Micronutrients' role in turf management

» Iron chlorosis on Kentucky bluegrass.

THE NEED FOR ELEMENTS other than N, P, and K in a turf fertility program is highly dependent on the soil. A clay loam soil will be different from a sand-based rootzone. Grass grown on soil with either excessively high or low pH will also have different needs than grass grown on soil with pH of 7. The environment may also play a role. For instance, deficiencies may occur in very wet years.

IRON (Fe). Iron is the micronutrient most likely to be deficient on turf. This generally occurs at high soil pH levels, where Fe changes its form and become unavailable to plants. The deficiency symptoms include a yellow discoloration that is referred to as chlorosis (a lack of chlorophyll). Iron plays an important role in the formation of chlorophyll (the material that gives the plant its green color) and deficiencies are readily visible on the tissue. The application of Fe will generally solve the problem in 24-48 hours following application. A "summer induced" form of Fe chlorosis is becoming more common on turf areas in recent years. This problem occurs as a yellowing of turf that comes on in midsummer and goes away in the fall as temperatures cool. This type of iron chlorosis generally does not respond to normal rates of Fe and may require higher rates of Fe than those usually needed to overcome normal chlorosis. For more information on summer induced chlorosis, see Devetter, D. N. Christians, and D. Minner. 2008. Dealing with summer induced chlorosis of turf. Golf Course Mgt. 76 (5): 123-126.

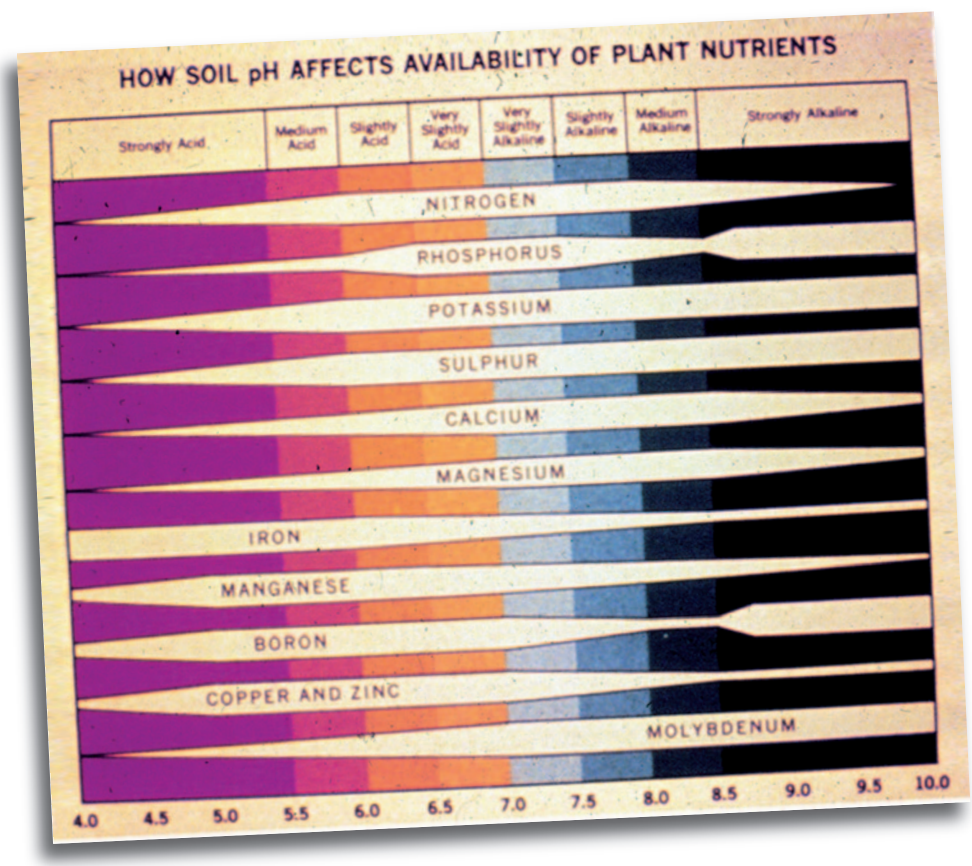
> The symptoms of nutrient deficiencies often overlap and may be difficult to diagnose the problem.

