Turfgrass water conservation essentials:
modified rootzones & current water management technologies

TURFGRASS WATER CONSERVATION is not just a concept of the minimum amount of water that can be used for turfgrass survival, it is also the concept of optimizing water use as a significant factor in getting the maximum performance from turf and not wasting water. Key elements of this concept are modifying root zones to promote optimal turf growth and taking advantage of improvements in turf irrigation technology.

MODIFIED ROOTZONES FOR EFFICIENT WATER USE

Soil uniformity. Uniform soil conditions make it easier to grow uniform turf and provide more efficient irrigation. However, turfgrass is frequently grown on nonuniform modified soils where topsoil has been removed or mixed with subsoil. Sod is often laid on compacted subsoils, which limit rooting into the underlying soil.

Soil variability increases the need for site-specific management in irrigation programming, using the knowledge of soil properties such as texture, structure, organic matter content, compaction, drainage, slope, fertility, and pH, as well as lighting and air movement. Water relations in soils depend on retention and transmission of water: soluble salts can control how much water is available to roots in salt-affected soils. As a soil dries or as soluble salt content increases, less water becomes available for plant uptake.

Sand-based designs. Sand-based profiles that have relatively narrow particle size distribution are widely used with or without amendment for highly trafficked turf areas such as golf putting greens and other sports turfs to ensure adequate water infiltration, percolation, and drainage, and to prevent the buildup of excessive soil water content. Profile designs that encourage the development of a water table can conserve water. These designs on limited slopes and when drained to field capacity can have a water content distribution ranging from unsaturated and well-aerated at surface depths to nearly saturated at the lowest depths.

Placing a finer-textured sand over coarser material such as gravel creates a zone of greater water retention (a perched, or suspended, water table) in the sand above the interface with the gravel layer. For example, the USGA Green Section specifications for putting greens use a 2-layer or 3-layer profile. The 2-layer profile is most widely used and has a 300-mm sand root zone mix of a specific particle size distribution placed over appropriately sized gravel. Drain tiles are installed in the gravel layer. During construction, these specifications are sometimes followed carefully, sometimes not; if not, undesired conditions may occur in plant-available water or drainage patterns.

The California design is a 1-layer system consisting of a specified well-draining sand placed over compacted (impermeable) native soil. Drain tiles are installed in trenches in the native soil. Water retained at the bottom of the root zone is more typical of a perched water table if there is very limited or no drainage into the underlying soil.

Drainage from the 2-layer USGA putting green profile tends to be independent of the sand mix, while the 1-layer California green profile drains slower, with finer sand mixes. Thus, the 1-layer profile tends to hold more water for turf use than does the 2-layer profile. The 2-layer profile has only a short-term effect on the perched water table due to the downslope subsurface movement of water. If the root zone mix is too deep, water stress increases, leading to localized dry spots, especially in the highest elevations of a putting green. If the top mix is too shallow on putting greens, it may be difficult to place the hole liner, and wet areas may occur, which can enhance development of black layer.

Better turf performance has been observed on root zones that retain more water with reduced rooting compared with root zones that retain less water with greater rooting. In sand-based root zones, greater rooting depth has not been related to better turf performance or greater efficiency in water use. There is evidence to suggest that greater water conservation can

Further Reading

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be achieved with sand-based root zones that retain more water.

Subirrigation. Subirrigation can use 70 to 90% less irrigation water than surface irrigation. Drainage tiles placed on top of plastic liners in subirrigation systems can be closed to prevent leaching. These tiles can be attached to pumps to draw water out or pump water into the sand profile. The water table can be raised or lowered as needed, depending on root depth. The particle size range and depth of the sand dictate the degree of capillary rise of water. Problems with subirrigation include managing high levels of soluble salts and sodium, as well as maintaining uniform root zone water content in sloping putting greens.

Topdressing with sand. Repeated sand topdressing increases infiltration on native soil putting greens and other sports turfs. Water that had previously run off sloping turf surfaces tends to be held in the sand layer. When dry, topdressed sports fields have a lower surface hardness. However, hydrophobic soil conditions, as found in localized dry spots or dry patches, frequently develop in sand media. These spots often occur in areas where irrigation coverage is inadequate, on slopes where water tends to run off rather than infiltrate, and on slopes facing the sun. Fully developed localized dry spots are difficult to rewet. Application of wetting agents, cultivation (aerification), thatch control, careful monitoring of soil water levels, and syringing are the most common corrective practices.

Several states offer automated, Web-based potential and reference ET values for irrigation scheduling. In California, the most commonly accepted source of ET data is the California Irrigation Management Information System (CIMIS, wwwcimis.water.ca.gov).

