction of micronutrient deficiencies***

RECOMMENDED RATES

Turf (Fairways, Greens & Tees): Apply 2-6 oz. per 1,000 sq. ft. or 3-6 quarts per acre in enough water to cover.

Trees & Ornamentals: Apply 4-6 quarts per 100 gallons of water as a drench or foliar spray. Repeat as needed.

PRODUCT INFORMATION

Harrell's MAX Minors (complete minors package) is a liquid foliar formulation of essential nutrients and micronutrients to aid in the prevention and correction of deficiencies. The ratio of minors in Harrell's MAX Minors micronutrient package has been optimized for higher pH soils where trace elements often become unavailable to the plant. In alkaline soils, Harrell's MAX Minors will remain available longer than many other products. Harrell's MAX Minors can be applied with most pesticides and fertilizers except high phosphate materials. The addition of a non-ionic surfactant will aid surface coverage which will help leaf absorption.

DIRECTIONS FOR USE

Harrell's MAX Minors may be tank mixed with most liquid fertilizer and pesticides; however a jar compatibility test should be performed on unknown combinations.

PRECAUTIONS

Shake well before each use. Avoid getting in eyes, mucous membranes or on skin. Use of side-shielded safety glasses is recommended. Use with adequate ventilation. Keep container capped when not in use. Do not contaminate feed, seed, or water supplies. Avoid spraying on concrete or painted surfaces as staining may occur.

Keep away from Children.

FIRST AID

Skin: Remove contaminated clothing. Wash with plenty of clean water and soap. Consult a physician.
Eyes: Rinse with clean water for a minimum of 15 minutes. Seek medical attention.
Internal: Drink 2 glasses of water. DO NOT INDUCE VOMITING. Seek medical attention at once.

STORAGE AND CONTAINER DISPOSAL

Store this product in a dry place, in original container only. Keep lid tightly closed. Keep away from open flame or intense heat. Triple rinse container and offer for recycling or dispose of in accordance with federal, state and local authorities.

CONDITIONS OF SALE

Seller warrants that products will be labeled as required under state and federal laws and that they conform to the label description. Any non-conformance must be reported in writing to Seller within Thirty(30) days after purchase as a prerequisite to maintaining any claim against Seller. Buyer agrees to inspect all products purchased immediately upon delivery. The seller's liability under this warranty is in lieu of all other warranties, expressed or implied, including warranties of merchantability and fitness for a particular purpose. There are no warranties which extend beyond this statement.

Figure 3. An example product label identifying the micronutrient sources and application rates.

Manufacturers often rate the effectiveness of each type of spray tip as good, very good, excellent or not recommended, for specific applications (e.g., broadcast liquid fertilizer; contact and systemic fungicides, herbicides and insecticides; …).

Since an application may, or may not result in a visual improvement in foliage color or turfgrass health even though test results indicate that one or more micronutrients are in the low or deficient ranges, it may be advantageous to treat a limited amount of turf with a product of interest before making a broadcast application over the entire sports field. ■

Dr. Tom Samples is an extension specialist for turfgrass management; Dr. John Sorochan is associate professor, turfgrass science and management; and Adam Thoms is research leader, all at the University of Tennessee in Knoxville. Brad Jakubowski is an instructor at Doane College, Crete, NE.

>> **FIGURE 1**. A dormant but extremely dense Riviera bermudagrass field in early December 2012 at Wilson Memorial HS, Waynesboro, VA (photo courtesy of Jimmy Rodgers).

Inside look at the turf team at Virginia Tech

INSTEAD OF A TRADITIONAL ARTICLE* on the STMA President for this month's issue, I asked for the opportunity this year to tell you a little bit about the turfgrass program at Virginia Tech and some of the great work my colleagues are doing that might apply to you.

Team: a number of persons associated together in work or activity. Being a part of a team certainly does not guarantee success, but teams that continually strive to improve and work together (i.e. demonstrate teamwork) will most likely perform at the top of their abilities. Nearly every month, *SportsTurf* features an award-winning team of sports turf managers recognized as 'Field of the Year" winners. A common theme in these articles is the value of teamwork. I received exceptional mentoring regarding the importance of a team and teamwork as a young faculty member at Mississippi State University from Dr. Jeff Krans. Since those formative years in my professional career, I have made it a point to emphasize to my colleagues how much I value being a part of a team. Something that gives the members of the turfgrass program at Virginia Tech great satisfaction is how our clientele refer to us as the VT Turf Team. And nowhere have I said being part of a team is easy—securing the information for this article and getting a cover photo of the team was akin to herding cats!

The VT Turf Team's collaboration across departments, programs, and colleges in our teaching, research, and extension programs has been cited by many administrators as a model for other programs at Virginia Tech to emulate. Our VT Turf Team is also much more than just the faculty, staff, and graduate students in our traditional academic programs, but it also includes our staffs that manage all VT athletic and recreational sports fields. Our athletics turf and recreational sports programs support turfgrass research, participate in our research field days, and are constantly "on call" for field and facility tours, something very important to our fund-raising and student recruiting activities. We also proudly claim as team members a large number of allied extension agents, private individuals, industry, and professional association cooperators around the state that assist us with financial support, on-site research opportunities, and the hosting of a variety of outreach programs.

I want you to meet a few of my VT team membersand I asked them to join me in providing a brief highlight of some of our sports turf-related research projects. These reports are but very small parts of their research programs, and if you have further questions of my colleagues regarding this or other projects they are leading, please be sure to get in touch with them by way of the contact information available at www.vt.edu.

BERMUDAGRASS EXPANSION ON VIRGINIA SPORTS FIELDS-Mike Goatley. Virginia's transition zone climate makes it possible to grow either cool-season or warm-season grasses on athletic fields, but none of them very well. Either type of grass is going to regularly struggle from an extreme summer or winter season. A part of my applied research program is variety evaluation and my turfgrass program manager, Whitnee Askew, and I have spent a great deal of time assessing bermudagrasses that we believe are well suited for athletic field

The data continually indicate what great potential the latest generations of cold tolerant vegetative and seeded bermudagrasses have for sports fields.

use in our climate. The data continually indicate what great potential the latest generations of cold tolerant vegetative and seeded bermudagrasses have for sports fields.

Depending on your perspective (see Dr. Askew's research brief below), bermudagrass is either an outstanding sports turf grass OR it is one of the world's worst weeds. For sports turf, bermudagrass offers transition zone sports field managers the opportunity to take advantage of the exceptional density and aggressive growth rate of this grass. In particular, these grasses have now made their way onto athletic fields throughout the Valley and Ridge region of Virginia at elevations of 2,300 feet or higher. As for any natural grass field, they still must be used and managed appropriately to meet expectations, but with proper traffic management, these fields are providing exceptional playing surfaces even as dormant turfs.

The one point of caution I bring to any facility considering a conversion is the intensive mowing requirement of bermudagrass in the summer. However, if this maintenance requirement is properly addressed, the end result is usually a more uniform playing surface and fields that require much less irrigation and pesticide use than comparative cool-season fields.

