Are you getting the most from your granular nitrogen fertilizers?

The N requirement of cool- and warm-season turfgrasses varies among species. Bermudagrass and Kentucky bluegrass usually need more N per growing month than tall fescue and perennial ryegrass.

NITROGEN (N) is the essential mineral nutrient required in greatest amounts by turfgrasses. Although more than 78% of the air we breathe is N2, turfgrasses are unable to capture it from the atmosphere so many researchers, chemists and fertilizer manufacturers spend considerable time and effort every year developing granular N-containing fertilizers for turf.

Some of these are homogenous, with granules having an equal amount of nutrition. Others are blends of several nutrient sources or carriers. Depending on how it is formulated, a fertilizer may release N very quickly or for an extended period of time. Since energy is required to convert atmospheric N to ammonium and nitrate, the forms that turfgrasses use, the cost of fertilizers increases as energy and fuel costs rise.

Knowing how much N a turfgrass requires, how long N is available after a fertilizer is applied, the factors that affect how N is released and the physical properties of a fertilizer helps sports turf managers make informed decisions when purchasing and applying granular fertilizers.

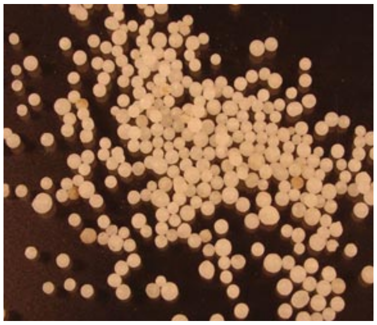
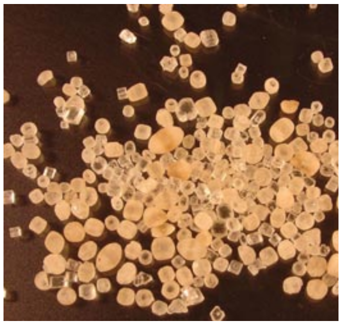
The N requirement of cool- and warm-season turfgrasses varies among species. Bermudagrass and Kentucky bluegrass usually need more N per growing month than tall fescue and perennial ryegrass. For example, bermudagrass and Kentucky bluegrass usually require from 0.5 to 1.5 lb. of N per 1,000 sq. ft. per growing month, and tall fescue and perennial ryegrass, from 0.4 to 1 lb. of N per 1,000 sq. ft. per growing month. This information is helpful when developing a fertilization program and budget.

The chemical properties of the N carrier(s) in a fertilizer influence how, and the rate at which, N is released. Physical properties such as the size and uniformity of granules influence the ballistic properties, and may also affect N release. If the granules contain an herbicide, their size and uniformity may directly influence herbicide coverage and performance.

CHEMICAL PROPERTIES

Highly Water-soluble N Carriers. There are two groups of highly water-soluble N carriers. Inorganic (containing no carbon) salts are synthetic, dry and solid materials formed as N from the air reacts with other materials. Urea, unlike the inorganic salts, is a quickly available, synthetic-organic (containing carbon) N carrier. It is made by reacting carbon dioxide with anhydrous ammonia under high pressure (e.g., 3000 psi) and temperature (~350 degrees F). Water is removed during this process and a molten N-containing substance is converted into small, hollow prills (Figure 2) or solid granules.

Inorganic salts like ammonium sulfate (Figure 3), calcium nitrate, diammonium phosphate (DAP), monoammonium phosphate (MAP, Figure 4) and potassium nitrate

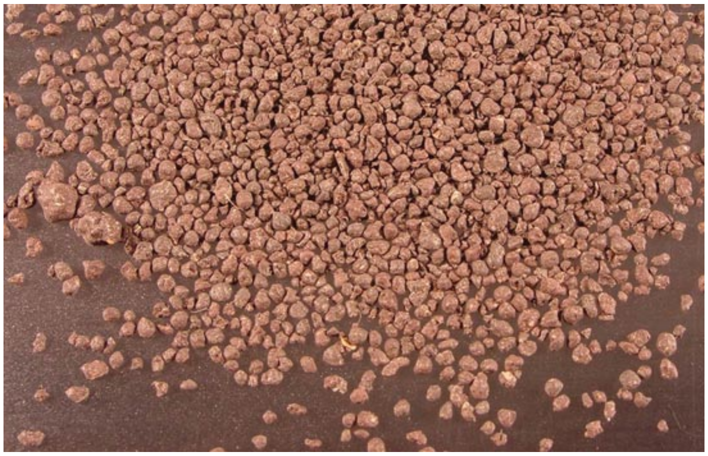

>> **Figure 2.** UREA Prills. **Figure 3.** Granular Ammonium Sulfate. **Figure 4.** Monoammonium Phosphate.