Avoiding black layer. Sand sports surfaces grown with aggressive, high-density cultivars of creeping bentgrass and bermudagrass can accumulate excess organic matter, which can seal the surface, causing loss of roots, turf stress, and the formation of black layer. Management practices to prevent or remove black layer include providing more oxygen to the affected zone through reduced irrigation (with emphasis on syringing), cultivation, topdressing to prevent layer formation, improving drainage, controlling organic matter, and monitoring fertility practices.

CURRENT WATER MANAGEMENT TECHNOLOGIES

Strategies to reduce unnecessary irrigation water use should include efficient irrigation systems and scheduling irrigation based on the actual water requirement of turf needed to maintain a desired quality level.

High-efficiency irrigation. To achieve high-efficiency irrigation, minimize losses such as droplet evaporation, surface runoff, leaching, and wind drift. Correct sprinkler head selection and spacing can match water spray patterns with the shape of the landscape, which helps avoid areas that are over- or underirrigated. Divide larger irrigated areas into hydrozones, areas of similar watering requirements. Consider subsurface irrigation systems: they have shown great potential for water conservation, despite difficulties associated with determining spacing and depth of trays, pipes, or emitters; higher cost of installation; difficulty in monitoring and/or troubleshooting damaged parts; potential interference with maintenance practices; and the inability to establish turf from seed when irrigated below the surface.

Estimating irrigation amounts. Irrigation amounts can be estimated based on climatic factors or calculated from the plants' water status by monitoring soil moisture or by using remote sensing technologies that detect and quantify drought stress. Evapotranspiration (ET) losses from a turfgrass stand provide an accurate measure of irrigation water requirements. These losses have been closely correlated with atmometer evaporation, open pan ET, and potential (model) ET estimates (ETp and ETo). ETp and ETo estimates are most commonly used when turfgrass irrigation scheduling is based on ET losses.

To match actual turfgrass ET, most ET estimates require adjustments in the form of multipliers or crop coefficients (Kc) to meet local climatic conditions and specific maintenance situations. Kc can vary from 0.4 to 1.1, depending on ET reference, quality expectations, season, grass type, maintenance level, and micro- and macroclimate. Crop coefficients can also be used to calculate irrigation amounts. Irrigation below 100% ET replacement (deficit irrigation) does not necessarily result in a significant loss of turfgrass quality and function.

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Smart controllers. Smart controllers automatically adjust to daily changes in evapotranspiration. Using them instead of traditional irrigation scheduling can yield water savings as high as 80%. Some municipal water authorities and utilities have introduced rebate programs for installing smart irrigation controllers. Irrigation scheduling based on soil moisture aims to keep the root zone within a target moisture range by replenishing ET and drainage losses. This is considered to be the most intuitive way of determining how much and when to irrigate.

Soil moisture sensors. Soil moisture sensor technologies currently used to schedule landscape and turf irrigation include dielectric sensors and heat-dissipating sensors for measuring soil water content, and tensiometers and granular matrix sensors (gypsum blocks) to measure soil water potential. Both types have advantages and disadvantages, and consideration must be given to the soil type, range of moisture measured, and expected soil salinity.

Tensiometers estimate soil matric potential and do not require soil-specific calibration, but they do need regular maintenance. Granular matrix sensors measure the electrical resistance between two electrodes embedded in quartz material and correlate the resistance with the matric potential of the root zone.

To calculate irrigation requirements based on volume, soil moisture tension or suction values must be converted to volumetric soil moisture content using a moisture release curve. Dielectric sensors record volumetric soil moisture directly; measurements can be affected by the length of the rods, soil texture, soil density, and soil electrical conductivity.

Absolute moisture values can vary considerably over a landscape. If a sensor is installed in a location representative of an irrigated area, and if it records moisture extraction between maximum and minimum over time, using this data can lead to more consistent irrigation scheduling than using absolute values alone. Reported reductions in irrigation water applied range from 0% to 82% when soil-moisture-based controllers were used for scheduling compared with either traditional or ET-based irrigation scheduling.

Crop water stress indices and normalized difference vegetation indices calculated from remotely measured reflectance of canopies have been suggested for irrigation scheduling of cool- and warm-season turfgrasses. However, to date no automated remote sensing irrigation scheduling technology based on reflectance is commercially available.

How do modified root zones and current water management technologies relate to sports turf? The construction and management of sports fields are directed to support the performance characteristics of safety, playability, durability, and aesthetics at some level of expectation. Water management, as expressed in irrigation, is key to meeting those expectations. Occasionally one finds a sport field that has been built by merely scraping off a spot and seeding it. Most often, though, the construction involves modifying the root zone in some manner. In either case, the turf manager must learn how to irrigate that field and ensure that the root zone grows the best grass possible. Water management technologies have been developed to make that job just a little easier and to obtain the highest efficiency from the water that is applied. ■

This article was adapted from *Turfgrass Water Conservation*, Second Edition (University of California Agriculture and Natural Resources, ©2011, Regents of the University of California), which was written by scientists for turfgrass managers and decision makers to address many of the issues relating to turfgrass irrigation. This excerpt is used by permission.