The most recent success story in Virginia's Shenandoah Valley is Wilson Memorial HS where football coach (and VSTMA member) Jeremiah Major seeded Riviera bermudagrass the summer of 2012. Jeremiah and his team delivered an exceptional field by the season opener in August, but even more impressive was the quality of his turf well into the playoffs in late November (Figure 1). The performance and condition of these fields certainly captures the attention of opposing coaches, players, and parents and has led to many fact-finding inquiries about a grass that they previously considered only to be a serious weed.

BERMUDAGRASS/WIREGRASS CONTROL–Shawn Askew. Dr. Askew has statewide responsibilities for developing weed management systems in turfgrass. He conducts weed control, herbicide physiology, and weed ecology experiments in all types of turf including athletic fields. His graduate students are currently working on several projects that may impact weed management in athletic fields.

In Virginia's climate, bermudagrass is both a desirable turf and a weed. Dr. Askew and his graduate students have worked hard over the past 8 years to develop selective bermudagrass control programs for cool-season turf, especially for Kentucky bluegrass athletic fields. Fenoxaprop + triclopyr programs were developed years ago in North and South Carolina and work great for tall fescue turf. In lower height turf and Kentucky bluegrass, the ester formulation of triclopyr can be extremely injurious to Kentucky bluegrass turf and fenoxaprop is much more injurious to immature turf of any species when compared to mature turf. Both of these phenomena can be problematic for athletic field management where Kentucky bluegrass and lower mowing heights are com-

>> **FIGURE 2.** White tissue symptoms that normally occur from the topramezone treatments (center plot is topramezone alone) are reduced or nearly eliminated and bermudagrass control increases dramatically when topramezone is tank-mixed with triclopyr (plots on left or right) (photo courtesy of Shawn Askew).

mon and immature turf will always be present due to the need to manage wear areas.

Dr. Askew's research suggests that fenoxaprop + triclopyr should only be used in early spring or late fall where immature turf is less prevalent and should be replaced with mesotrione or mesotrione + triclopyr at low rates during stressful periods of summer. Applications of either mesotrione or fenoxaprop mixed with triclopyr can effectively control bermudagrass in cool-season grasses. Just remember to reduce triclopyr rates in hot weather and on Kentucky bluegrass, switch from fenoxaprop to mesotrione both to save money and reduce potential damage to the bluegrass during stressful summer weather, and concentrate on fall treatments to get the best kill (repeat treatments at a 3-4 week interval).

Two new herbicides that are currently under investigation by Dr. Askew's group include topramezone and metamifop. Both herbicides show great promise for selective bermudagrass control and topramezone could be registered within the next year (Figure 2). Both herbicides work better when mixed with triclopyr but offer superior turf safety and bermudagrass control to other herbicides currently on the market. No herbicide, however, will control bermudagrass alone but must be mixed with other herbicides and applied 4-6 times per year in a program approach to bermudagrass eradication.

TURF TOLERANCE TO RIGID TURF PROTECTION SYSTEMS–Erik Ervin.

Dr. Erik Ervin is a Professor of Turfgrass Physiology in the Crop and Soil Environmental Sciences department of Virginia Tech and has primary responsibilities in teaching and advising in the undergraduate program. This research brief summarizes work supported by VT Athletics and the U.S. National Park Service and was completed in 2012 by M.S. student John Royse.

The presidential inauguration, the national book festival, the solar decathlon, and a U2 or Dave Matthews Band concert: what do these events have in common? They are all multi-day set-up and take-down events (often involving cranes) that take place on natural turfgrass surfaces (e.g., the National Mall and MLB fields) with thousands of attendees. Many times the activities are so intense that major turf death occurs and complete re-grassing is required. Managing or softening the conditions that cause major turf loss, however, is preferred. Unfortunately, there have been almost no scientific studies investigating the positives and negatives of current practices.

In 2010 and 2011 we conducted multi-season event cover simulation trials to determine how long a mature tall fescue turf (2.5 inch mowing height on a silt loam soil) could survive and what some of the controlling factors might be (e.g., light, compression resistance, soil moisture, temperature). Two commercially available rigid high-density polypropylene covers were compared to plywood-alone or plywood over Enkamat (Table 1). Terratile is a single-sided, white, translucent cover with foot pads and air holes used primarily for seating or foot-traffic protection, while Matrax LD is a double-sided, white, translucent cover with no air holes used primarily for vehicle-traffic protection. Each spring, summer, or fall season covers remained on the turf for 2, 4, 6, 8, 10, 12, 14, 16, 18, or 20 days giving us a look at turf persistence and recovery every 2 days during a 3-week period (Figure 3). Using linear regression we were able to estimate how long tall fescue could be covered (and driven over daily with a truck) and not have more than 40% turf loss (Table 1).

We found that light availability played a major role in turf persistence and recovery. The translucent Terratile and Matrax prod-

Table 1. Light transmission, average maximum high temperature under cover, and the predicted days until 40% or greater tall fescue loss following covering of various turf protection systems in summer or fall/spring.

		High temperature under cover	Number of days under cover before >40% turf loss, tall fescue	
Cover name	**Light transmission**	**Mean across 2 summer seasons (°F**	**Summer[1]**	**Fall/Spring[1]**
Terratile	25%	108	10	>20
Matrax LD	5%	100	12	>20
Plywood over Enkamat	0%	101	1	5
Plywood	0%	104	1	5

[1]Average high air temperatures during the two summer test periods was 94°F, while that over the four spring and fall test periods was 70 °F.

>> **FIGURE 3**. Differential tall fescue response after covering for 6 days in the fall with Matrax/Terratrak (top) or Plywood+Enkamat (bottom) (photo courtesy of John Royse).
>> **FIGURE 4**. Spring Dead Spot on a Riviera bermudagrass athletic field in Rocky Mount, VA (photo courtesy of David McCall).

ucts allowed 5 to 25% of photosynthetically active radiation through to the leaf blades when measured at solar noon. During cooler spring and fall periods this resulted in almost complete turf persistence and recovery even when covered for the entire 20-day test period, while both plywood treatments allowed for only 5 days of cover. During summer, extra light transmission through Terratile resulted in significantly higher temperatures reducing turf persistence to 10 days compared to 12 days for Matrax. Plywood or plywood over Enkamat resulted in almost complete turf death after only 2-4 days of cover in the summer. Our results were clear and consistent: Use of a rigid cover that allows some photosynthetically active light to reach the turf canopy is of primary importance, with air exchange and compression resistance being important, but secondary.

SPRING DEAD SPOT (SDS) MANAGEMENT IN BERMUDAGRASS –

David McCall. David is a research associate and PhD candidate in the Plant Pathology, Physiology, and Weed Science Department of Virginia Tech. He has primary responsibilities in turfgrass pathology.