Top left image: Grass image © istockphoto.com/cloki. Nitrogen fertilizer image © istockphoto.com/sb-borg.

have several characteristics in common. In addition to being very soluble in water, N carriers in this group produce an initial rapid-growth response, even at low temperatures; have the potential to burn turf; have a growth response limited to about 4-6 weeks; are prone to leaching in the nitrate form; and are usually less expensive than more highly processed, extended-release N carriers. To avoid fertilizer burn, these N carriers should be applied to dry turf when the air temperature is less than 80 degrees Fahrenheit and at a relatively low rate (for example, no more than 1 lb. of N per 1,000 sq. ft.).

Due to its strong acidifying properties, ammonium sulfate is commonly applied to turfgrasses growing in soils with an excessively high pH (for example, >7.2). The burn potential of ammonium sulfate is greater than that of the other synthetic-inorganic N carriers. Monoammonium phosphate supplies plants with both N and phosphorus (P). Granular MAP contains about 11% N and 52% phosphate. Like MAP, DAP contains both N (about 18%) and phosphate (about 46%). An application of MAP creates an acidic zone around each granule, while the zone around granules of DAP is basic. Potassium nitrate contains about 13% N and about 36% K. The entire amount of N in potassium nitrate is in NO3- form.

Urea was discovered by a French scientist in 1773 and was first



>> **Figure 5.** Activated Sewage Sludge / Milorganite.™

>> **Figure 6.** Urea Formaldehyde.

produced from two inorganic materials, silver cyanate and ammonium chloride, by a German chemist in 1828. Today, urea is used worldwide to fertilize agronomic and horticultural crops, ornamental plants and turf. The N in urea must be converted to NH4+ before being absorbed from the soil by turfgrasses. When broadcast over turf, molecules of urea are converted to ammonium carbonate by hydrolysis (reaction with water). The enzyme urease, which is found in turfs, speeds this conversion and leads to the formation of NH4+and the release of CO2. More than 60% of the total amount of applied urea may be hydrolyzed in 24 hours. Urea is usually completely hydrolyzed within 7 days after a turf is fertilized.

When the soil is warm, moist and slightly acidic (for example, pH between 6.0 and 6.9), soil microorganisms convert NH4+ to NO3- within a few days. Conversely, once inside a turfgrass plant, NO3- is converted back to NH4+, a process requiring energy.

Extended-release N Carriers. Several carriers release N slowly compared to highly water-soluble carriers. These include natural organics with N bound in organic compounds; synthetic organics with urea in short-, medium- or long-chain compounds; sulfur-coated urea (SCU); polymer-coated urea (PCU); polymer-coated, sulfur-coated urea (PCSCU); and carriers with a reactive layer coating (RLC).

Natural organics are categorized as water-insoluble N, or WIN carriers. A natural organic fertilizer may originate from plants or animals. Nutrient concentrations are often low (for example, Milorganite with a grade of 6-2-0 + 4% Iron). About 70 to 85% of the N in natural organics, such as activated sewage sludge (Figure 5), bone meal, composted turkey litter, feather meal, leather meal, soybean protein and spent mushroom compost are in WIN form. The rate of N release from natural organics is influenced by soil moisture, temperature and the activity of soil microorganisms. The rate of release of N from natural organics becomes very slow at soil temperatures below 55 degrees Fahrenheit. Natural organics have a very low burn potential and may release N for 12 months or longer.

Isobutylidene diurea (IBDU) and urea formaldehyde (UF, Figure 6) are examples of synthetically produced, extended-release organic N carriers. Presently, synthetic-organic N carriers receive greater use in sports turf management than natural organics. Because IBDU and UF are produced by reacting urea with other compounds, they are sometimes referred to as reacted products.

Isobutylidene diurea contains 31% N with more than 80% N in slow-release, water-insoluble form. There are no coatings for water or nutrients to pass through. The rate of release of N from IBDU is influenced by soil moisture and particle size, and does not depend on the activity of soil microorganisms. Since the release of N is minimally dependent on soil temperature, sports turf managers may apply IBDU in late summer or early autumn to provide cool-season turfgrasses with N during September, October and November. The release of N from IBDU may last for 12 or more months.

Urea formaldehydes, or ureaforms, are produced by reacting urea with formaldehyde under controlled conditions. The longer these two chemicals are allowed to react, the longer the urea-containing molecule. The longer the molecule, the more C and N it contains, the longer it takes for N to release and the lower the possibility of fertilizer burn.

Theoretically, all of the granular fertilizers formed by reacting urea with formaldehyde are methylene ureas (MUs). However, the fertilizer industry recognizes three distinct groups or classes in a UF fertilizer. The classes MUs, MDU/DMTUs and ureaforms are based on the length of urea chains. Ureaforms have the longest urea chains, MUs are intermediate in length (primarily four- and five-urea chains), and MDU/DMTUs are shorter, having two- and three-urea chains. The release of N from these carriers is affected by moisture, which releases N from non-reacted urea and some of the shorter-chain compounds, and microbial activity, which influences the release of N from longer urea chains.