MAGNESIUM (Mg). Next to Fe, Mg is the second most likely element to be deficient on turf. Like Fe, the symptom is chlorosis. Deficiencies in Mg are most likely to occur on grass grown on sandy soil with a low pH, below 7. Remember that Fe chlorosis generally takes place on high pH soils. Magnesium deficiency often occurs during grass establishment on sand-based sports fields. The problem often expresses itself first as a lack of response to N. Yellow grass often occurs during establishment and generally responds quickly to N with a green-up and increase in growth. In this case, however, the grass doesn't seem to respond to N. The application of more and more N does not provide a response. The first thought when this occurs is that there is a Fe deficiency, but in this case the grass does not respond to Fe either. When this occurs, consider Mg next, particularly on low pH sands. The problem can be solved by applying Epsom salts (magnesium sulfate) or dolomitic lime, a product that contain both Mg and Ca. The turf will respond very quickly to Mg containing fertilizers and the establishment process will proceed normally.

CALCIUM (Ca). Calcium deficiencies are rare on turf. Its deficiency symptom in extreme cases is a reddish discoloration of the leaves. This would only occur under very acidic conditions and a simple application of lime (calcium carbonate) is generally used long before actual Ca deficiencies occur. A number of Ca containing products have been developed in recent years to boost the Ca levels of turf. Research conducted at Iowa State has shown that these materials are not needed on turf grown in soils with high pHs. For turf grown on low pH soils, where Ca problems may occur, lime is low cost solution to the problem and these more expensive materials are usually not necessary.

SULFUR (S). Grasses deficient in S become chlorotic, similar to the conditions that develop when the grass is deficient in Fe and Mg. This condition is very rare in most of the United States

» **THE EFFECT** of soil pH on nutrient availability; the wider the line, the greater the availability.



ELEMENTARY GROWTH

SEVENTEEN ELEMENTS are currently accepted to be essential for the growth of plants. This number changes over time. Several years ago, the accepted list included 15. In the 80's and early 90's, scientists accepted 16. By the mid 90's, Ni was added to the list to make 17. A few others are considered to be beneficial to some plants, such as cobalt (Co), silicon (Si), sodium (Na), selenium (Se), and vanadium (Va) and it is possible that some of these may be added to the essential list as more information on their function is gathered.

Most of the plant is made up of carbon (C), hydrogen (H), and oxygen (O). These three elements are obtained by the plant from water and carbon dioxide and are not added as fertilizer. The other 14 are generally obtained from the soil by the root system and are referred to as the mineral nutrient elements. Some may also enter the plant through the leaf or stem when applied in liquid solutions.

These 17 essential elements are usually divided into macronutrients and the micronutrients. The definition depends on the amounts needed by plants to function. Macronutrients are used in the greatest quantities and are generally found in plant tissue in amounts of 1000 parts per million (ppm) or more. Micronutrients are found in plants at levels of 100 ppm or less.

By this definition, carbon (C), hydrogen (H), oxygen (O), nitrogen (N), phosphorus (P), potassium (K), sulfur (S), calcium (Ca), and magnesium (Mg) are macronutrients and iron (Fe), copper (Cu), zinc (Zn), manganese (Mn), boron (B), molybdenum (Mo), chlorine (Cl), and nickel (Ni) are micronutrients. These definitions have nothing to do with importance of an element and micronutrients are just as important to the function of the plants as are macronutrients. The definition refers only to the amount of each element found in plants. ■

because of our use of high sulfur coal. This puts a lot of S into the atmosphere that returns to earth in rainfall. In most regions, plenty of S is provided by rainfall to prevent S deficiencies on turf. The exception is a narrow band along the West Coast where prevailing winds bring in rainfall that lacks S and along the western coast of Florida where the rains come from the Gulf of Mexico. The test to determine if chlorosis is due to S deficiency is an easy one, simple apply an S containing fertilizer. If the turf responds, it was S deficiency. If it does not respond (which is likely), consider Fe or Mg as the cause and do some tests with these materials.

MANGANESE (Mn). A Mn deficiency can result in chlorosis similar to many of the other elements such as Mg. True Mn deficiencies are very rare, however, because of the very small amount of this element required by plants. Deficiencies are most likely to occur on grass grown on soils with very high or very low pHs. This may be a particular concern on sand-based systems, such as sports fields or golf greens. There are Mn-containing fertilizers that can be used if true Mn deficiencies occur. There are also micronutrient "packages" available that contain Mn in addition to other micronutrients that will solve the problem relatively inexpensively.

OTHER ELEMENTS. Deficiencies of other elements, such as Zn, Cu, Mo, Ni, Cl, and B are exceedingly rare and would not generally occur under most of the conditions in which we manage turf. In the rare situations where they do occur, the generally micronutrient "packages" can be used to overcome the problem. Elements such as Mo, Cu and B are more of a concern because of toxicities that can occur if they are present in very high levels. This can happen with B particularly where sewage effluent is used for irrigation. There are also rare conditions in some mountainous regions where Cu and Mo can be present in excessive amounts.