In Virginia, where a growing number of athletic facilities have transitioned to improved varieties of bermudagrass, the most frequent disease-related question I hear is "What can I do about my Spring Dead Spot?" As most who have managed bermudagrass know, spring dead spot (SDS) is the most common and damaging disease of bermudagrass (Figure 4.). Not only is the disease highly unsightly, but a severe patch can be depressed to bare ground, often half an inch or more below the surviving turf stand. This can play havoc on playability and increase the chance for athlete injury.

For decades, a standard recommendation for suppressing SDS has been to use ammonium sulfate as a primary nitrogen source throughout the summertime. This was based on research on one of the pathogens, *Ophiosphaeralla herpotrica*, which is most commonly found throughout the Great Plains and other Midwestern states. The general belief was that all species of the causal agent (there is also *O. korrae*, most common in Southeastern US, and *O. namari*, most common in Australia and New Zealand) would respond the same to nitrogen sources. However, research from the turfgrass pathology program at North Carolina State clearly demonstrated that *O. herpotrica* and *O. korrae* responded differently when clean bermudagrass was inoculated. *O. herpotrica* responded as expected, and was suppressed with ammonium sulfate. *O. korrae*, on the other hand, did not respond to this, but did to calcium nitrate. While the impact on disease activity is not fully understood for each species, we do know that sulfur-based nitrogen sources will lower pH in the upper rhizosphere, and most nitrate sources have little effect on pH.

Because of the widespread problem for turf managers in Virginia, field research trials were initially established on sites with severe SDS epidemics in the spring of 2010 to see how quickly this new guideline may reduce disease. Trials were established on one soccer field (Southwestern Virginia), two golf course fairways (Central Virginia and the Eastern Shore), and one research plot at the Hampton Roads AREC in Virginia Beach. Plots with pre-existing SDS were fertilized with ammonium sulfate (21-0-0), calcium nitrate (15.5-0-0), or soluble urea (46-0-0). Two additional management strategies were applied to test confounding effects of nitrogen source. Plots were split to test whether fall applications of fungicides can speed the recovery of SDS. Interaction with late summer vertical mowing was also examined.

While the NC State research showed dramatic results for new patch development, incorporating various nitrogen sources into pre-existing conditions in our trials has not

Table 2. White grub counts in 2011 Turfgrass Soil Insecticide Efficacy Trials, Tazewell Co., VA.

Treatment/Formulation/ Application Timing[1]	Application rate (amt product/acre)	White grubs per sq ft (± SEM)[2]
Untreated check	—	24.13 (3.48) a
DPX-HGW86 20 SC April	8.0 fl oz	23.25 (5.22) a
Merit 75 WP April	6.4 oz	22.00 (4.26) a
Zylam 20SG July	32.0 oz	19.00 (3.42) ab
Allectus GCSC April	4.5 pints	9.00 (1.63) b
Acelepryn 1.67 SC July	8.0 fl oz	2.00 (1.08) c
DPX-HGW86 20SC July	8.0 fl oz	0.75 (0.48) c
Acelepryn 1.67 SC April	8.0 fl oz	0.00 (0.00) c
Merit 75 WP	6.4 oz	0.00 (0.00) c

1Early application: 20 April; late application: 19 July

2Means within a column followed by the same letter are not significantly different at $P < 0.05$ according to LSD tests.

reduced disease as rapidly. To date, results from site to site have been highly inconsistent, but no fertility regimen in combination with other management strategies has proven to be a silver bullet. What appears to be effective in one plot may have little to no response in the next. This inconsistency led to us to wonder whether each site had mixed populations of the SDS pathogen. If both species of *Ophiosphaerella* are present at one site, then no one nitrogen source would suppress the disease. One of the treatments included both ammonium sulfate and calcium nitrate, but this still has not adequately suppressed disease. While the current research will continue for at least 1 more year, we are shifting our primary focus to understanding the population dynamics across the state and within a given field. In collaboration with the Plant Disease Clinic at Virginia Tech, we are working to develop a rapid identification test that will allow turf managers to know what is causing the majority of their SDS problems. While SDS suppression strategies are still evolving, we are growing increasingly confident that our work will improve sports turf managers' ability to make well informed and site-specific management decisions.

WHITE GRUB CONTROL - Rod Youngman. Dr. Youngman is an extension entomologist with statewide responsibilities in integrated pest management in turfgrass, field corn, and forage crops.

White grubs have been the major focus of my applied research and extension outreach programs in Virginia. These root-feeding larvae feed on all of Virginia's sports turf grasses from mid-spring until killing frost, but they cause the most damage on cool-season athletic fields during the heat of summer. Damage from a heavy infestation of grubs is often made worse by the burrowing of foraging animals and birds such as skunks, raccoons, and crows. The damage can literally make fields unfit for play due to the surface damage and the subsequent poor footing of damaged turf (Figure 5).

The results of this research (Table 2 indicate several important findings regarding chemical grub control. The mid-April applications of the experimental DPX and Merit 75 WP (imidacloprid) treatments did not perform well, but at the late application (same rates) they ranged among the top performers. DPX-HGW86 is being positioned as a rescue treatment by its company. Although the traditional grubicide Merit no longer has the staying power (April-August white grub control) it once enjoyed, the performance of its July application is directly in line with the white grub life cycle. White grub egg-laying typically begins mid-July and peaks the first-second week of August in our area. Acelepryn (chlorantraniliprole) provided excellent grub control in either early or late season applications; the season-long grub control from its April application and its additional control prospects for turf caterpillars makes this a very promising insecticide for many turf uses.

>> **FIGURE 5**. Damage to a Kentucky bluegrass/perennial ryegrass athletic field from skunks foraging for white grubs.

In addition to continuing work in this area, we have also started evaluating entomopathogenic fungi and nematodes as biological control agents against annual white grubs. If successful, these combinations might greatly expand our options in biological grub control.

DALLISGRASS CONTROL IN BERMUDAGRASS - Jeffrey Derr and Adam Nichols, Hampton Roads Ag. Res. and Ext. Center. Dallisgrass *Paspalum dilatatum* is a warm-season perennial that spreads by short rhizomes as well as by seed. Dallisgrass clumps expand over time due to rhizome growth. Its wide blades and tall seed heads make the weed especially apparent in bermudagrass turf. Dallisgrass is a troublesome perennial grass in a number of turf situations, including sports turf. It invades both warm and cool-season turfgrass, where there are limited control options. MSMA, the most commonly used herbicide for dallisgrass control, currently can only be used in golf courses, sod production, and rights of way areas. It is unclear what turf labels will exist for MSMA in the future. Additional control options are needed for this weed in turf.

We have been investigating herbicides, herbicide combinations, and herbicide application timing for dallisgrass control in bermudagrass. The herbicides tested include Revolver, Celsius, Tribute Total, and Monument. We have included MSMA for comparison. All of these herbicides will injure dallisgrass, although this weed will recover from single applications. Label restrictions prevent making more than two applications per season for some of these products. We have rotated herbicides in our repeat applications to stay within label restrictions. We have tested multiple spring, multiple fall, and spring followed by fall applications. We compared broadcast applications to spot treatment. For certain herbicides, a higher dose can be applied using a spot treatment, although only about one quarter of the total turf area could be treated using these doses.