The ratio of urea to formaldehyde and the activity index are helpful when predicting how N will release from one of these carriers. For example, a fertilizer with a 1.3:1 U:F ratio has about 67% slowly soluble N and 33% cold-water-soluble (77 degrees F) N (CWSN). The CWSN fraction contains non-reacted urea and low-molecular-weight, short-urea-chain compounds. The cold-water insoluble (CWIN) portion of UF is not soluble in cold water.

Hot-water-soluble N (HWSN) is released slowly for a period of weeks. Hot-water-insoluble N (HWIN) is very slowly soluble, so slowly soluble that it may not be available to turfgrasses. The Activity Index, or A.I., is the fraction of CWIN that goes into solution in hot (212 degrees F) water. The higher the A.I. value, the more rapidly N becomes available.

Urea formaldehyde should have an A.I. of at least 40%. Granular UF fertilizers contain at least 35% N with 60% or more N in cold-water-insoluble (CWIN) form. Granular MU fertilizers contain 39 to 40% N with 25 to 60% in CWIN form. Granular MDU/DMTU fertilizers are at least 40% N with less than 25% in CWIN form. Two or more fertilizers containing ureaform, MU and DMU/TMDU can be compared based on their CWSN, HWSN and HWIN contents.

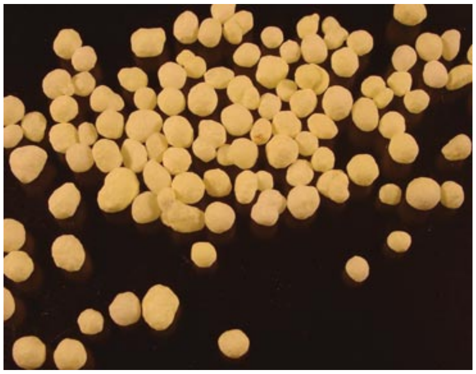
Urea can be coated to reduce its burn potential, and delay N release. Sulfur-coated urea is formed when granular urea is coated with molten sulfur. The Tennessee Valley Authority (TVA) began developing sulfur-coating technology in the 1960s. Pilot SCU manufacturing plants were constructed by TVA in the 1960s and 70s. Several plants were then built in the United States and Canada from 1975 to 1985. Sulfur-coated urea contains from 30-40% N and 10-30% sulfur.

The rate of release of N from SCU is influenced by temperature, soil moisture, coating thickness and the number of granules with broken coatings. If wax has been used to seal the sulfur coating, soil microorganisms also influence N release. The wax coating is degraded by soil microorganisms before N is released. The release of N among fertilizers containing SCU is often highly variable and may last from several days to months. Sulfur-coated urea may cause mottling if the coating is cracked during transport, handling or as the fertilizer is applied. If the sulfur coating is cracked, N releases too rapidly, a condition known as "burst."

>> **Figure 8.** Polymer-coated Urea.

A soil pH range of 6.0 to 7.0 usually favors microbial activity and N release from natural organics, UF and SCU with a wax coating. Since populations of many species of beneficial microorganisms are reduced at low pH, the release of N from these carriers may be delayed in strongly acid soils.

Polymer-coated fertilizer technologies vary among manufacturers. Several materials are used as polymer coatings including polyurethane, polyethylene and alkyd-resin. Depending on polymer chemistry and coating width, temperature and soil moisture level, the release of N from PCU (Figure 8) often lasts from one to two or more months. Unlike SCU which releases N through small, pin-hole-like micropores in the sulfur coating, the N in PCU releases by diffusion through the polymer coating as it swells. Nitrogen release is delayed until water penetrates the polymer coating and begins dissolving the N-rich granule inside. Nitrogen then diffuses out through the expanded polymer coating and is available for uptake by turfgrasses.



>> **Figure 9.** Polymer-coated, Sulfur-coated Urea.

Polymer-coated, sulfur-coated urea (Figure 9) combines both polymer- and sulfur-coating technologies. Sulfur is usually applied to urea before the polymer. The sulfur coating of PCSCU is most often thinner than that of SCU. Similarly, the polymer coating of PCSCU is usually thinner than that of PCU. As a result, PCSCU is often less expensive than PCU and the coating weighs less than that of SCU. The release of N from PCSCU depends on both diffusion and capillary action. For example, Water first diffuses through the polymer layer. Then, as it encounters the polymer-sulfur interface, water penetrates the micropores in the sulfur coating by way of capillary action. Once inside, the urea granule begins dissolving and N makes its way through both coatings.