The symptoms of nutrient deficiencies often overlap and may be difficult to diagnose the problem. Soil tests for the micronutrients are generally considered to be of only minimal use in diagnosing the problem. The best way to determine the source of the condition is to do some simple testing on your own. Chlorosis is a common problem and can be due to a number of things. Start with nitrogen. This will generally solve the problem. If it does not, try other things. If the pH is high, it may be Fe. If the soil is sandy and the pH low, it may be Mg. If the problem is caused by an unusual deficiency of one of the other element, a micronutrient solution of several elements may overcome it. Some simple application of test strips of these materials in an out of the way area is the best method of diagnosis. ■

Nick Christians, PhD, is a professor in the Department of Horticulture at Iowa State.

Update on university turf-related research projects, Part III

***Editor's note:** Following are more reports from leading turfgrass researchers in the US on their current studies. Part I appeared in December 2009; Part II in February 2010.*

University of Georgia Tifton Campus

Turfgrass breeding efforts at the University of Georgia, Tifton Campus are focused on the development of stress tolerant cultivars. Recent evaluations using rain-out and shade structures, non-irrigated plots, and reduced fertilizer input have been prioritized. Pesticide applications, including insecticides and fungicides, have been eliminated from routine maintenance programs to aid in the identification of natural resistances or tolerances. Specific germplasm screens have been initiated to develop plant-parasitic nematode resistance due to the loss of the most widely used nematicide and the increased regulations on alternative soil fumigants.

Turfgrass breeding in Tifton has produced broadly adapted cultivars during the last decade that have been licensed to numerous growers in many different countries and planting across the globe. In 2009, TifGrand hybrid bermudagrass was released on the basis of it shade tolerance, mole cricket non-preference, deep green color, fine leaf texture, and plasticity of response to a range of mowing heights. TifGrand has been distributed to a network of sod producers across the US and will become widely available for sale to the public during 2010.

Currently the program encompasses breeding material from the seedling stage to advanced experimental hybrids that have persisted through rigorous testing for more than a decade. More than 40 laboratory, greenhouse, and field evaluations are underway to maintain the pipeline that has provided leading turfgrass cultivars for more than a half century. An example is a promising bermudagrass hybrid that has demonstrated the ability to maintain turf quality 12-14 days longer than currently available cultivars when water is withheld.

Collaboration with other institutions has been important during the past few years and has included work with North Carolina State University, the University of Tennessee, the University of Arkansas, and the University of Florida. A new relationship has been formed with Texas Tech University in efforts to establish a breeding location outside of the southeastern US to test advanced turf bermudagrass and centipedegrass genotypes for increased salinity, high pH, and cold tolerance, stresses not found in Tifton, GA.-Brian Schwartz

University of Georgia Griffin Campus

The turfgrass breeding program at the Griffin Campus is focused on the development of fine turf cultivars with broad adaptation and tolerance to multiple environmental stresses. Our primary focus at the Griffin Campus is the development of seashore paspalum cultivars, but we also have significant breeding efforts on tall fescue and zoysiagrass. Our multi-disciplinary team of turf scientists at the University of Georgia work closely with the breeding programs and include a stress physiologist, plant pathologists, weed scientists, an agronomist, and an entomologist.

The seashore paspalum breeding program is the largest in the world and is focused on the development of improved cultivars suitable for fine turf applications including the golf courses and athletic fields. Thus far, our cultivars, SeaIsle 1, SeaIsle 2000, and SeaIsle Supreme have been well accepted both domestically and internationally. We currently have the largest and most diverse collection of seashore paspalum ecotypes in the world and are now using this growing germplasm collection to generate new genetic variation through recombination. This approach allows us to generate thousands of new and unique individual lines each year that are subsequently screened for salt-tolerance, tolerance to low mowing, diseases, herbicides, and drought.

Superior lines are extensively evaluated for turf quality and performance over a wide range mowing heights and turf conditions for multiple years in replicated turf evaluation trials at multiple locations across the southern U.S.

The tall fescue breeding program is developing cultivars for home lawns and low-maintenance commercial applications with high levels of tolerance to soil and environmental stresses common to the southeastern US. Lines are systematically screened for tolerance to low soil pH, compaction, heat, diseases and drought. The results of these efforts are attractive tall fescue cultivars with good persistence even under the most stressful conditions.