>> **FIGURE 6**. Dallisgrass is very noticeable in bermudagrass due to its wider blades and tall seed heads.

Two applications of Celsius plus Revolver in spring provided 45% dallisgrass control in summer, but the dallisgrass com-

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Clarifying and magnifying concepts in the pesticide industry

I SAT IN ON AN INTERESTING DISCUSSION at the National Entomological Society of America meeting in Reno, NV in late 2011. There were talks on the uses, advantages and disadvantages of simultaneous pesticide combinations in integrated pest management strategies. Here are some of the highlights:

First of all, the terminology is confusing and certain words mean different things to different people. Let me define a few terms according to the Insecticide Resistance Action Committee (IRAC) before I go too far.

Pesticide combinations: applications of two or more compounds to the same pests at the same time. Specific examples are tank mixes and premixes.

Tank mix: a mixture of two or more products (they don't just have to be insecticides) onsite or on a mix/load pad by an applicator. Each product is often applied at a high labeled rate. Sometimes a "tank mix" may be thought of as mixing one product with water in a tank, but that is not how I'm using the term in this article.

Premix: a commercial product containing two or more active ingredients. At least one active ingredient is usually applied at a lower rate than if used alone. This "premix" category is different from the use of something like water-soluble packaging of a single insecticide.

Why would anyone use a combination of products, rather than just applying one product at a time? There can be pros and cons, either way. The most common reason to combine pesticides is to kill more pests with one application. Many of the newer insecticides have fewer target pests (are "narrow-spectrum") and may have different routes of entry (contact vs. plant systemic), so if you apply two or more at one time, then you have a more "broad-spectrum" treatment. Other benefits may include reducing transportation costs (if you kill most pests initially, there may be fewer call-backs), like saving on fuel, reducing the amount of packaging, decreasing possible turf injury from repeated traffic or soil compaction and decreasing the spread of disease or pests on equipment. Client satisfaction (at least in agriculture) tends to be higher when mixtures are used, and mixtures may be less expensive than do-it-yourself tank mixes.

Another reason to use a mixture or pesticide combination is to slow down the development of resistance in some pests. However, this is not the typical motivation of applicators, and I would appeal to you to weigh the pros and cons of this when choosing your pesticide inventory. I was amazed that in agriculture, a lot of insecticide mixtures have been used over the last 50+ years—e.g., abamectin (Avid) plus thiamethoxam (Meridian) on pears against psyllids and aphids. The list was so long, I couldn't write down all of the combinations.

Mixing products is not as easy as it sounds. With any kind of mixture, there are some things to watch out for. It is possible to get "**antagonism**" between compounds, which means that the mixture is less effective than when the single products are used alone. There is also the risk of plant damage or "**phytotoxicity**," which is more likely to occur when mixtures are applied to stressed plants (e.g., drought-stress), but separate applications of the compounds would not hurt a plant. And, "**physical incompatibility**" can happen if two compounds or formulations react to each other or physically can't combine (an issue of compatible solubility). The result could be a big glob of goo in your spray tank.

Some cautions to be aware of: Avoid mixing insecticides that have the same "mode of action" or are in the same chemical class. From a resistance management perspective, if an insect is resistant to one insecticide (e.g., bifenthrin), then what good would it do to add another pyrethroid (e.g., permethrin, deltamethrin, lambda-cyhalothrin, etc.) to the mix? There could be cross-resistance within the same chemical class or even across other classes, so you would only be exerting the same selection pressure to the pest. For example, carbamates and organophosphates act essentially the same way on an insect, and pyrethroids and DDT similiarly have some cross-resistance. Hopefully, you remember that a mode of action is how an insecticide acts (e.g., interferes with the sodium channel) at its target site (e.g., the nervous system) within the insect.

Another caution is to avoid using the same mode of action (single product or mixture) against the same generation or life stage of the target pest. This may be easier said than done in the southeastern US, especially Florida and the Caribbean, where we have overlapping life stages of pests nearly year-round. Ideally, one treatment could be used to knock out most of one pest generation, then if needed, you could come back to treat the next generation or whenever damage reoccurs.

Similarly, if a treatment of some product doesn't work the first time, don't keep applying it again in the hopes that attempt #2 or #3 might be more worthwhile. Doing the same thing over and over again when you know it doesn't work is insanity (and arguably unethical if you're getting paid for the job). Be aware that treating with a brand name product and at the same time with a generic product at the highest labeled rates equals a 2X application, which is illegal. Again, the goal is to reduce selection pressure and use products wisely, not nuke everything. Modes of action can be determined by finding the "Group" number on a product label or by looking up the active ingredients on the IRAC website (http://www.irac-online.org).

The last caution I heard at the meeting was that premixes should not be used unless all components within the product are needed.

ADVANTAGES, DISADVANTAGES OF MIXES

The advantages and disadvantages of tank mixes and premixes were thoroughly discussed at this meeting. For example, commercial premixes have the advantages of being convenient to use, the active ingredient rates are unchangeable, the component rates and formulations are optimized during development, no mixing or stability issues should exist, and at least one component is usually applied at a lower-than-labeled rate. Some disadvantages include the inability of an applicator to change the active ingredients, all target pests should be present at the same time, and premixes may have been designed for specific pests or regions of the US but could be used outside of the optimal treatment zone. From an economic standpoint, premixes may be created by manufacturers as part of a post-patent marketing plan to obtain a licensing extension.

Some advantages of tank mixtures include giving the applicator some flexibility to provide treatments that fit the pest control need at that time, and they help to reduce any excess pesticide inventory that might exist. However, the flip side is that creating a tank mixture is less convenient, it's potentially hazardous to people who are not trained to properly mix products, "homemade" tank mixes may not be as stable as a premix, and the products being combined tend to be mixed at the highest labeled rates.

According to IRAC there are some requirements for a mixture to be considered effective. First, all toxins should persist the same length of time where the mixture is applied. Complete coverage of the treated plant is essential. There should be no cross-resistance between the toxins. In effect, both compounds should each be able to kill the target pest, which is called "**redundant killing**." As turfgrass managers, we are not chemists, and we don't know if only one of the compounds in the mix is doing all the heavy lifting or if there is really a benefit to having both compounds in the mix.

Whether or not mixtures are useful in pesticide resistance management is controversial among applicators, researchers and regulators. Some say that the use of mixtures in resistance management is not supported by either computer models or field experiments, although lab tests can make mixtures appear to work. It is possible that a mixture could incompletely kill multiple life stages of a pest, instead of killing everything it was intended to kill. That means that some bugs still survive, lay eggs and pass on their resistance genes to the next generation.

I asked someone at that meeting if they thought it might be possible to restore the use of a product when resistance levels were really high (like bifenthrin and chinch bugs in parts of Florida), and they pessimistically said that it was too late. I hope that's not true. They also said that resistance management should start **before** field failures occur. So the time is NOW to determine how to delay resistance development in the neonicotinoids like Arena (clothianidin), Meridian (thiamethoxam) and Merit (imidacloprid).