Reactive Layer Coating, or RLC, is a fairly new technology that creates a very, very thin polymer coating as two reactive compounds are applied simultaneously to fertilizer granules in a "continuous coating" drum. Several N carriers including ammonium sulfate, MAP, potassium nitrate and urea are available with RLCs. The RLC encapsulating a urea granule may weigh as little as 1% of the total weight of the coated urea granule. This process often costs less than several other coating processes and, like PCUs, and PCSCUs, the release of N from RLCs is influenced by temperature and soil moisture.

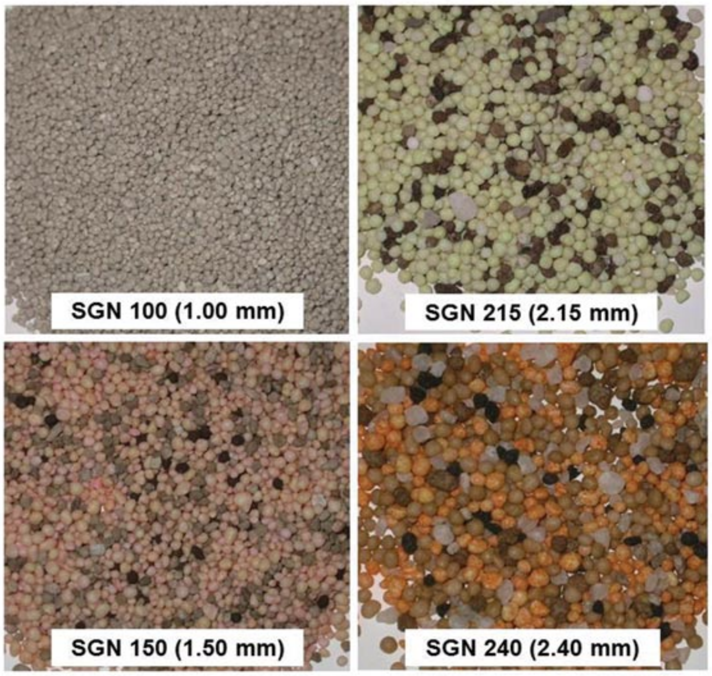
PHYSICAL PROPERTIES

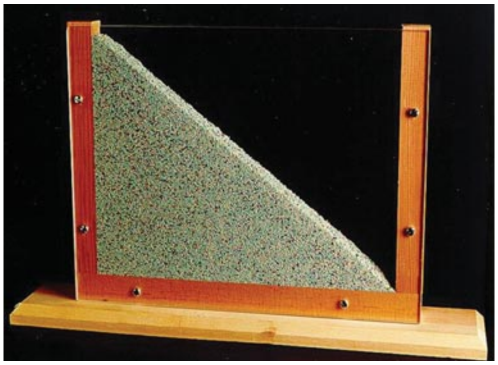
In addition to the chemical properties of N carriers, the size and uniformity of granules deserve consideration when comparing turf fertilizers.

Size Guide Number. The size guide number, or SGN, is a measure of fertilizer quality developed by the Canadian Fertilizer Institute. It represents the average or median particle size diameter in millimeters multiplied by 100. To calculate SGN, the sieve opening (in millimeters) that retains or passes 50% of the weight of a fertilizer sample is determined and is then multiplied by 100. Turf fertilizers often have SGNs ranging from 80 to 280 (Figure 10). Greens fertilizers have a low SGN (for example, 80 or 90) compared to fertilizers formulated for turfs maintained at greater cutting heights with SGNs often ranging from 145 to 230 or more.

Uniformity Index. The uniformity index (UI) is a means of de-

>> **Figure 10.** A Comparison of Fertilizers with Size Guide Numbers of 100, 150, 215 and 240. Photo Credit: Brad Jakubowski.





>> **Left: Figure 12a.** Calculating the Size Guide Number and Uniformity Index of a Fertilizer. **Right: Figure 12b.** Testing for Fertilizer Granule Segregation.

termining how consistent the diameter of granules within a bag or lot of fertilizer is. To calculate the UI, the size of the sieve opening in millimeters that retains 95% (or passes 5%) of the sample is divided by the size of the sieve opening that retains 10% (or passes 90%) of the sample. This fraction is then multiplied by 100. For example, a fertilizer with a uniformity index of 50 contains a range of variable-sized particles with the average small particle being one-half the size of the average large particle. The average smallest size granule in a fertilizer with a UI of 33 is one-third the size of the largest particle. Sports turf fertilizers often have a UI of 40 or more.

Granule Segregation Test. One way to observe the variation in the relative size of granules in a fertilizer is to construct a box 24 in. long, 2 in. wide and 18 in. high from clear plastic (for example, Plexiglas) and wood, and perform a granule segregation test (Figures 12a and b). When fertilizer is poured through a funnel positioned just above the top left corner of the box, larger and heavier granules move further to the right than smaller and lighter granules. For most uniform application, granules in turf fertilizers should be nearly the same size and weight.