The recently initiated zoysiagrass breeding program is using a similar strategy to that used for the tall fescue breeding program in attempts to develop new cultivars for home lawns, golf, and commercial applications with improved drought tolerance and performance in the Southeast. Our program has excellent resources including laboratories, greenhouses, more that 20 acres of irrigated managed turf area, warm-season and cool season research greens, low pH field plots, and automated rain-out shelters for drought tolerance evaluations.-Paul Raymer

Iowa State University

Seedbank research. Multiple trials are underway to determine the ability of both Kentucky bluegrass and perennial ryegrass to form a transient seed bank. This research stems from previous research at ISU to combat intense traffic scenarios and the commonplace recommendation from professionals to practice continuous seeding to establish a seedbank. We are interested to know if high inputs of seed will equate into bankable seed to perpetuate turf cover during a traffic season. Multiple and single seedings of higher than normal seeding rates are being evaluated. Also of interest is the loss in seed viability over time. Seed of both species have been buried in nylon bags to test both short and long-term viability.

Poa annua. Annual bluegrass has long been a problem for intensely managed golf courses and now it has become problematic in many closely mowed high performance athletic fields. Mesotrione (Tenacity) is a new product that was first introduced for golf courses and sod production but is now labeled for athletic fields in 2010. Mesotrione is foliar and root absorbed and has pre and post emergence activity on crabgrass, some broadleaf weeds, and annual bluegrass. One of its unique attributes for sports turf managers is that it can be applied at time of seeding. Our trials show that it requires the maximum yearly rate of 16 fl oz/A of Tenacity made in 3-6 multiple applications for effective post-emergence control of annual bluegrass. Three applications in October made 10 days apart and each at 5.3 fl oz/A has completely eliminated annual bluegrass. Applications at other times during the year may require 4-6 applications over a 2-week period to reach the recommended annual rate of 16 floz/A. Mesotrione will be a very effective tool in managing annual bluegrass as well as other weeds that compete when establishing turf from seed. Mesotrione turns the affected weeds white and they will be very noticeable on the athletic field.

Fertility and establishment. Recent demonstration trials have shown that it is possible to generate more above ground biomass during establishment from seed with increased nitrogen. Our demonstration showed that 8-10 lb N/1000 ft2 applied to Kentucky bluegrass over 2.5 months in the fall resulted in the highest percentage of turf cover when compared to lower rates applied in the same manner. In the current study, we have established grasses (KB, PR) at one seeding rate per species and four fertility rates to establish 100% cover as quickly as possible before subjecting the plots to simulated traffic the following season relative to seeding time. This study will encompass all possible establishment periods for cool season sports field managers. The first portion of this trial was seeded in April and traffic will start in June; the second portion will be seeded in June and trafficked in August; the third will be seeded in September and traffic will start immediately. Our main goal is to determine how the accelerated aboveground biomass will affect traffic tolerance and which season best fits this establishment strategy.

Earthworms and thatch. Earthworms are known to be major decomposers of organic matter on the surface of the earth. Thatch is constantly degraded by earthworms, leaving no protective layer between the soil and the grass blades to mitigate traffic wear. We are attempting to control/irritate earthworms with Sevin (carbaryl) to minimize surface disruption to the thatch layer. Once different thatch levels are established, simulated traffic will be applied to determine if earthworm control can help increase wear tolerance in a turfgrass system. Recent developments (Dr. Daniel Potter, University of Kentucky) have demonstrated that a by-product of tea tree processing results in a product that is very irritating to earthworms. We will evaluate its potential for managing earthworms and biomass on athletic fields.

Recommended seeding rate (lb/1000 ft2) during the traffic season or during a non-traffic reestablishment period for Kentucky bluegrass, perennial ryegrass, and tall fescue.

	During traffic season	During non-traffic reestablishment
Kentucky bluegrass	6-12	3-6
Perennial ryegrass	30-90	15-30
Tall fescue	30-60	15-30

Calcium products. The roles of gypsum and calcium in turfgrass are often heralded but not well understood on a research level. We are working with Calcium Products, Inc. to evaluate multiple products and their impact on turf appearance, rigidity, soil physical properties, biomass yield, and infiltration rates in a series of experiments.

Bermudagrass in the north. The use of bermudagrass continues to creep north. Bush Sports Turf established a 2000 ft2 section of Patriot bermudagrass on our ISU practice football field in Ames at the STMA Midwest Regional field day in June 2009. It completely survived the winter in both covered and non-covered plots. It is the first time that bermudagrass has survived an Iowa winter and we will continue to monitor its success in this northern climate.

Barenbrug seeding trial. A series of evaluations began this spring with a variety of different species and mixtures from Barenbrug USA. We will be testing spring, summer, and fall as establishment times for the various mixtures and traffic will commence at time of seeding to determine which species, mixtures, and blends are most appropriate for immediate traffic stress.