RESISTANCE MANAGEMENT STRATEGY

Okay, so I also had the question of what a resistance management strategy should look like. Should each pest generation only be exposed to one active ingredient? Should all of a species' populations be treated with the same compound at the same time, or should each infested site be treated differently? In lawn care, that is what we do—each lawn is treated differently often by different companies, thereby creating a "mosaic" effect, unless a whole neighborhood is under the management of one pest management company. If property 1 is treated with bifenthrin (Talstar) and neighboring property 2 is treated with clothianidin (Arena), then what happens next? Any surviving insects on either property may find each other, mate and have offspring that can better survive an application of either compound applied alone or mixed together. Almost sounds like a cliff-hanger; we can't predict how fast resistance will develop to another compound in this common type of scenario.

So, what does this all mean? Be good product stewards and help us develop a functional resistance management plan for turf. Implement integrated pest management or IPM. Avoid treating turfgrass unless you absolutely have to, which admittedly challenging for a route-based business. Just because you treat green grass and it stays green after an application does not mean that a product worked—it may mean that no pests were present and causing damage at the time of application. Overuse of products like this is one route to developing product failures down the road. ■

Dr. Eileen Buss is an associate professor, Entomology & Nematology Dept., University of Florida. This article first appeared in the Florida Turf Digest's July/August 2012 issue.

Getting faster turf recovery coming out of winter

Editor's note: *We asked some top-of-their-game STMA members about strategies they employ to help their fields recover from winter more quickly. Here are the questions:*

1. What's your experience with fertility strategies coming out of winter?
2. What's your experience in controlling any winter diseases you've seen?
3. What topdressing materials do you use? Why those particular materials?
4. If you overseed, what's your advice on removing the overseeded grasses?

GRANT SPEAR, CSFM
Athletic Fields Supervisor
University of Nevada, Las Vegas

Winter in Las Vegas typically means dormant bermudagrass fields for 3-4 months. If a field is not overseeded, the bermudagrass will start to slowly grow in March. Fertilizing with a 3/4 to 1 pound N per thousand square feet and 4% Fe in late March or early April following topdressing with sand or better yet, sand with 20 to 30% peat helps to speed things along (the darker the topdressing, the better). Of course longer days and 80+ degree highs and 60+ lows help much more. I have yet to see any disease issues other than physical damage from excessive use of a dormant field when it's wet in the winter.

Overseeded fields behave and are treated differently here. Typically, ryegrass remains green but grows very little for us after mid-November until the end of January. Topdressing with a dark sand helps a little but most fertilizer seems to have very little effect until the days get longer in early February. Late January, I start fertilizing overseeded turf at about 3/4 pound of N per thousand square feet with about 4% Fe every 3-4 weeks until about a month before I want to transition the turf back to bermudagrass.

The bermudagrass base turf is much slower coming back when competing with perennial ryegrass, but by late May it's usually coming back. Depending on field use in May through the end of June we spur the bermudagrass along by controlling the water to stress the ryegrass and lowering the mowing height from 1" to 3/4" or from 5/8" to 5/16" on infield turf. Heavier applications of urea (1-1.5 lbs N per thousand square feet) add to the stress on the rye and speed the encroaching bermudagrass.

If more complete, quick removal of the rye is optimal and adequate time is available for the bermudagrass to grow, transitioning herbicides like Monument and Revolver are the way to go. One week after treatment, I start to hit it with fertilizer again.

JEFF HAAG
Sports Turf Specialist
John Carroll University, University Heights, OH

Currently I try to avoid making any fertilization application in this region until late April so that I don't deplete the carbohydrate reserves I have built up heading into winter for our cool-season grass. If there would be a need to apply any I would try to limit it strictly to recovery areas and not as a blanket application for an entire field.

I do apply a dormant fertilization application to continue to store carbohydrates for the following spring and summer the last week of November. Last year it was applied on November 26.

In this part of the country (outside Cleveland) the main concern is pink snow mold; however, here at John Carroll we do not apply any fungicides to any of the athletic fields. But when I was the golf course superintendent/sports turf manager at Bowling Green State University, I applied a tank mixture of iprodione (Chipco 26GT) and Daconil (chlorothalonil) as a preventive for pink snow mold with great success.

I topdress using a coarse USGA spec sand because the coarser grade allows for better drainage.

Since we have cool-season grasses here at John Carroll we do not have to overseed. When I was at the University of Louisville we overseeded the bermuda fields with perennial rye, and found that the product Katana removed the rye the quickest and with minimal turf discoloration.

CHRIS "BUTTER" BALL
Sports Turf Manager
Gwinnett Braves (GA)

Typically we load up our bermuda with potassium for the winter. We usually apply 1-1.5 lbs of N all winter, typically done with one granular app, supplemented by foliars. In the Southeast it has been rare the last few years that the bermuda has gone totally dormant, in my opinion, which really helps as the weather starts to turn. We start the spring by lowering the mowing heights on our ryegrass, and applying small but frequent amounts of N as soon as the air temp breaks 65-70 and our bermuda starts to show signs of life.

Most of the winter diseases we see in the Southeast are on our ryegrass. Preventative apps of broad spectrum fungicides made starting in late January and early February, usually do the trick. We also are on a phosphate program that has been a large piece of our puzzle the past few years. I also believe it is a must that getting your potassium built up in late summer and all fall is a vital to a healthy transition.

We typically use a sand for topdressing that is very similar to our rootzone base. We are 100% sand and have found a source that matches our rootzone very, very closely. We also topdress with green sand in thin and wear areas as needed. Kiln-dried green sand is a must in our program.

We do overseed, (unfortunately) due to some of the February and March games we play. My philosophy the past 10 years or so has been to go out late and very light with our ryegrass seed. Last year (2011) we were close to 5lbs/M and this year (2102) we are at 4-4.5lbs/M.

We do not take the rye out chemically for transition. We start to drop the mowing heights as soon as possible (late March-early April) typically from 5/8" to 1/2". When our team is on the road for an extended period of time we will often take our turf down to 3/8". We will apply a poly-coated N-P-K granular and really start to pour our foliar program to our turf by spraying small amounts of N every 7-10 days. We also use green pigments as much as possible to draw heat into the plant and start to aerify with small solid tines as much as possible early during transition, while large core aerification is done in June, July, August, and September. Frequent light topdressings also help us push our transition.

TODD TRIBBLE

Athletic Field Superintendent Oklahoma State University

Like most athletic fields in the transition zone we are forced to overseed our bermuda stand with perennial ryegrass. We have to stay fairly lean on our nitrogen inputs on our baseball field in mid-September and October when the overseed is somewhat weak and hasn't yet begun to tiller and mature. During this time we supplement once a week with a light foliar application until November. As soon as fall practice is over the first of November we push out a starter application of 18-24-12 at 0.75lbsN/1000.