By evaluating each N carrier used in the fertilization program in addition to the overall turfgrass quality and field performance from one year to the next, sports turf managers can make sure that they are getting the most from their granular N fertilizers. ■

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Precision Turfgrass Management for athletic fields

PRECISION TURFGRASS MANAGEMENT (PTM) is a new concept for the turfgrass industry; but, it is based on the same principles as Precision Agriculture (PA), which has been evolving since the early 1990's. Both PTM and PA are based on these foundational principles:

• Site-specific management is the first premise of PA and PTM, the application of inputs (water, fertilizer, cultivation operations, salinity leaching fraction, etc.) *only where needed, when needed, and at the amount needed.* The idea is to foster more precise and efficient application of inputs by management on a smaller area basis than the current practice, such as at the single irrigation head area of influence or a sub-area on a sports field.

• "Intensive" site-specific information is necessary to make wise site-specific decisions. Site sampling is across the whole area, not just selected locations, and on a close sample-grid in order to define the degree and nature of spatial variability for all measured parameters.

• Key soil and plant properties must both be measured to allow accurate definition of spatial variability and to allow investigation of the relationships of measured parameters. For example, PA did not rapidly advance until mobile platform devices were developed that could determine key soil factors that could be related to plant data from remote sensing or crop yield mapping.

• Mobile, multiple-sensor devices are necessary to measure multiple factors in a timely manner on a close spacing and across the whole site. Unfortunately, the mobile devices developed for PA are not well-adapted to turfgrass situations, so lack of appropriate devices has hindered PTM development.

• All data are GPS-labeled (global positioning system), which allows the data to be imported into powerful geographic information system (GIS) programs for geostatistical analysis, comparing measured parameters at specific locations, and in order to develop detailed map presentation.

Recently, the Toro Company has developed mobile, multiple-sensor units specifically designed for turfgrass sites that supports several PTM field applications that are discussed later (Figure 1, top). The Toro Precision Sense 6000 device has a mapping speed of 2 mph, which covers about 2.5 acres per hour using a grid of 8 x 8 feet sample grid or approximately 900 samples per high school football field.

Parameters for Performance Testing of Sport Fields

COMPREHENSIVE Site-Assessment parameters that can be determined with mobile PTM devices are noted by a * for currently available devices or with a ** for those with a high potential for a device to be developed in near future.

Soil Surface Characteristics. Each determination should be conducted under two field conditions, namely: during dry period with irrigation system is used; and field capacity such after a rain to produce field capacity conditions across the field.

• Surface hardness/resiliency (Clegg Impact Tester)*
• Surface hardness/compaction. Surface penetrometer (< 1.0 inch)*; deep
• penetrometer (4 inch)*
• Surface levelness. Any minor or major depressions**
• Traction (torsion device with twisting action)**
• Shear strength/stress (divot device)**
• Soil moisture content – surface 0-4 inches*

SOIL PROFILE

• Soil type and clay type
• Soil physical lab analysis
• Profile description. Surface or subsurface layers
• Infiltration
• Surface drainage – slope, contouring patterns (flat field, crowned, pocketed);
• Subsurface drainage – tiles, slit trenching
• Soil fertility tests

TURFGRASS COVER

• Turf type
• Turf uniformity and density**
• Grass sward height
• Stress indice – NDVI (plant density and color; degree of stress)*
• Bare ground – precent, wear patterns*
• Weeds – precent and types
• Rooting depth
• Thatch or mat

IRRIGATION WATER AUDIT

First Phase – system maintenance

• Evaluate and "maximize" system performance
• Determine head to head spacing measurements and effect on water distribution*
• Determine malfunctioning sprinklers, nozzles, system pressure, head alignment, etc. *
• Scheduling settings and capability
• Irrigation water quality test

Second Phase – water distribution (two options)

• Catch-can assessment (traditional water audit approach) – determines water distribution as affected by irrigation system design and performance
• Soil moisture distribution based water audit (i.e., new soil water audit approach) using GPS, GIS, mobile sensor platforms* – determine soil moisture spatial distribution as affected by irrigation system, soil texture/organic matter content, wind, drainage, and any factor affecting soil moisture content.