This publication, along with many other useful resources for the turf professional, can be found at http://anrcatalog.ucdavis.edu/TurfLawns/

Polo fields:

uniquely challenging turf management

>> The fields were built without drainage, without proper grading and it appears as though 4 to 6 inches of sandy loam was thrown on top of the native soil and rock that were left over from the cobblestone mine that the area was used for at the beginning of the century.

AT THE BEGINNING OF 2011, all I knew about polo was that Prince William liked to play the sport and that I could buy a t-shirt with a polo player in the corner for more money than I am willing to spend on a t-shirt. As an assistant golf course superintendent, I didn't even know that Colorado had polo fields.

As I toured the J-5 Equestrian Center during my first interview, I knew immediately that my first year managing polo fields might provide a unique variety of challenges.

When these polo fields were built more than 20 years ago, the intention was to use them for polo as a hobby, not as a professional polo facility. The fields were built without drainage, without proper grading and it appears as though 4 to 6 inches of sandy loam was thrown on top of the native soil and rock that were left over from the cobblestone mine that the area was used for at the beginning of the century.

When our team, Valiente, took a lease on the fields the team owner and players realized that in order to play at a competitive level, the condition of the fields would need to change dramatically. Valiente's vision is to bring these polo fields to a level beyond past expectations and to create a standard for the turf and playing surface that could be compared with the world class polo fields in Florida, California and Argentina that they are used to playing on.

POLO BASICS

Outside of polo circles, little is known about the sport, so let's start with a few polo basics. These fields are regulation size, 300 yards long by 160 yards wide. That is just less than 10 acres per field. In perspective, each polo field is larger than 9 football fields. This facility has two regulation playing fields and a 3-acre practice field. The entire length of each field is lined with 11-inch high side boards. Although the side boards and end lines indicate the boundaries of the field of play, the areas outside of these boundaries are not considered out of bounds. If the ball or the players move outside of these borders, they simply continue playing and move back into the boundaries. The field markings are simple. The end lines are painted across the length of the field; the center is indicated with T-shaped markings, and the 30, 40 and 60 yard lines are marked for penalty shots. The goal posts are 10 feet high, 24 feet apart, and are placed in the center of each end line.

Each player rides 4 to 6 polo ponies during the course of the game to keep the ponies rested for maximum performance. Each team has four players on the field, plus two umpires on horses. The game is played in 6 chukkers (periods) of 7 minutes each. So there are 10 horses running, stopping, and turning at full speed for 42 minutes. Every step a horse takes creates four divots. I don't know how many divots are made when 3 to 5 games are played each week, but I can assure you, it is a lot, and that is where the job of turf manager comes in.

The divot operation is probably the most unique aspect of polo field maintenance compared with other sports. A 1,100-pound horse running at 40 mph

Polo Illustration above ©istockphoto.com/anelluk

and cutting at 180 degrees creates a whole new category of divot. Most of you have probably heard about the divot stomp, where the spectators enter the field between chukkers and stomp down the divots. This is very helpful, but we only hold one formal event each year where we have spectators to fulfill this duty. The first thing the turf crew does after each match is walk the field, flipping and stomping the divots. Doing this immediately is extremely important so the divots don't dry out. The field is then rolled to keep a smooth surface and to protect the mowers from scalping the mounds that each divot creates. Now it's time to fill 10 acres of turf that are covered in divots wall to wall. Sod is not an option. If a horse slips on unrooted sod and breaks its leg, then that horse, unfortunately, has played its final match. Therefore, we must use seed.

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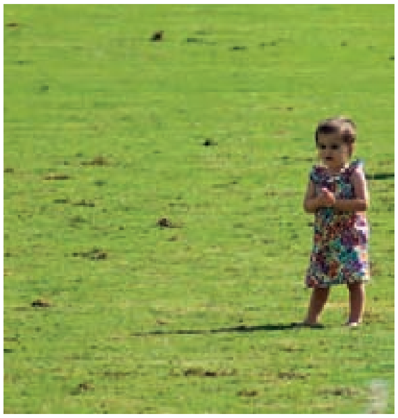

COMPOST NEEDED IN DIVOT MIX

The divot mix is 80% sand and 20% compost. The compost is an absolute necessity to hold moisture for germination because we are restricted to a very delicate watering regimen (more on this later). We use an 80% Kentucky bluegrass and 20% perennial ryegrass blend for the divot mix. The ryegrass germination is critical to hold the divot together until the KBG comes in. We always are experimenting to find the best methods for germination. In the heat of the summer, we began experimenting with pre-germination. The methods were extremely scientific and calculated, meaning we threw the seed bags in a horse trough full of water and poked holes in them, letting them soak for a day. Did this help? I can't tell you for sure, but I believe that it worked to our benefit.