Our other go-to product when the soil temps begin to drop to the upper 50's at a 4" level has always been an IBDU product at 1.5 lbsN/1000. This is a can't-miss product for us here. It is perfect for cool season grasses such as rye as it is slowly soluble and the release is based on moisture availability, not temperature or the activity of microorganisms. Usually we will come back 8 weeks later at 1lbN/1000 of the same product to get us through the end of February when our soil temps are warm enough to use more conventional fertilizer methods such as ammonium sulfate.

If I see a 4 or 5 day window of warmish weather for Stillwater during January or February (mid-upper 60's) we will usually go out at light rates (.25-.33lbsN/1000) of a soluble product to give our rye a quick kick of growth and allow for some recovery from the daily practices and games. Unfortunately, after this winter draws to an end we will be forced to find a different slow release source that mimics IBDU as it is more or less unavailable to us now. Beyond the end of February, we use a 13-2-13 at 0.75lb rates to help with repair and color maintenance until early June when the season comes to an end. We know that with fairly low nitrogen rates for that 7-month time frame our team is playing on rye we can keep growth where we need it[DASH HERE]not too lush but still be able mow each day and remove some tissue.

We have been fairly fortunate here in Stillwater to not have great winter disease pressure. We do get snowfall each year but in all years but one it has burned off within 4 days or so. In the winter of 2010 we did get 9" of snow and in our right field corner at baseball snow drifts piled up 3+ feet of snow. It took about 2 weeks of good temperatures for this to burn off and we did see some light instances of snow mold. Consequently, I will only spray preventatively for snow mold if we have a storm coming that will blanket us fairly heavily with snow and the 10-day forecast does not allow for melting. In such cases I will use a chemical with a combination of the active ingredients chlorothalonil, propicanozole and fludioxonil before the storm arrives.

The practice of topdressing is important for many reasons, including quicker recovery from turf injury/damage, enhanced overseed, thatch decomposition, and smoothing out our playing surfaces. We are always sure that the material we use is of a similar or slightly coarser particle size than our overall rootzone. If you really want to take a sci-

On our other fields I also consider how aeration will mix the existing soil and topdressing material as not to upset the rule of thumb; coarse materials over fine equal positive drainage.

entific approach to it, test the percolation rates of your field as is, then test your proposed sand. If the sand from the supplier drains at a faster pace than what your current perc rates are, that might be a good option for a topdressing material; just make sure it isn't too course so that it can't be worked into the turf canopy with a mat.

A particle size that is finer than what was used at the time the fields were built can lock up pore space, decreasing air, water and gas movement, impacting the availability of nutrients due to roots hitting a "physical barrier" in the rootzone, and create compaction issues over time. Obviously for us, it is important to find a USGA spec type sand that fits our needs and is not much more expensive per ton than a local, "dirtier" type of masonry sand. We recently built a new 4-acre football complex and are lucky enough to get our sand from the same plant as the one who provided the rootzone mix at time of initial construction.

Certainly we overseed in Stillwater with our being in the transition zone. Each year we use perennial ryegrass to keep our softball, soccer, and baseball fields green for the late fall/winter/spring months. As soon as the season ends for each sport we immediately (day after) eliminate the stand of rye chemically with the active ingredient foramsulfuron. We are fortunate in the fact that our coaches understand our urgent approach to ryegrass removal. Our camp schedules in the summer are usually played on a weaker stand of bermuda as it recovers from the smothering of the overseed. Like most turf scientists have included in their presentations, the importance of having as close to a 100-day time frame of having a healthy stand of pure bermuda cannot be overstated.

For our baseball field specifically this can be a difficult thing to accomplish with the season extending into June. The past two seasons we have regularly maintained our rye at 0.75" but dropped to 0.625" when the team is out of town. This imparts some stress on the rye for that time period and we hope that our permanent stand of bermuda can jump in and slowly overtake the rye in May. During this same time we begin to up our nitrogen inputs to further encourage the bermuda to take off. These two practices certainly do not lead to a 100% stand of bermuda and probably never will but it does allow us to cheat a little before June 5 spray out time. Rye that isn't removed simply hangs on all summer in clumps and alters the uniformity of the bermuda.

AMY J. FOUTY, CSFM
Athletic Turf Manager
Michigan State University

The fall and winter in Michigan can be very different from year to year. Over the years I have changed my fertility strategies to best match the changing environment. I have gone away from late fall applications of fertilizer and typically wait to fertilize in the spring time until the soil temperatures averages 50 degrees. Fifty degree soil temperatures signify that the ground will most likely not freeze again and that the turfgrass plant is beginning to actively grow. We often get periods of rains and warm spells during the winter months that unthaw the ground; by waiting I feel that we do not waste our fertilizer or money. As far as the type of fertilizer we use in that first application I like a quick to medium release to quickly green up the turf and start the rejuvenation process for the plant.

We use a combination of cultural practices and chemical applications to control winter diseases. We typically do not push the bluegrass with a lot of N in the fall. I believe that the plant can better store carbohydrates using this fertility method and prepare the plant naturally to defend against the winter if I am not pushing shoot growth. Second, we try to solid deep tine aerate the fields that we need to get out on the earliest in the spring so that the soil and plants have the healthiest environment possible through the winter months.

Diseased areas are often low light areas or compacted soils that do not drain well, so we try to alleviate these issues as best we can by opening them up in the late fall. Finally, at the end of our fall season we typically make preventative snow mold application. I like to wrap these applications up the last week of November.

The type of topdressing materials that we use is based on the existing soil structure in each of our facilities. For example, we have an engineered sand system in Spartan Stadium that we have matched sod and soil to, and then in 2010 engineered topdressing material for as well. It is all based on the distribution of the particle size of our soil test to maintain positive drainage and air movement through the soil structure.

Finding the proper balance of fines, medium, and course particles is critical for stability and drainage. Basically it equates to 95% well graded sand and 5% silt and clay in the stadium. On our other fields I also consider how aeration will mix the existing soil and topdressing material as not to upset the rule of thumb; coarse materials over fine equal positive drainage.

In our northern climate we typically overseed year round with Kentucky bluegrass seed mixes on the fields just before events, camps, and rentals for the athletes to work in the seed. We have had great success over the years just sticking with the Kentucky bluegrass. The only fields that receive any rye/Kentucky bluegrass blends of seed are our practice fields in the fall. The winter weather typically desiccates the rye for us so there is no need to chemically remove it. We start again in the spring with straight Kentucky bluegrass.

JOHN WATT, CSFM
Athletic Field Manager
North Kansas City Schools

My best results of turf quality coming out of the winter come from applying a pound of nitrogen that is quick release in the late fall. Then in late winter months, end of February, we apply ½ pound of nitrogen to kick start the bluegrass. Three weeks later, when soil temperatures warm up, apply the ½ pound of nitrogen to continue growth and recovery from spring sports. At the K-12 level, spring sports season is very short, so we need to start as early as possible to get the grass growing for quick recovery.