Fixtures and Surrounds. Factors that may affect player safety.
• Goals, fences, etc
• Sprinkler placement & maintenance
• Surrounds – spatial mapping may be of use in some cases, drainage

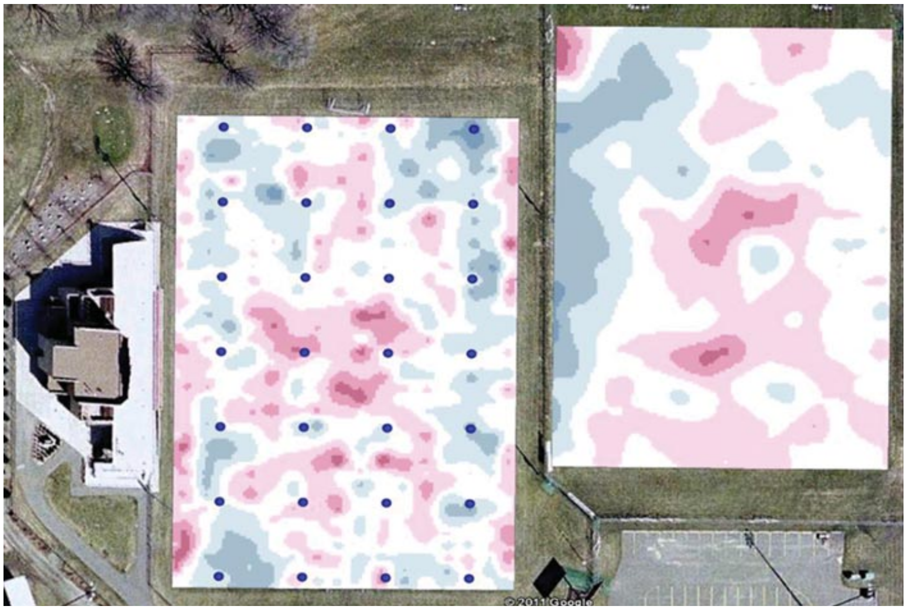
>> **Figure 1. MOBILE SPATIAL MAPPING** devices for sports fields. Top: mulitple sensor device to map soil moisture, salinty, penetrometer resistance, turf quality, and topographic relief. Bottom: accelerometer device that is similar to the Clegg Accelerometer to determine surface hardness (images courtesy of The Toro Co.).

The multiple-sensor device determines several parameters, all with GPS labeling, namely: a) soil volumetric water content (%VWC) in the surface 0 to 4 inch zone; b) soil salinity in the surface 0 to 4 inches; c) surface hardness by penetration resistance as force to insert the probes in top 0 to 4 inch; d) plant performance by normalized difference vegetative index (NDVI), which is a measure of plant density and color; and e) topography slope and aspect at one foot intervals using current GPS data, but more refined topography information is possible with more expensive GPS units. Additionally, a mobile accelerometer similar to a Clegg Impact Soil Tester is in final testing and other measurement devices are in development (traction, shear, surface levelness, etc.) that can be attached to the mobile platform (Figure 1, bottom).

APPLICATIONS OF PTM IN SPORTS TURF

Performance Testing and New Soil-Based Water Audit Applications. An evident application of the scientific methods and protocols of PTM to sport fields would be performance testing, the determination of key surface conditions for various purposes, including: a) assessing current conditions relative to player safety and field playability (benchmarking); b) developing field standards; c) guiding maintenance operations; and d) as a key component in formulating a site-specific, comprehensive "sustainable sports turf management program."

Determining surface standards is not a new research area, but started with considerable efforts in the 1980's and continues to the



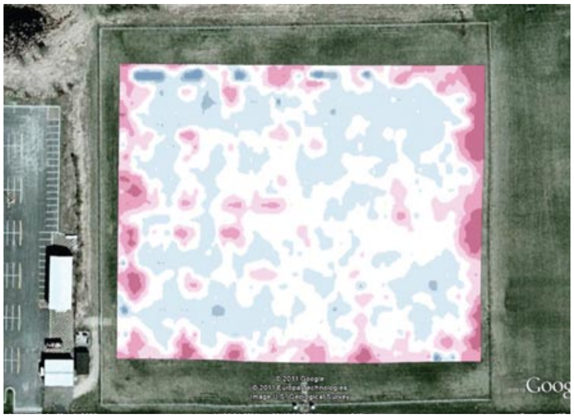
» **Figure 2. SOIL HARDNESS** determined by the Toro accelerometer presented in standard deviation format maps that illustrate the lowest and highest hardness areas in a field. These can often be related to soil moisture and traffic patterns. Blue dots are irrigation heads.

current time. However, in recent times the term "performance testing" has been used to describe assessment of surface conditions of sport fields.

Regardless of the terms used, a common theme of almost all surface characterization research to date has been to sample only 4 to 6 sites on a sports field due to: the necessity of using several individual hand-held instruments to obtain the necessary multiple soil and plant information; difficulty in inserting hand-held instruments into the soil surface; and high labor/time/cost requirements for sampling which precluded closer grid-sampling. These limitations are reflected in current approaches for performance testing such as the PASS system which is low tech but also results in much less information.

An exception of using only a few sample sites is a study by Miller on hardness of soccer fields where an 80 sample grid was used and geostatistical analysis techniques were applied, but only Clegg Impact hardness was measured. There has also been the occasional use of mobile spectral reflectance devices to determine plant performance primarily as NDVI across the whole sport field surface area, but without associated soil data. The PTM approaches and technology provide the opportunity for performance testing to evolve to a more geospatially precise assessment of sports field playing surfaces along with better mathematical treatment of relationships of measured parameters and detailed GIS-based visual presentations in spatial maps (Figure 2).