Results from high seeding rate establishment. Many trials over the last 5 years at ISU have concentrated on establishment of perennial ryegrass, Kentucky bluegrass, and tall fescue in high traffic situations. Our general approach to this type of study is to sow seed in excess of established seeding rates to evaluate if higher seed input results in a higher percentage cover of the intended species at the end of the simulated traffic period. In our study the traffic simulator was used to cleat-in seed and also apply traffic to emerging seedlings during the traffic season. The following seeding rates are recommended to quickly maximize turf cover. Higher rates are needed during traffic because much of the seed is lost to attrition. When traffic is absent, do not exceed the maximum seeding rates suggested or excessive seedling competition will produce weak turf.

Thanks to: Bayer, Syngenta, Calcium Products, Bush Sports Turf, United Seed, and Barenbrug, USA- Dr. Dave Minner and Andrew Hoiberg

Mississippi State University

Dog parks are becoming more popular in communities throughout the US. Most parks start out as a grassed area but many become devoid of grass or the turfgrass stand becomes very thin due to heavy dog traffic. Last spring (May 2009) we installed an experiment to examine different grasses for use in dog parks in the southeastern US. Plots (9 ft x 10ft) of ten different grasses were planted at the Starkville, MS dog park to see how they respond to dog traffic, including the effects of dog urine.

The grasses in the experiment are Tifway bermudagrass, MS Express bermudagrass, common centipedegrass, Raleigh St. Augustinegrass, Sea Isle seashore paspalum, Seadwarf seashore paspalum, tall fescue, Meyer zoysiagrass, Palisades zoysiagrass, Zorro zoysiagrass. At establishment 1 lb of N-P-K was applied from 13-13-13. The grasses were maintained under normal park maintenance and mowed week. Since this was an establishment year, nitrogen was applied at a rate of 1 lb of N per 1000 ft2 per month from 19-0-

19. The grasses established from sod, and dogs were fenced out of the plot area for 2 weeks after the sod was laid. The area was kept well watered for these 2 weeks.

During the first season of observation, all grasses except for the tall fescue performed well. No grass variety was found to attract more dog excrement than any other variety. Dog urine spots occurred in all varieties but none lasted for more than a week. This was a very rainy summer in Starkville and the seashore paspalum cultivars had some problems with disease, but the grass did come back when the disease pressure lessened. The plots were not located in very high traffic areas of the park and it is doubtful any grass would hold up well in these areas, such as along the fence, and near the gate areas.

The fall of 2009 was one of the wettest on record in Starkville and soil at the site remained saturated for much of this period and the winter of 2009-2010 had some of the lowest temperatures we have seen in the last decade. In the spring of 2010 it appeared that some plots of centipede grass and St. Augustine grass had not survived the winter well. All the rhizomatous warm season grasses tested survived the winter with more than 50% cover of the intended grass on May 15, 2010.

Plots of these grasses were also established on our research farm for a more controlled test of the effects of dog urine on grasses. That experiment will be conducted this summer.-Dr. Barry Stewart

Virginia Tech

Seeded bermudagrass blends have generally been discouraged because of concerns with turf uniformity due to the different morphologies and colors of multiple varieties. Superior cold-hardy varieties such as Riviera have proven to be well adapted to Virginia's climate, but the seed is very expensive and the grass is typically one of the slowest bermudagrasses to establish. What would be the outcome of blending Riviera seed with Common bermudagrass, a low-cost, cold intolerant variety, or Wrangler, a cold-tolerant, slightly cheaper cultivar developed for animal grazing systems? The hypothesis was that the improved Riviera variety would ultimately dominate the stand.

To test our hypothesis, Riviera seed was blended with Wrangler or Arizona Common at 0, 25, 50, 75, or 100 % by weight and seeded at either 0.5 or 1 lb pure live seed per 1000 sq ft in Blacksburg, VA in the summer of 2004. A commercially available blend, Riata (containing 60% Wrangler and 40% Riviera by weight) was also included in the experiment. The plots were maintained at a 0.75 in cutting height (all clippings returned) by mowing twice per week during the active growing season. The plots received a total of 3 lbs of N/1000 sq ft per summer season (1 lb N/1000 sq ft every 4 weeks) each year. No supplemental irrigation was supplied after establishment. Data were collected on % establishment rates, visual turf quality, and spring greening characteristics. At study completion in late summer 2007, all plots were allowed to go to seed in order to measure for visually distinct differences in seedhead heights.

Establishment rates. As expected, the 1 lb/1000 sq ft seeding level tended to provide quicker establishment rates for all treatments in year one as compared to the 0.5 lb/1000 sq ft level, but there were no significant differences in other treatment responses between the seeding levels beyond initial establishment. There were no significant trends in establishment rates for any blend at the 0.5 lb/1000 sq ft seeding level. However, there was a significant linear increase in ground cover as % Riviera increased in R/W blends. As larger percentages of Common were blended with Riviera, plot establishment rates tended to increase, but were only significant at the 1 lb/1000 sq ft seeding level on one date in July 2004. Riviera establishment from seed has consistently been slower than other seeded bermudagrasses in Virginia Tech research trials and led to our hypothesis that blending the fast establishing Common with Riviera could improve establishment and coverage ratings.