My budget doesn't allow for a preventative fungicide program, so I try to stick to cultural practices going into the winter months. My crew and I use growth blankets as much as possible. We focus in areas that can be prone to winter disease or where there is a low threshold for thin turf when spring season starts up, for example soccer goal mouths.

I usually use a 90/10 sand:peat mixture. I choose this for ease of application and addition of organic material into the native soil.

We don't overseed.

VINCE HENDERSON, Park Services Manager
JASON MELTON, Sports Turf Manager
Henrico (VA) County Parks & Rec

We are 100% warm season turf and since we are in the transition zone we try to be patient with our nitrogen fertility on overseeded and non overseeded fields. We overseed mostly for color on our baseball fields and for early season tournaments on soccer fields. We start fertilizing these fields when we begin mowing and typically use a water soluble fertilizer such as ammonium sulphate or urea with a urease inhibitor at .25 -.50/ lb per 1000 rate. We are even more patient with non overseeded fields due to the possibility of a late freeze. Very mild winters usually lead to early green-up of these fields, but a late heavy frost or freeze can really hurt these fields if they are too lush. We really take a wait and see approach to these fields. Sometimes we may get into April and need to push them a little, but more often we try to wait until the grass wants to grow.

The only major problem we have with disease has been spring dead spot on our baseball stadium field. We have had mostly good results in using fenarimol (Rubigan) at split 4 oz/1000 rates. The best timing for the applications has been late August or early September and then again 4 weeks later. Going forward, Rubigan will not be available, so we will have to use an alternative fungicide if we decide to continue with fungicide applications.

Another way we have tried to combat this problem is the use of nitrogen sources. Calcium nitrate seems to help, but we cannot be sure if it is the fertilizer source or the fungicide applications or a combination of both that has helped. We have tried to use information from Dave McCall at Virginia Tech and research done by Dr. Lane Tredway at North Carolina State to combat this problem.

Over the years we have mostly used sand to topdress our fields, but we have moved more to using compost on all of our fields except our sand-based stadium field. The sand-based field is topdressed with a matching sand when we core aerate. We do not use compost on this field so that we keep from creating a layer that will inhibit drainage.

On our native soil fields we try to incorporate .25" of compost with some type of cultivation process, whether it is core or solid time aeration. We have seen a great response with using compost in early spring to promote growth and enhance color and believe that over a period of time we will create a better soil structure. We have also found that topdressing compost in conjunction with sprigging has really helped our grow-in process.

We started using compost due to a recommendation by Dr. Andy McNitt at Penn State when we renovated a native soil field to improve soil structure and drainage. This particular renovation required 2" of compost be tilled into the top 8" of soil. The results were excellent, so we have since incorporated this into our cultural practices.

It is important to note that we have found an excellent source for compost that is clean of sticks and debris and is easy to spread and also free of weed seeds due to their composting process. The cost of compost has also been cheaper than sand. The truth is that with the number of fields we maintain (81 irrigated fields) we don't have enough time to topdress as much as we would like.

This question really depends on the type of weather we have. Our perfect scenario would be to scalp the rye and turn off our irrigation systems for a week or so and let Mother Nature take care of the rest. This also works well with some type of cultivation process such as slicing. If it is a cooler-than-normal spring and the ryegrass is thriving and the bermuda is lagging a little we may wait a short time, but then use a chemical application to reduce the competition between the two grasses.

Another factor to consider is if we will need to sprig or repair worn areas of a field that has been overseeded. In this case, we must be careful to plan the chemical application accordingly in case a window of time is needed. We have typically used trifloxysulfuron-sodium (Monument), because we are also able to control sedges and some broadleaf weeds if needed. We try to use as few chemical applications as possible.

SHANE YOUNG, CSFM
Grounds Supervisor
Prince William County (VA) Park Authority

I don't fertilize warm or cold season turf until my pre-emergent app in early April.

Since being in my current position for past 12 years, I have only seen spring dead spot on bermuda. It usually it grows right out of it.

I don't topdress my bermuda soccer fields anymore because the reward wasn't worth the cost.

I overseed my bermuda and let it transition out naturally. I use transitional rye though. ■

Use earthworm castings tea for better turf

HOW CAN EARTHWORMS BE BENEFICIAL TO US AS TURF MANAGERS? We know of the natural aerification that takes place from earthworm activity in the soil, ultimately opening up pore space for root growth and improving water and oxygen movement, but is there any other way that we can benefit from these slimy creatures? It turns out that through a process called vermicomposting we can potentially reap countless advantages in making turfgrass more stress tolerant while improving soil structure while reducing dependence on chemical and pesticide use.

Vermicomposting is an organic process used to convert agricultural and other waste into valuable living soil amendments. The end result of the vermicomposting process is the production of earthworm excrement, referred to as castings. These castings are packed with beneficial nematodes, protozoa, fungi, organic matter, plant growth regulators (humates and fulvates), plant growth hormones (IAA and gibberellins), and soluble nutrients (N, P, K, Ca, and Mg).

Organic matter serves as a storehouse for nutrients in the soil.

SOIL NEEDS ORGANIC MATTER AND MICROBES

To fully understand the benefits of worm castings, it is best to first comprehend the need for sufficient organic matter and healthy microbial activity in the soil. Organic matter serves as a storehouse for nutrients in the soil. Unlike soluble synthetic fertilizers, the nutrients stored in organic matter and microbial bodies do not easily leach out. The organic matter forms aggregates with fungus and other beneficial bacteria making it difficult for nutrient leaching from heavy water movement through the soil profile.

The diverse addition of microbial life to the plant's leaf surface and rootzone has many benefits, but perhaps the greatest and most direct benefit comes as a population addition to the soil food web. This addition helps to maximize a continual cycle of breaking down and releasing nutrients into plant-available forms accessible to the roots. As bacteria and fungi feed on organic matter in the soil, they store nutrients within their body while releasing others. Then as nematodes and protozoa in turn prey on them, nutrients are released from the bacterial and fungal bodies into the soil in a plant available-form ready for

Worm image ©istockphoto.com/knorre

>> **THE BEGINNING** of the brewing process—the straining bag of worm castings is placed in water.

root uptake. When organic matter is fed to the soil, the microbial life then feeds nutrients to the plant.

BENEFITS OF WORM CASTINGS

Nutrient Cycling and Retention: As mentioned earlier, aggregates formed from microorganisms within the soil greatly reduce nutrient loss, ultimately reducing groundwater contamination. Less nutrient leaching, coupled with a healthy microbial population unlocking nutrients already in the soil, leads to a lessened need for the quantity of fertilizer output.

Microbial Diversity: The addition of an incredibly diverse population of microorganisms from the worm castings helps maximize the productivity of the soil food web.

Water Retention: As the amount of organic matter within the soil increases, so too does the water holding capacity of that soil.

Disease Suppression: Spraying worm castings tea populates the soil and leaf surface with an exorbitant amount of microbes all searching for a food source to survive.

>> **LEFT:** The middle of the brewing process. The foam indicates good microbial activity in the tea.
>> **RIGHT:** This is the finished solution with a tea bag in the foreground.

