FOOTBALL MAINTENANCE FOR COOL-SEASON HIGH SCHOOL FIELDS

For as long as I can remember, I have spent most of my winters going to continuing education classes. I can recall many great talks about baseball field maintenance for all different levels of competition. There are many sources of information about the craft of maintaining baseball fields. However, when it comes to the sport of football, I don't recall many talks or articles about maintaining a high school field or any other type of football field.

» Our maintenance program doesn't begin and end with the football season but rather focuses on a yearlong approach. **The new season begins as the old one ends.**

I hope maintaining a cool-season natural grass football field is not becoming a dying art. It is an art, you know. Taking a beautiful turf canvas in pleasant September weather and keeping it safe and playable as the temperatures drop through Thanksgiving takes an artist's touch. A couple of years ago I spent some time talking with Tony Leonard of the Philadelphia Eagles about this subject on our way back from the STMA Conference in Daytona. Even at the highest level of completion, Tony is often asked "Why can't you grow grass on that field"?

During our discussion, I found out that there are many reasons why it is difficult. Sharing the stadium with Temple University, dealing with shade issues, hosting many non-football related events and maintaining turf in a very narrow set of hash marks are just a few of the hurdles that Tony and his crew face . In addition, the pro game is played by the largest athletes in all of sport. The fact that they play the bulk of the game in a small area of the field causes a variety of maintenance problems. Tony has adjusted by changing his field over to bermuda grass during the warm weather months. This allows him to get through most of the season on a very durable surface. As the weather cools the bermuda is removed to the depth of 1.5 inches and thick cut bluegrass sod is installed to finish out the late season schedule with good turf cover. This process has been very successful for Tony and the Eagles.

While this may be a good answer on the professional level, what about those of us on the high school or park and rec level? Are there answers to the problems we deal with on our football fields or are we facing a future with plastic football fields as the solution? I don't claim to have all of the answers, but we have had a lot of success with the maintenance of our football fields at Overbrook. Our maintenance program doesn't begin and end with the football season but rather focuses on a yearlong approach. The new season begins as the old one ends.

ENJOY AN EARLY SPRING

Spring is a very important time for football fields. The fall season really wears out most fields and springtime is usually the time that significant recovery can take place. This process can be slowed by lacrosse but recovery must be taken into consideration regardless. March 1 in New Jersey is the first day you can apply fertilizer **legally** and we do; at least .5 lbs of N per 1000 sq. ft. are applied through an application of ammonium sulfate. This provides food for the new turf planted at the end of last season and promotes growth of established turf also.

In addition to an early application of N, there must be a concentrated effort made to begin mowing to remove dormant turf and promote new growth. It is tempting to allow football fields to lie dormant in early spring. There are a lot of other things going on and football is not one of them. Don't fall in to this trap. The quicker your turf is actively growing, the quicker it has the ability to establish and endure the stress of drought and pest pressures that are coming later in the spring and summer. Fertilizer is provided on an as needed basis during the spring with the intention of not applying more than .5 lbs N per 1000 sq ft. per month.

AERATION

Aeration is something that is very important but commonly overlooked. In our case, we have a core aerator but have no good way to clean up the messy cores. In addition to the mess, coring during the football season may not always provide the results you are looking for. Problems occur during the season if you open up a worn field by coring. Sometimes because of a busy schedule there is not enough time for the field to recover before the next game is played. This can cause a poorly rooted field to suffer damage even though that was not the intention.

At Overbrook we have found a nice window of opportunity right after Memorial Day. Early June is after our spring season and usually before the weather gets too hot. The fields seem to really respond well at this time of year. The turf is actively growing and our activities are limited. We try to make up for the few coring opportunities that are available by using our slicing aerator when we are seeing signs of compaction. This aerator provides us the ability to open things up without disturbing the playing surface. It is a very valuable tool that also aides us in our fall over seeding program by providing a nice seedbed. Another added benefit of slice aerating is the ability to find grub damage quickly during August and early September. It is much better for us to find grub damage and treat it, rather than an injury occurs due to field conditions. Ultimately, it is up to the turf manager to find the right time and aerator for your site.

SUMMER STRESS

Summertime is a time of rest for our football turf. We are lucky that there is very little activity during the summer months until football camp opens around August 15. Our cutting height is raised to 3 inches and mowing frequency is set at 3 to 4 times weekly. The thinking is that I don't want to put any extra stress on the turf. Higher cutting heights do cause other issues though. Suppressing dollar spot with nitrogen often causes brown patch to develop when the weather conditions are right.

In an attempt to break this cycle we tried an organic-based product. It is not a pure organic product but rather a bridge product that is easy to use and can be applied at workable rates. The results last year were very interesting. We had both diseases pop up last summer but in very small amounts and with no noticeable damage. I am going to use this product again this summer to see if we can obtain similar results. Fungicides are not part of our maintenance program so we are constantly making adjustments to see if we can suppress disease without their use. With that in mind, our irrigation routine is based on need not schedule. This sounds like common sense but it gets complicated with tricky summer weather. The fields are checked daily for soil moisture and then irrigated or not based on this information. I have found that it is ok to get a little dry over the summer. Proper water management is crucial for surviving summer heat and humidity. Please don't set your timer box and forget it.