Spring greening. As spring greening progressed in all studies, the increase in % Riviera in blends with Wrangler resulted in linear increases in spring greening rate. In addition, significant positive linear and quadratic trends were recorded for spring greening as the % Riviera increased in blends with Common bermudagrass. The spring greening advantage of the more cold tolerant Riviera as compared to Common increases the competitive advantage of Riviera in dominating stand densities of these seed blends over time.

Visual turf quality. Significant linear and quadratic responses in visual turf quality were evidenced at all rating dates as % Riviera increased in R/W blends. Similarly, significant linear trends were evidenced at all rating dates as % Riviera increased in R/C blends, and significant quadratic trends were observed at 2 of the 5 rating dates in 2006 and all rating dates in 2007. The significance of the quadratic trends is that this indicates that treatments containing 50% Riviera by weight are visually similar in quality to treatments that were either 75 or 100% Riviera.

Seedhead height data. All R/C blends had significantly different mean seedhead heights from the 100% Riviera and Common standards, but were statistically similar to each other. All R/W blends had significantly different seedhead heights from the 100% Wrangler plots, and all heights for R/W blends were statistically similar (including the commercially available Riata blend). These quantitative data support the results of the subjective visual quality ratings in indicating that shifts in bermudagrass population over time favor Riviera.

In a transition zone climate, blending an improved turf-type bermudagrass variety that is highly adapted to the transition zone (Riviera) with lower quality, cheaper bermudagrasses (Common and Wrangler) resulted in:

- Riviera began to dominate the blends as early as the second growing season with as little as 25% Riviera in the initial seed blend with Common or Wrangler, resulting in a dense, high quality turf maintained at a 0.75 inch height.
- The Common component of the R/C blends was advantageous in first season establishment rates, but not at the expense of the ultimate goal of Riviera succession.
- Blending Riviera with cheaper seeded bermudagrasses offers the potential for savings of 25 to 75% of seed costs.

Blending superior cold-tolerant varieties of bermudagrass with lower cost, less persistent varieties is a viable grassing alternative for transition zone athletic fields. This strategy puts the likelihood of extreme winter temperatures to work for you in shifting the competitive advantage to the improved varieties.-Mike Goatley, Jr. ■

Sustainability: time to be proactive

Societal, regulatory, and political pressures are steadily moving toward environmental stewardship or "sustainability" for all public and private facilities or businesses; but, how it is defined in these realms can be very diverse. Rather than staying on the sidelines while others define sustainability related to sports turf industry, it is best to proactively address the issue ahead of time. I encourage STMA and managers of sports turf facilities to proactively develop and foster a **"sustainable sports turf management" (SSTM)** program.

Fostering sustainability encompasses: a) development of sustainable concepts and documents, adoption of the concept, and implementation at national, state, and site-specific levels; and b) promoting these concepts in state regulatory and political realms as the best, holistic, science-based management approach available.

While each individual sports facility could develop a sustainable program with associated documents, it is more efficient for an umbrella organization to develop the basic concept and materials that a state sports turf association or an individual facility could use and adapt to their specific situations.

TABLE 1. BMPs for community sports fields related to enhancing water-use efficiency and conservation while considering impacts to all stakeholders.

Alternative irrigation water sources.

Site design for water conservation – determining areas needing irrigation, water harvesting, appropriate soil media, surface and subsurface drainage, surrounding landscape;

Irrigation system design, installation, and maintenance; the water audit assists in these decisions – also since soil surface moisture conditions are very important relative to player safety and field playability a water audit is critical for these aspects as well as water-use efficiency.

Irrigation scheduling.