This diversity ensures that all of the organisms have a predator in the soil; because of this, no one organism can easily reach populations high enough to cause damage of any significance. Working symbiotically with the plant's roots system in this way helps to eliminate harmful molds and fungi from inoculating the plant's surface.

Worm castings don't do miracles against all plant disease; however, research completed by Dr. Norman Arancon and Dr. Clive Edwards at Ohio State has shown that worm castings suppress *Pythium ultimum* and *Rhizoctonia solani* diseases. Further research conducted by the Plant Sciences Department at Cornell University shows that the beneficial microbes colonize seed surfaces masking the chemical signaling needed for the pathogen to locate the host material.

>> **THIS IS OUR BREWING SET-UP** with the air compressor in the middle of the four containers and PVC piping branching off of that.

Insect Control: Worm castings are rich in chitinase, a chemical that decomposes the exoskeleton of insects. Many researchers believe that its presence in the castings prove inhibitory to many damage-causing insects.

Plant Available Nutrients: Worm castings provide soluble nutrients to the plant. The nutritional analysis can vary depending on the food source during the vermicomposting process, but generally the castings have around 1-3% N, .5-1% P, and 1-2% K. These levels are low, but they are immediately ready for plant uptake.

>> **CLOSE-UP** view of the dry worm castings.

APPLICATION PROCESS

Worm castings can be applied a couple of different ways. Like any compost, the castings can be spread in a finely ground, dry formulation. Dry application would be more useful in a situation when it could be added directly to the soil profile during a renovation or construction.

When applied to the plant, the best and most cost effective application method is by making a tea from the castings. Much like making a pot of tea at home, the concept of this tea is to simply use water to extract all of the "good stuff" from the worm castings into a liquid solution that can easily be applied. This process can be done two different ways: extracted or aerobically brewed. Aerobically brewed teas require more time to produce, but the end product is a solution with exponentially higher microbial populations than that of extracted teas.

This aerobic tea brewing process is fairly simple, but it does require some time, attention, and know how. A variety of brewing containers and methods are available and can be used; however, a key point to keep in mind when producing the castings tea is that because the tea is a living solution, oxygen and a food source must be continually available to the microorganisms in the tea for survival and maximum population growth.

During the STMA Conference last year in Long Beach, CA I sat in on an educational program presented by Leif Dickinson about his practices with growth regulators on his bermudagrass at Del Mar Thoroughbred Club. During the presentation he mentioned his use of worm castings tea brewed with alfalfa to jump start his turf out of large patch symptoms in the spring time. Our field had experienced large patch the previous fall, so this concept caught my attention. I began looking for any additional information or research anywhere about the benefits or drawbacks from the usage of worm castings tea on turfgrass. What I found was a wealth of success stories from gardeners, crop producers, and the greenhouse production industry, but nothing more documenting real success on turfgrass. After reading all of the different uses and benefits, I came to the realization that once you strip everything down, growing quality turfgrass isn't really that much different from growing other crops, so I decided to give brewing an aerobic castings tea a try.

For the brewing system I retrofitted an air bubbling system off of a 10-gallon air compressor we had sitting around. We began spraying in mid-March as our bermudagrass had begun coming out of dormancy. My intention was to make three applications on 2-week intervals with my last application coming in mid-April; instead I got hooked on the results we were having and continued spraying on the bimonthly interval schedule for the remainder of the growing season.

OBSERVATIONS FROM TRIAL AND ERROR APPROACH

• Because our field displayed the visual symptoms of large patch in the fall, I naturally anticipated those same areas to appear as the field broke dormancy in the spring. When the turf woke up from the winter, the infected areas from the previous fall where nowhere to be found.

• I was amazed how well the "usual suspect" wear areas handled traffic throughout the year. Even before the bermudagrass season really kicks into gear, the turf dealt with our 18 high school game, pre-Lookouts season slate with ease. From my observation, this improved wear tolerance continued throughout the 2012 season.

• Even though we had a substantially drier summer, two different observations I made this year can speak to improved water retention in our soil. First, we did not have an occurrence of fairy ring, which the field had experienced the previous six seasons.

Our fairy ring symptoms are the result of the inability of water to penetrate through the hydrophobic tendencies of the thatch layer, ultimately resulting in a plant thirsty for water. Secondly, we dodged having to babysit any dry spots resulting from our deficient irrigation system.

These are only the observations over the course of the 2012 growing season when compared to the previous season. Are these results an anomaly or were they because of a tweak in our cultural and fertility management? I would be naïve to think that these results can be only be attributed to the addition of the worm castings tea, but I do believe when coupled with good management practices, positive results will follow.

>> **BEFORE A GAME** on August 14, 2012.

WHERE TO GO FROM HERE

The idea of turfgrass benefiting from vermicompost is a relatively new concept. Much additional education and research is needed about the functionality of the addition of these microorganisms from the worm castings to the soil; however, our results over the past season indicate that there is a place for castings tea in environmentally friendly turfgrass management practices. Whether it be reducing synthetic fertilizer, pesticides, groundwater contamination, water use, etc., it is becoming difficult to escape ever-growing environmental concerns and restrictions. Because of this, any product or concept that can assist in limiting negative environmental impacts while working in conjunction with our daily management practices should be explored. ■

Joey Fitzgerald is the head groundskeeper for the Chattanooga Lookouts.

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pletely recovered by fall. Applying a single Celsius plus Revolver treatment in spring followed by a single Celsius plus Revolver treatment in the fall also did not provide acceptable long-term control of this weed. Two applications of Celsius plus Revolver in fall, two applications of Celsius plus Revolver in spring followed by two applications of Monument in the fall, or two spring applications of Monument in spring followed by two applications of Celsius plus Revolver in fall are all providing 80% or greater dallisgrass control going into winter, comparable to that seen with multiple applications of MSMA. Multiple fall applications of Tribute Total have injured dallisgrass, but have not provided acceptable long-term control. Injury to the bermudagrass was noticeable but not unacceptable, especially at higher doses, for certain of the herbicides tested, and longer lasting in the fall.

We will be following these trials in the spring to determine if dallisgrass can outgrow the effects of these treatments. With the products available for dallisgrass suppression in bermudagrass, it appears that multiple spring and fall applications will be needed for acceptable dallisgrass control. Applications may need to be timed to spring when dallisgrass greens up and resumes growth in spring, as well as treatments in the fall to weaken the plant going into winter. Adjuvant addition, including ammonium sulfate and methylated seed oil, may also be beneficial in these spray programs.

Those reports come from a few of my VT Turf Team colleagues. I encourage you to also get to know your state or regional college and university turf teams and familiarize yourself with the work that they are doing. You never know when a turf emergency might arise where you could use another set of eyes and ears to help you solve a problem. Your support of these programs makes you a part of the team and teamwork is always a key to success.

*Martin Kaufman, CSFM was to be the new STMA President but when he took a new position last year he was forced to resign per association bylaws so Dr. Goatley agreed to stay on the job through 2013. ■