I plan on continuing pre-germination and comparing with other methods like using a pre-coated-seed for higher germination rates. The best and most efficient process will never be found because there always will be something new to try and see what happens. Once the seed and sand are mixed we load it into a trailer. The trailer is pulled back and forth slowly with 8 to 10 divot fillers following, each with a bucket in hand. For the next 6 to 8 hours, it's scoop, drop, smooth and move until all of the divots are filled. A final drag with a chain between two carts will help clean up any sand piles and save the life of the reels for the next mow.

Our watering situation is also very unique compared to most turf properties, mostly because there is no in-ground irrigation on the fields. We use large water reels, each 300 yards long. We also have water cannons outside the playing field that are spaced at every 75 yards. The reels are pulled out with a tractor and reeled in as the water pressure turns the turbine to move the gears. I mentioned before that we are on a very delicate irrigation regimen. These fields have no drainage, and the reels, even at their fastest rates, will put out enough water to replace the ET on a 90 degree day, so it is impossible to throw a light syringe over the property to cool it down.

The moisture level in the soil directly affects the horses' ability to run, turn and stop. Too wet and the turf becomes too soft and sloppy, too dry and the turf becomes too firm and slippery. There is a 4-to-6 hour window of optimal playing conditions where the irrigation has dried enough to play on and before the fields are too dry and firm. Timing is everything and adjusting to weather conditions is extremely important. For spot treatment over such a large area the best option is to pull around above ground lines with pods that hold the irrigation heads upright. This allows us to keep the moisture levels adequate and even due to the inconsistencies of the fields. As if all that weren't difficult enough, we share our pump station with the HOA and cannot water at night due to pressure loss. The irrigation challenges are plentiful, but with a strong dedication to spot watering we have been able to keep a consistent playing surface and green grass throughout this season.

These fields were not originally intended for professional polo. They had been aerated, but need more than a simple aeration twice a year. Compaction from polo requires increased cultivation. Using a verti-drain we were able to get down 8" on the 1st attempt, 11" on the 2nd and 15" on the 3rd. Adding 3 core aerations, 5 times slicing, 3 times verti-cutting for thatch removal, and adding over 2,000 tons of top-dressing sand, the turf and soil received a sigh of relief from 2 decades of compaction and thatch build up. These cultivation practices brought the surface firmness to an acceptable, and at a few times this season, an optimal level for polo play.

The increased cultivation is a key factor in the level of improvement that these fields experienced this year. Paying attention to details that may have been overlooked before has created a more optimal growing environment for the turf. Adding practices such as adjusting fertility based on soil tests, getting disease diagnosis from extension labs and the introduction of wetting agents have all contributed to a very successful product for our polo team to play on.

My goal when I arrived here was to make our fields comparable with the world class facilities where the highest level of polo is played. I believe at times during this season, we have achieved that goal. With a little fine tuning, my goal now is to keep those conditions on a consistent level throughout the playing season. There will always be new methods to try, new innovations in our industry and more opportunities to learn from mistakes. Improvement is always on the horizon, and perfection, although never obtainable at its true definition, is the only acceptable outcome for the future. ■

Dave Radueg is Polo Fields Manager at the J-5 Equestrian Center, Littleton, CO.

» **BATTER BOARD** was used to define and elevate the infield arc to establish a diversion around the infield.

» **Top Left: BASE PATH:** Offset foul lines minimize lip buildup in the grass adjacent to 1st and 3rd base.

» **Middle Left: "WALK SOFT AND CARRY A BIG RAKE."** Low ground pressure equipment was used to install the big roll bluegrass sod.

» **Bottom Left: RED SCREENINGS** were used to create wide paths and minimize turf wear.

Considerations in infield construction and renovation

MOST OF US have managed an infield under less than perfect conditions at one time or another. The infield may be in need of reconstruction due to years of use or it may have inherent problems caused by improper construction. Whether simply a facelift for an existing infield, or the construction of a new facility, a successful project requires consideration by those involved in the construction process and by those who manage the use of the field.

It's natural to want the best infield you can have when the opportunity arises to renovate or construct an infield. Typically, designers and engineers look to construction practices used on professional infields as a reference when designing for schools and municipalities.

For the sake of this article I would like to take the liberty of providing my perception of a professional infield. A professional infield is an infield constructed on a full gravel blanket below a loamy sand or pure sand root zone. It has a ½% slope radiating out in all directions from the area around the pitcher's mound. The skinned area is constructed with two distinct layers. The base is constructed using an infield mix with less than 70% sand. This mix is managed at a precise moisture level to provide just the right resilience to the players. The base is covered with a thin layer of topdressing such as calcined clay, vitrified clay or possibly a mixture of both. The integrity of these layers is protected with the utmost care. For most of us, managing a professional infield such as this would be like Charlie Daniels playing Tchaikovsky's Violin Concerto. Rather most of us maintain infields in the grey area of right and wrong somewhere between a professional infield and chase out the cows close the gate and play ball.