On-site weather station is present

ET data from weather station is used to adjust irrigation scheduling

Soil sensors are used to assist in irrigation scheduling

Water budget approach is used in scheduling irrigation

Rain shut-off devices are incorporated into the irrigation control system

Grass selection – permanent, overseeded, dormant;

Additional management practices to foster water conservation – cultivation, fertilization, wetting agents, soil modification (topdressing, sand-capping, organic and inorganic amendments) , mowing practices, etc.;

Pest control during drought;

Traffic control measures – site use policies;

Alternative surfaces;

Maintenance facility, buildings, surrounding landscape areas; water conservation measures for these

Education of manager and staff relative to water-use efficiency practices

Developing written water conservation and contingency plans for the facility;

Monitoring and modifying conservation strategies;

Assessing costs and benefits for all stakeholders – includes listing of current and past water conservation BMPs practices for the facility; economic, social, adverse effects on other environmental issues (e.g. loss of cover causing soil erosion). The information collected under item 14 will be used to address the economic, social, and impacts of water conservation measures on other environmental issues under the primary (MAV, 2007)

UNDERSTANDING "SUSTAINABILITY"

Concern about how to manage environmental problems on a site-specific basis is the driving force behind the sustainable development and management. Society expects all enterprises to effectively address any environmental issue that may arise on their site. It is important to recognize that environmental issues can only be successfully addressed by site-specific management and not by one-size fits all bans or edits.

This was the reality that caused the US EPA in 1977 to evolve and adopt the Best Management Practices (BMPs) concept for protection of surface and ground waters from pesticides, sediment, and nutrient pollutants. **The BMPs concept is the "gold standard" management approach for any single environmental issue.** BMPs have been adopted by the turfgrass industry for both water quality and quantity challenges.

Most sites have more than one environmental issue so the Environmental Management Systems (EMS) concept became prevalent worldwide in the 1990s. **The EMS approach encompasses all environmental issues on a facility** where: a) the site is assessed or evaluated to determine environmental concerns that are present; b) for each environmental problem, BMPs are developed to manage it; c) BMPs for all environmental issues are combined together to form the EMS plan and document, and d) management aspects in the BMPs are expected to be incorporated into daily management decisions.

"Sustainable Management System" terminology has increasingly replaced the EMS name in recent years. Essentially, these two concepts are the same, except sustainable management emphasizes a more balanced approach that considers environmental issues plus economic and social aspects. The core concern in either sustainable management or EMS is the environment.

How "sustainability" is defined is critical. Some environmental activists groups define sustainability in narrow terms such as only environmental considerations; or even on a single environmental goal, such as protecting the spotted owl or the California delta smelt; but this leaves out adverse impacts on the economy, society, and even other environmental issues. Sustainability should be defined in the full dimension of potential impacts—**sustainable resource management relative to all the environmental issues at a facility and not just one; economic effects, and society impacts**.

PRIMARY COMPONENTS OF SSTM PROGRAM

While all sustainable programs include environmental, economic, and social components, sports fields have two other unique components – player safety and playability for the sport. In fact, the player safety aspect should be considered the most important "sustainable" issue. Sustainability in all its dimensions for sports facilities entails six components or "site goals":

• Player Safety: player-surface interaction: surface hardness, traction, uniform surface, surface soil moisture, turf surface characteristics.

• Playability for the Sport and Aesthetics: ball-surface interaction: rebound height, uniformity of bounce, smoothness, speed of surface, soil and turf parameters affecting ball; coverage, weeds

• Environmental: water, soil, and energy resources; waste, etc. This is the central focus of all sustainable programs and includes a number of possible issues.

• Economic: viability of community in terms of providing goods and services, ability to attract individuals and businesses.

• Social: community sports programs, community pride and social activities, youth crime. For insight on the importance of economic and social components of a SSTM program, readers the document by MAV (2007) is very comprehensive and directly related to sports fields. Community sports fields SSTM impacts not just the site but the community.

• Aesthetics and Future Use: degree of turf and weed coverage as related to aesthetics and use in the future (i.e., will renovation be needed that may limit field use).

For each of the six SSTM components, it is necessary to develop an evaluation template to assess conditions on the site and arrive at an SSTMP score for each component and for a total overall SSTM score. Except for the economic and social components, a BMPs approach is suggested for use in the evaluation template since these entail site management decisions.

To illustrate, under the Environmental category one of the environmental issues would be water-use efficiency and conservation. To develop a template for water-use efficiency/ conservation, a list of all possible BMP strategies to address water conservation is developed such as shown in Table 1. For each individual BMP strategy, a list of practices that would enhance this strategy is developed that the turf manager would respond to concerning their site, such as the examples given under the BMP strategy No. 4 "Irrigation Scheduling" in Table 1. Reasons for a BMP-based template site assessment approach are: a) a template essentially provides an outline of all possible site management options for a particular goal (e.g., water conservation); and b) by assessing what is the current practices on a scale (e.g., 1 to 5 with 5 being a specific practice is being implemented to the fullest extent possible), it highlights the areas where improvement can be made in the future.