An overview of the site information obtained in a comprehensive, sports field site-assessment can aid in understanding how PTM concepts and technology can be integrated into performance testing. Henderson and Stiles et al. provide excellent reviews of various hand-held devices that have been used for surface assessment. Of the soil surface characteristics, soil hardness, traction, and shear strength are the most important factors for player safety and playability. Soil hardness as determined by a Clegg Impact Tester or by penetrometer resistance is a function of soil moisture (most important factor), compaction, percent clay, thatch/mat, and soil organic matter content. As soil moisture decreases below field capacity, soil hardness dramatically increases. Thus, spatial variability in soil hardness should first be determined under normal irrigation conditions during dry periods since uniformity of irrigation water application, as affected by system design and scheduling, dramatically influences soil moisture spatial distribution, and thereby, soil hardness. But, to determine how soil hardness is affected by traffic-induced soil compaction, data should be obtained 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 and shear strength are also strongly affected by soil moisture as well as grass type, degree of coverage, thatch/mat/OM content, soil texture, and soil structure (compaction). Thus, traction and shear strength should also be determined under both drier and field capacity conditions.



» **Figure 3. SOIL MOISTURE** variability of a soccer field presented in standard deviation format to reveal the areas with the lowest and highest soil moisture (see std dev legend). The arrow identifies irrigation head No. 13.

Because soil moisture has such a dominant influence on soil hardness, traction and shear strength, a new, soil-water audit approach is especially useful for investigating the spatial relationships of soil moisture level versus these surface characteristics (Figures 3, 4). The new water audit is based on spatial mapping with the Toro Precision Sense 6000 of soil VWC during a dry-period when the irrigation system uniformity of water application would be exhibited. In contrast to the traditional catch-can audit, the soil VWC-based audit considers any factor influencing soil moisture distribution (irrigation system design and performance, wind distortion, runoff, high ET areas, etc.) and mapping is of the whole area and surrounds if necessary. A proprietary GIS-based software program allows geostatistical analysis of spatial variability of soil VWC and other measured parameters as well as GIS map display at three critical spatial levels, which are: a) across the whole sports field (Figure 3); b) within the zone of influence of each individual irrigation head to assess any head distribution problems and provide insight into potential causes (Figure 4); and c) assessing head spacing and system performance issues. The software program has been developed as a practical decision-support system to provide information on how uniform is soil VWC status (and all other measured parameters) at these spatial levels and to generate recommend corrective measures or fixes at each spatial level in order to enhance water application efficiency. If an irrigation system is not well-designed, the degree and nature of design flaws are characterized and illustrated. For practical and cost-effective use of multiple-sensor, mobile PTM platform information, decision-support systems software such as described is critical in order for large quantities of data to be processed, analyzed, and presented in a timely manner.

On non-sports field sites, the soil moisture-based water audit would be used to assess water-use efficiency and conservation. But, for sport fields, of most importance is the spatial variability in soil moisture as related to the player safety and field playability factors of soil hardness, traction, and shear strength; while still receiving the other water audit benefits. Plant performance can also be assessed by spectral reflectance (NDVI) and possibly mobile digital imaging devices in the future. Spatial differences in NDVI can be related to traffic patterns (wear and soil compaction aspects) as well as soil moisture distribution.

OTHER PTM APPLICATIONS FOR SPORTS FIELDS

In addition to performance testing and soil-based water audit applications, site-specific cultivation and salinity mapping are other applications of PTM applicable to sport fields. Penetration resistance data obtained at field capacity can determine areas requiring cultivation. The salinity data on sites with saline irrigation water can be used to determine spatial variability of soil salinity and aid in developing site-specific leaching programs. Surface hardness of infill systems has also been investigated on a preliminary basis. Over time, other measurement devices such as the ones identified in the sidebar will likely be developed that will allow other PTM field applications.

Performance testing on sports fields can be significantly advanced by using PTM concepts and technology. Of special importance is to move beyond the practice of sport field “site-assessment” being based on only 4 to 6 sample areas per field and the lack of exploring inter-relationships of soil surface characteristics. ■

Dr. Robert N. Carrow is with the Crop and Soil Science Dept., University of Georgia-Griffin Campus; Dr. Van Cline is Toro’s manager of agronomics and turf. The authors would like to acknowledge The Center for Advanced Turfgrass Technology for research funds and Kathy Rice of the CATT for her expertise in development of the Decision Support System software package.

>> **ROSS KURCAB, CSFM** on-site during construction of Invesco Field at Mile High in 2000.