Some designers recommend a heavy textured clayey infield mix like XYZ stadium, not understanding that unless the moisture in that mix is impeccably managed, it's going to get hard as a rock.

PERCEPTION IS NINE TENTHS OF THE FLAW

I have witnessed municipal infields constructed on a full gravel blanket using heavy textured impermeable top soil and a heavy clay infield mix because the perception is that this gravel blanket is going to provide superior drainage for the infield. These designers don't realize that unless the root zone has a very high rate of hydraulic conductivity and is capable of allowing water to pass through it efficiently, the only real benefit to any subsurface drainage is the control of ground water or a high water table.

These same designers like the ½% slope because; actually I don't know why they use it other than because it's used on professional infields. What they fail to realize is that ½% slope is almost as ineffective as a gravel blanket in a turf area unless again, you have a very permeable root zone and some form of subsurface drainage. On the skinned area, ½% slope is very difficult for the average maintenance crew to manage effectively and typically requires laser grading a few times a year to remain effective.

Some designers recommend a heavy textured clayey infield mix like XYZ stadium, not understanding that unless the moisture in that mix is impeccably managed, it's going to get hard as a rock.

I witnessed a regulation little league infield constructed with a conical grading plan similar to the professional field I described. In this case the designer was sharp. He understood that ½% slope isn't sufficient. He therefore recommended a 1% slope radiating out in all directions from a point centered on the infield turf. What he failed to realize is that you cannot construct a regulation pitcher's mound using this grading plan and adhere to the requirement that the pitching rubber be 6" above home plate. In fact, there would be no mound at all. A 1% rise from home plate to a pitching rubber at a distance of 46' would be about 5.5". This would however be a very effective grading plan for a softball infield with no mound.

This same consideration afforded to a little league infield is necessary for a 90' baseball infield where the height of the pitching rubber is required to be 10" above home plate. In this situation you cannot construct a regulation mound using any more than a ½ % slope from the pitcher's mound to home plate. Even at ½% slope, the mound would only be about 6" high allowing only enough elevation for a 6' landing zone in front of the rubber. In this situation the desires of the coaches and athletic director need to be understood and the requirements prioritized to allow for a successful project.

ST. ROSE HS GETS A NEW FIELD

I had the opportunity to be involved in a construction project at Saint Rose High School in Belmar New Jersey. The loss of a facility they had used for years required the school construct a new varsity baseball field at another site comprised primarily of soccer fields.

The project started with the inspection of the new site and selection of the location for the new field. The proposed location was in the corner of one of the existing soccer fields. The site was rectangular in shape with a diagonal slope of 1% across the entire tract. We had the option of selecting from two potential locations for the construction project. We could use the upper corner which would entail dealing with a diagonal cross slope away from the proposed home plate or we could use the bottom corner which would mean dealing with a 1% slope right down the center line of the proposed infield. Personally, I believe a cross slope is the most difficult slope to deal with on an infield. The excavation necessary to eliminate the cross slope was cost prohibitive so right or wrong we opted to deal with the 1% slope down the centerline.

After the site selection, all those involved

>> NO COWS on this infield.

>> A WALL was constructed to elevate home plate 24" and create an acceptable grading plan.

>> **Above left: CLAY BRICKS** were installed in the pitcher's mound and home plate.
>> **Above Right: 6"** of topsoil was applied to all turf areas.

in the construction process were assembled to provide their particular expertise in the project. Those involved were: the coach/field maintenance supervisor; the athletic director; the landscape architect; and me, the consulting construction contractor.

For a few different reasons including budget, it was decided that an engineer was not required for the project and the coach/field maintenance supervisor, Mark Fletcher would be serving as general contractor on the job.

Based on the combined input from Mark and the athletic director, the architect developed the footprint for the field, including dugouts, warning track, backstop, fencing etc. Mark and I took soil tests, evaluated the existing topsoil and chose an infield mix that was compatible with the level of maintenance he would provide. The mix was about 75% sand with about 1:1 silt to clay ratio. Tuckahoe Turf Farms in Hammonton, NJ was chosen as supplier for the bluegrass sod we would be installing. Mark also lined up an irrigation contractor to install the irrigation and quick connect behind the pitcher's mound. A mason was chosen for the dugouts and the retaining wall. A fencing contractor would be installing the backstop and perimeter fencing.

THE INFIELD GETS A PASSING GRADE

Literally every infield I have seen that is constructed in the corner of a multipurpose facility has a problem with home plate washing out due to the prevailing slope. For this reason we decided to elevate home plate 24" by means of a wall directly behind the back stop. Along with this a diversion was designed around the outfield radius of the proposed infield to divert the prevailing flow of surface water around the infield. By elevating home plate 24" we were able to create a grading plan with a level center line and approximately a 1% slope to 1st and 3rd base that continued beyond the infield. I believe 1% to be the optimum slope for a baseball infield at this level of maintenance and play. It's enough slope to get the water off the infield turf when internal permeability of the root zone isn't sufficient. 1% slope on the infield skin provides good surface drainage, doesn't require quite the precision in maintenance a ½% slope requires and 1% slope minimizes the potential for erosion associated with a steeper slope of 1¼ to 1½%.