Player safety and playability of the sport has received considerable attention under the term "performance testing" (i.e. site assessment). Performance Testing includes five major areas:

• Surface Characteristics of the Soil: soil hardness; any depressions (level surface, irrigation heads too high or low); slope; soil compaction; traction; shear stress; soil moisture; water infiltration. Soil hardness is the most important factor in both player safety and playability; and it is a function of soil moisture (most important factor), percent clay, soil structure, thatch/mat, and soil organic matter content. Spatial variability in soil hardness should be determined under normal irrigation conditions during dry periods since irrigation water application uniformity, as affected by system design and scheduling, strongly influences soil moisture spatial distribution, and thereby, soil hardness. Soil compaction also affects soil hardness, but it should be determined at field capacity – i.e. to eliminate the influence of irrigation system on soil moisture uniformity. Soil compaction spatial variability is a function of traffic patterns, soil type, and soil structure.

• Traction is the second most important surface characteristic related to player safety and is a function of soil moisture, grass type, degree of coverage, thatch/mat/OM content, soil structure (compaction), percent clay. Soil moisture plays a central role in traction as it does in soil hardness.

• Surface Characteristics of the Plant: grass height; grass uniformity and density; turf type; bare ground – percent; wear patterns; weeds – percent and types; rooting depth; thatch or mat.

• Irrigation (Water Audit) (Two Parts): First, evaluate and maximize system performance, like head to head spacing measurements; malfunctioning sprinklers, nozzles, pressure, head alignment; scheduling settings and capability; irrigation water quality test. Second, evaluate uniformity of water distribution by traditional catch-can assessment; or preferably by soil moisture spatial distribution.

• Irrigation System Maintenance. This was the first part of a water audit; however, there should be a routine means to maintain the irrigation system with responsibilities assigned to the appropriated person. The reason for emphasis on the irrigation system is that surface hardness and traction are most affected by spatial variability in soil moisture in the surface few inches.

• Fixtures and Surrounds: goals, fences, etc; sprinkler placement and maintenance; any safety issue with surrounds.

Performance testing has been by hand-held devices and visual ratings; but researchers are currently focusing on mobile multiple-sensor devices coupled with GPS (global positioning systems) and GIS (geostatistical information systems – a means to visually display and analyze spatial information). Mobile devices allow for using multiple sensors, sensor probes that can be easily inserted into hard soils, and more measurements per unit area with less labor. More detailed mapping (i.e. <10 ft. sample grid) and integration of data with GPS and GIS are critical to: a) define relationships between parameters, especially surface soil moisture and surface hardness and traction; b) adequately determine spatial variability in key parameters; and c) express data and relationships with GIS developed maps (i.e. the show and tell visualization of results).

DEVELOPING A SSTM

To develop a comprehensive SSTM program that can be adopted at state and site-specific levels, key aspects to consider are listed below. Miner recently noted several of these aspects:

• National association vs. state/local. As noted, considerable time and effort is saved if a national entity fosters environmental sustainability and stewardship by developing basic program documents.

• Couple with an environmental group that has environmental stewardship programs beyond the turfgrass industry. They assist in development of the plan and already have a number of BMP-based assessment templates for various environmental issues. Also, these groups can assist in the certification program development (see below).

• Allow multiple levels of sustainable management. Environmental stewardship is an on-going and evolving process that allows a facility to be good, better, and best over time.

• Develop site assessment in a BMP template with BMP strategies for each issue and determining how comprehensive the site BMPs are for the issue. There may appear to be overlap in some areas but that is acceptable since each issue is evaluated on its own.

• Report in BMP Format should include suggested BMPs for each necessary issue to improve. Since site assessment is already in a BMP format, a final report can easily be presented as a BMP document; and when these are combined together, they form the final SSTM program document.

• Use online format for the basic program and as much as possible. Developing assessment tools that can be achieved by online input as much as possible allows site managers to develop their SSTM program over time as work schedule allows. There should be options for types of site assessment that may require outside assistance.

• Couple with academic entities to incorporate a sound science base, as the STMA has done.

• Include certification with multiple levels where there are options for improvement over time. Third party certification is best. By using a BMP-based template for site assessment, it is easy to evolve a multiple level certification program.

• Target governmental agency acceptance to this sustainable approach and the site sustainable plans that evolve. Certainly, at the state level, the state STMA organization may be able to work with the state environmental agency responsible for sustainability in the state. In reality, very few business organizations have proactively developed sustainable programs in cooperation with their state environmental agency. State STMA chapters can take leadership in doing this.

The sustainability emphasis is increasing and will not go away. If there is not a proactive response by each segment of the turf industry, we must accept what others develop, which likely would not include the best environmental management approaches being adopted into laws and regulations. As in sports, spectators do not have much to say about the outcome of the game. ■

Dr. Robert N. Carrow is Professor of Turfgrass Science in the Department of Crop and Soil Sciences at the University of Georgia in Griffin.