Tips from NFL turf veteran Ross Kurcab, CSFM

ROSS KURCAB, CSFM, turf manager for the Denver Broncos, gave an engaging presentation on "sight turfing" as he calls it, at STMA's Conference in January. Kurcab shared his observations on how by using their eyes, turf managers can increase their field management skills.

"How do you make critical decisions?" Kurcab asked the crowd. "Because it can be the difference between success and failure.

"There is no operations manual for a field; it's the only part of any facility that doesn't have one," Kurcab said to a nodding audience. "There's no set standard for doing your job. It's a cowboy world; you have to figure it out."

Kurcab said in 26 years he's never had a turf boss. "I'm a self-taught idiot," he joked. He said he learns day to day and acknowledged that his situation, managing only one field, isn't a typical situation for the audience, yet the sight-turfing approach has benefits for multi-field operations.

Several times in his talk Kurcab mentioned Attention to Detail. He mentioned having a back-up plan in case your mower breaks down—do you have a 2nd mower or access to one?

"My style of field management is a daily read-and-react, using my eyes, which I consider my most valuable asset."

"My style of field management is a daily read-and-react, using my eyes, which I consider my most valuable asset. For example once we had a coyote peeing on the field and it was making the grass greener around the outside of the spot, so I decided it needed nitrogen," he said.

"You have to know how to look at your turfgrass and develop a working hypothesis on what's going on with it. When you see something not green, address it. We see green best with our own eyes, it's been proven scientifically," he said. "I believe we see green better through evolution because our ancestors recognized green as a food source."

SUNGLASSES ARE A TOOL

Kurcab called sunglasses, holding up the pair hanging around his neck, "light conditioners" and pointed out the safety factor in wearing sunglasses. He said polarized sunglasses are safe against UV rays, reduce glare and increase clarity. "If you are getting too much glare in your eyes, you are getting too much light; that glare can be coming from your turf," he said.

"The lens tint makes a difference. I've found a green tint provides the best color contrast. Copper, rose and brown lenses are better for sight-turfing, as they minimize the green and blue 'wash' and clarify any turf off color," Kurcab said.

"I call my purple lens-glasses my "plant stress detection" glasses. That color is the best for seeing where it is NOT green. I recommend purple for giving you advanced notice of disease and other potential problems. "Give your eyes time to adjust to the purple lens," he said. "They work best in bright sunlight and are great for wilt patrol but they aren't for everyday 24/7 use."

SIGHT TURFING TIPS

Kurcab shared some ideas on using your vision to improve your turf. "See what you are not looking for," he said. "Look for tonal contrast and ask yourself 'Why?' if anything's not green. And look at your turf from different sun angles, especially looking toward the sun which gives more tonal contrast."

"I think you should practice your sight turfing. Don't do it just on your field but your lawn, when you're at a park, wherever. Practice seeing the contrasts. Look macro and look micro," Kurcab said. "Don't walk past colors that look off. I try and diagnose 'every day and in every way'. I get a working hypothesis and try to get an action plan for what I just saw.

"You can't sight turf unless you know how grass plants grow in soils; you need some education and you can get it online these days."

He said a turf manager's job description is basically a "daily update on working hypotheses." "Your maintenance plan should include a daily read-and-react. Sight turf your field(s) during the game. Watch the play from the knees down. Watch different position players and skill-types. Note the footwear being used. How is the field or pitch performing? After the game, check the depth of the divots whether they are "skates, moguls, flaps, wrinkles or blowouts," he said.

TIPS

If others come to look at a problem, don't try to sell them on your theory of what's wrong, Kurcab advised. "Let them have their own diagnosis, maybe it will help."

Other tips included managing the weakest link on your field; doing no harm—grass often knows how to solve the issue; and remembering sometimes taking no action is the best action.

Kurcab said it's key to find out if your problem is man-made or natural. "See a straight line of trouble? That's likely man-made.

Kurcab said when tackling a problem make sure you determine if it is a safety issue, a playability issue or an appearance issue. "Remember in football, it's between the sidelines that is important. Be sure to consider how much time you have to mitigate a problem if it's not affecting play. Teach your crew to sight turf to multiply the number of eyes watching the field," he said.

"The best advice is no good if you can't execute it though. Try and boil down your plan to a simple sentence. Analyze the effectiveness of past treatments or solutions," he said. "And always save a spot where you don't spray when trying a different product; use it as a control spot to check for effectiveness of that product."

Kurcab urged the audience to use all their senses, with a nod against tasting your turf. But smelling is fair game. "Only sports turf managers smell their own turf," he said.

He recommended managers use a digital camera and its cheap storage to take a lot of pictures of your turf and to consider making a video as your check your fields that includes a running commentary about the issues. He mentioned the infamous band camp that he wanted to make sure he remembered about the next year.

Kurcab closed by responding to a question about his biggest challenges as a turf manager. "I can figure out the fields; it's managing people and staying calm in a stressful environment that is most challenging to me." ■