The elevation of home plate created a need for about 500 cubic yards of fill material to raise the entire infield. Luckily the original construction of the complex had left a mountain of material that would work as an excellent fill material. The material was similar in texture to a sandy unscreened infield mix. I would compare it to select fill which has a specified range of hydraulic conductivity between 2" and 20" per hour. Select fill is a material sometimes used to help regulate percolation in a septic system. Because the topsoil we would be using to cover the fill material was a heavy textured soil that was not very permeable and we all know that infield mix is not very permeable, we decided subsurface drainage would not be necessary. The only drainage pipe we installed was at the base of the wall and we installed a sand slit drain around the outfield radius of the infield to help with any water that might lay in the diversion. We did allow for channel drains to be installed in front of the dugouts at a later date if necessary. As with most any infield, we were relying on surface drainage to evacuate surface water from the infield.

>> SINCE THE TOPSOIL would be reused, we stripped and removed the sod.

Once the grading plan and the architect's footprint for the facility were finalized and documented, we were ready to begin the project. Consideration on the part of all involved in the construction project allowed for a successful project and the construction of a safe, durable and playable field that is currently the pride of Saint Rose High School. ■

Jim Hermann, CSFM is President of Total Control Inc. Athletic Field Management www.totalcontrolinfields.com.

SportsTurf's Point–Counterpoint: SLAN vs. BCSR

Soil fertility interpretation: base saturation or sufficiency level?

SOIL FERTILITY TESTING is a valuable agronomic tool composed of four steps; sampling, analysis, interpretation, and recommendation. Sampling practice is standard boilerplate stuff. Perhaps modified in regard to depth; e.g. by potential rooting depth of species or need for subsoil investigation, sampling accuracy improves with each additional sub-sample pooled from the area of interest.

The next stage is analysis, and "routine" soil fertility analysis affords little artistic liberty. Submitted soils are dried and homogenized before an exact mass is mixed with an extraction solution. Typically chosen on the basis of regional parent material or sample soil pH, extraction solutions include Mehlich-1, Bray P-1, Morgan, and Mehlich-3. Their purpose is to rapidly displace nutrients from soil and preserve them in their soluble forms, facilitating precise measure of solution nutrient concentrations by state-of-the-art analytical equipment. Since a known volume of extractant is added to a known soil mass, each resulting soil nutrient level (in parts per million, ppm) is derived precisely from extractant concentration (mg/L).


>> Max Schlossberg, PhD

Success through the first half of the soil fertility testing process relies on consistency, and this is something I believe we can all agree upon. If only the second half were so easy.

Interpretation is simple characterization of soil pH and nutrient levels by keywords like suboptimal, deficient, adequate, optimal, supra-optimal, and/or excessive. Dependable interpretation relates inversely to the number of presumptions made in the process (fewer presumptions = better interpretation).

The recommendation component communicates the rate and application frequency of the liming agent, amendment, and/or fertilizer(s) required to achieve the turfgrass manager's expectation, and may be divided into pre-plant and annual maintenance sections. The value of the recommendation depends on the provider's interpretation of soil nutrient levels and familiarity with the growing environment and maintenance level imposed. The best consultants base their recommendations on soil nutrient levels, resident turfgrass species/cultivar(s) adaptation, irrigation water quality/quantity, soil pH, seasonal climate patterns, and the client's cultural practice "schedule." Recommendations to engage in very specific fertilizer/amendment "programs" composed of numerous products containing similar nutrients should be considered suspect.

The base saturation tool in turf management

THE CONTROVERSY over the use of the base saturation ratio (BCSR) versus the sufficiency levels of available nutrients method (SLAN) has perpetuated for many years now and with very little change in either side's thinking. The reality is that base saturation is one tool of many that most independent agronomists use to help their clients become more successful. The other important reality is that most of us using the BCSR method also look very closely at the sufficiency levels of nutrients studying both standard colloidal soil test audits and water soluble paste extracts.


>> Joel Simmons

For 25 years I have been a strong advocate of the BCSR model and have heard everything from "it's wrong" to "he's going to ruin golf courses." A university agronomist recently said to me "We don't agree with the BCSR method but we know that most independent consultants use this tool." That spoke volumes, if it was in fact wrong or going to ruin golf courses we wouldn't be using it because our clients wouldn't pay us to come back. There are strengths and weaknesses to all models which is why using a broad spectrum approach to managing soil and building fertility programs is critical.

Base saturation measures the percentage of the cations on the soil colloid. Based on the extensive works of many people, most notably Dr. William Albrecht from the University of Missouri, the ideal cation percentages are 68% calcium, 12% magnesium, 5% potassium, 3% trace nutrients, 2 % sodium and 10% hydrogen. These ideals are never found in practice and are simply a guideline to start from. This model is not a great tool in sand-based low CEC soils or calcareous soils as compared to clay/silt based soils so we compensate in these situations and lean much more on the sufficiency models. However since most soils that we do evaluate are true soil profiles the BCSR model is a good tool to start with and provides us with much information as to the nature of the soil.

Perhaps the greatest value that those of us that lean on the base saturation tool gain is the one that tends to generate the most passionate debate. Base saturation helps us primarily with the physical properties of the soil, as we move a soil into

The question of how soil nutrient levels are used to recommend fertilizer/amendment applications to a turfgrass-environment-culture system is typically answered by one, or both, of the predominant methodologies; the *base cation saturation ratio*(BCSR) or *sufficiency level of available nutrients* (SLAN). Brief and objective summaries of each method follow (in no particular order).

The BCSR concept, developed by F.E. Bear and colleagues in 1945, supports maintenance of an "ideal" soil having: 65% of cation exchange sites occupied by calcium (Ca) charge, 10% by magnesium (Mg) charge, 5% by potassium (K) charge, and 20% by hydrogen (H) charge. Thirty years later, "The Albrecht Papers" defined the ideal BCSR as 10% H, 10–20% Mg, 2–5% K, 60–75% Ca, 0.5–5% Na, and 5% other cations. In support of plant productivity and health, BCSR embraces balanced availability of base-cation nutrients in soil. The SLAN concept, introduced by Mitscherlich in 1909 and further-developed by Bray in 1945, supports comprehensive maintenance of nutrient levels (i.e., thresholds) on a soil mass basis. The SLAN method seeks to rectify nutrient deficiencies that would otherwise limit productivity and health (yield). Discussions relating each concept to justifiable attributes follow.

SIMPLICITY

Remember: the less presumed, the better the result. Interpretation by BCSR requires conversion of soil nutrient mass to nutrient charge concentration, and presumes divalent cations of interest

a range of "balance" we have repeatedly seen the soil open up physically allowing more water and air movement through the soil profile. We are not changing clay into sand, we are not making silt into clay, but are flocculating the soil just enough to relax the soil colloids to create the tiniest of pore spaces to allow air to flow through the soil a little more freely. The range that we are looking for from on a true base saturation test puts calcium into the 60-70 percentile, magnesium down to the 12-18 percentile, keeping potassium close to 5% and holding hydrogen levels to around 10%. On a true base saturation soil test when hydrogen is at 10%, the soil pH is always at 6.3 which is generally recognized as the point at which we have maximum potential nutrient mobility.

Unfortunately, many laboratories do not run what we call true base saturation soil tests; they may show only the percentage of calcium, magnesium and potassium. Some very popular labs run reports that have pH readings in the low 6 range, which clearly suggests that there is close to 10% hydrogen on the soil colloid. Since pH measures the acidity of the soil, or in layman's terms the percentage of hydrogen, when the soil pH is below 7.0 we know that hydrogen is on the soil colloid. Too often the soil report does not show a hydrogen percentage or for that matter show the percentage of either the trace elements or sodium which in combination could add up to over 15% of the colloidal makeup when the soil pH is in the low 6 range.

(Ca+2 and Mg+2) each occupy two soil exchange sites. However, modern solution chemistry models show this dependability diminishes with increasing alkalinity of soil. The SLAN approach interprets the soil nutrient mass as is (ppm soil), and simply recommends nutrient delivery equal to the difference between the current nutrient level and the field-calibrated deficiency threshold.

SCALABILITY

The SLAN concept offers interpretational flexibility both practically and agronomically, specifically in regards to yield expectation, sampling depth, and extractant. Examples of SLAN sensitivity to yield expectation are the widely—adopted Mehlich-3 soil K deficiency thresholds of: 232 lbs/acre in intensively—maintained recreational turf systems, and 167 lbs K/acre for general use turf under limited culture. A logical approach considering support of turf vigor and recuperative potential requires more growth-stimulating inputs (e.g., culture, N, irrigation) than general use turf systems. Consequently, increased K-sufficient tissue off take results in greater seasonal K uptake/requirement. The likelihood of clipping removal from the former system, and return of clippings to the latter further validates the intuitive scalability of SLAN.

Similarly, a sampling depth example involves a recreational turfgrass target of 250 lbs soil K per acre (from above SLAN-based Mehlich-3 recommendation). Since a 6-inch deep acre of soil typically weighs 2 million pounds dry, this target equates to 125 ppm

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The other truth of base saturation is that it is a percentage so it always has to add up to 100%, not more and not less as many labs report, so it is easy to see the concern about using this tool when it is not a true percentage. I have heard an industry leader say to a group of turf managers that he can tell the base saturation by looking at the pH which was truly baffling. A soil pH can be driven by many different cations on the soil colloid and understanding their relationships to each other and reducing the excesses by supplying the deficiencies we have repeatedly and with great consistency brought the soil into balance. This in turn opens the soil up physically and provides a better environment for the proliferation of beneficial micro-organisms.

"SELLING" POINT?

My favorite criticism of the base saturation model is that it is used exclusively to sell more fertilizers when in fact the exact op-

K in soil sampled from 0-6 inches. I understand managers of sand-based football fields are investigating lower mowing heights to promote "shallow" root density and enhance divot resistance and stability of the playing surface. A clever tactic given lower mowing heights (within recommended ranges for a turfgrass species) correlate to lesser mean rooting depths (all other things equal), but not less total roots! Like many superintendents managing annual bluegrass putting greens, these athletic field managers may constrain fertility assessment to the upper 4" of soil. But how can SLAN cope? Easily, the recreational turfgrass target of 250 lbs K/acre translates to 188 ppm K in 0-4" of soil. Thus, if analysis shows exchangeable K of 150 ppm soil, then optimal K fertility will require a 38 ppm soil K increase. The 0-4" deep acre root zone weighs 1.33 million pounds, thus a rectifying application of 51 lbs K (61 lbs K2O) per acre is recommended.

To these scenarios application of BCSR theory generates an identical recommendation, hardly as intuitive or meaningful as those shown.

SUITABILITY

BCSR-derived recommendations typically fail to optimize K availability in soils having limited cation exchange capacity (CEC). Considering SLAN effectively interprets fertility over a wide range of soils, suitability serves as yet another harbinger of doom for the BCSR–turfgrass relationship. For example, a 6" sand rootzone sam-

posite is true. When the soil opens up physically and more air and water is moving through the soil biology is more active and the nitrification processes work better. We consistently see athletic field managers using less fertilizer and getting better vigor, color and recovery. The one input that we may shift for a year or two is the use of calcium products, if the soil test calls for that, as we bring the base saturation of calcium up to the 60 percentile mark. This may be the least expensive input in any program but the impact is significant. The calcium products are not exclusively designed to feed the plant but instead are used to flocculate the soil, opening it physically, and helping to stimulate soil biology which will in turn puts the plant into a position where nutrient mobility is improved.

Once the soil is balanced chemically to allow for a better physical and biological profile the entire focus is sufficiency levels of nutrients so that we can assure that the plant is getting all that it needs especially at high stress times on the athletic fields. This approach makes sense, it addresses both the soil needs and the plant needs not just the latter. It has been proven in the field for years, over and over again, helping turf managers become more successful with less, reducing plant stress. This reduces the need for many inputs including fertilizers and pest control products.

The bottom line is if using base saturation models as a tool truly did not work, sports turf managers would not use it a ple extracted by Mehlich-3 to show both the 'ideal' base cation saturation (5% K) and a CEC of 2 cmol/kg contains approximately 78 lbs exchangeable K/acre. While BCSR is considered a "relatively suitable" calibration technique in fields comprised of high-CEC soil, our greatest challenges currently relate to effective and efficient nutrition of sand-based (low-CEC) turfgrass systems.

In summary, the SLAN (sufficiency level of available nutrients) approach is your boy for effective interpretation of turfgrass sand/soil fertility and responsible fertilizer recommendation. There is no debate regarding claims of soil physical property enhancement via BCSR recommendations. Of all the techniques available for maintaining porosity in highly-trafficked mineral soils, none invokes more laughter among turfgrass scientists than the "fertilizing to obtain a balanced base saturation" approach.

Why not both SLAN and BCSR together? Because there are already too many unimaginative fence-sitters proclaiming hybrid harmony. Furthermore, the hybrid model deviates from the concepts originally proposed! The above-mentioned scientists, who spent significant portions of (if not all) their careers developing these mutually exclusive methods, just wouldn't approve. Besides, do you know how labs using BCSR for Ca, Mg, and K make P recommendations? SLAN . . . because it works. ■

Max Schlossberg, PhD, is associate professor, turfgrass nutrition & soil fertility, for Penn State's Center for Turfgrass Science.

second time because they are responsible and understand their needs to produce a quality product every single day. As we have been focusing on in our "Soil Profile" series in *SportsTurf*, like the Wellesley article featuring the successes of turf manager John Ponti, base saturation a good tool to start with to help create the environment for a stronger chemical, physical and ultimately biological profile to help better mobilize nutrients that do become available to the plant. So with this level of success and a thorough program that does focus on both BCSR and SLAN, where is the controversy? ■

Joel Simmons is president of EarthWorks Natural Organic Products and Soil First Consulting. He has a master's degree from Penn State, is a former PSU extension agent, and former soils instructor for Rutgers University.