THE SEASON BEGINS

Football season at Overbrook starts around the middle of the month but it actually begins for us around August 1. This is when the fields are laid out. Before the fields are painted we cut in a football pattern consisting of end zones cut in the same direction and every 5 yards cut in the opposite direction. This is done to burn the pattern in without having to waste paint before field use begins. The weather has been pretty unpredictable over the past couple of years. We have had wet weather that causes a lot of damage due to the repetitive nature of football practice. Our coaches do a great job of moving around but sometimes damage is inevitable.

After a wet practice we will sometimes use a light roller to push down damaged turf and broadcast perennial rye seed. This process

▲ **Carmelo Anguilla** running a mower.

is used in wet or dry conditions in order to keep up with field damage. Seed is the great equalizer in this equation. It allows us to keep some turf cover. Summer camp is different from our regular practices during the school year. Practices are longer and are held 6 days a week for around 3 weeks. In addition to seeding, managing moisture is probably the key to surviving this time of the season. During warm weather irrigation is run just after practice to help the turf recover and allow plenty of time to dry before the next practice. A wet field can be ruined in a single practice. Monitoring your field during this period is very important. Your practice field is going to be used all year long. If no maintenance is done, it will be a very long and bare season.

▲ **Bill Loftus** filling divots.

GAME ON

It always amazes me how much more energy and time we spend on our game fields. The team spends much more time on the practice field but the game field garners all of the attention. At Overbrook we have a very good situation when it comes to our stadium field. One of the reasons the field holds up as well as it does is the fact that it really is just a football field for games. Our coaching staff has even volunteered to move their Friday practices to the practice field in order to preserve conditions on the game field. The Overbrook marching band has their own practice area at the back of our school that allows them to practice whenever they want. They do however practice on the game field for longer periods of times than I would like during the competition portion of their season. It does force us to aerate more and keep an extra eye on the area of the field that they practice on over and over again. I guess the best advice is to have a good relationship with your coaches and administrators to make your life easier.

Cooperation is great but you need a good plan going in to the week of a football game. Start by looking at the weather forecast to set up a painting and mowing schedule. Typically we will cut Monday, Wednesday and Friday for a Saturday game with painting reserved for Thursday and Friday. Our cutting height is a little higher than most fields (2.5-3 inches). We counter that by using a light roller on game day to provide a smooth flat surface. In order to keep our sidelines straight, they are cut a quarter inch shorter that morning before rolling. As the season progresses we begin to broadcast perennial rye seed before our games. This allows the athletes to work the seed in with their cleats.

This year we have purchased a Woods seeder that we will use to renovate the center of the field throughout the season. The combination of all of these things is what allows us to provide the best surface possible on a tight budget. Post-game repairs and rest are what really holds the field together from week to week. In the beginning of the season when it is hot, we will irrigate the field as soon as everyone is off after a game. This helps the recuperation process begin. We may also lightly roll the field to push down any loose turf. This allows that turf to re-root if given enough moisture. In addition, we also remove all loose divots that are not still attached. The divots then are filled with a pre-made divot mix consisting of mushroom compost soil and seed. Sometimes this doesn't happen until Monday depending on manpower and time of the game. However, it is better to get as much repair work done as soon as possible to give the field maximum recovery time.

BEDTIME

As one season ends another begins. After our last home game of the year, we get ready for the following year. Seeding throughout the season definitely helps this process. Our goal at the end of the year is to fully repair the entire field and have as little bare soil as possible exposed. We start by topdressing all divots and low spots and then seed the entire field with tall fescue seed. Over the past few seasons we have been trying to incorporate more turf type tall fescue varieties in to all of our fields because they seem to do a better job resisting disease damage in the summer than perennial rye. The rye serves its purpose during the season by being durable and germinating under difficult circumstances but the addition of the tall fescue gives us more cover going into the season. After the field is topdressed and seeded, we roll one more time and put the final application of ammonium sulfate out. I recommend that you do whatever it takes to keep any type of play off of your field at this time because it is almost at the point of dormancy and any wear will be difficult to repair. A couple of pick-up games can cause a lot of unnecessary damage that will need to be repaired in the spring.

Football in New Jersey is a long season. It starts with heat and humidity and finishes with a mix of cold unpredictable weather. The best way to survive is to have a plan that you can communicate to coaches and administrators in order to provide the best possible playing surface for the athletes to use and enjoy. ■

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BEATING SUMMER STRESS
FOR COOL-SEASON SPORTS TURF

Cool-season turfgrasses, such as Kentucky bluegrass and perennial ryegrass are widely used species on sports fields in cool climatic regions. Managing cool-season grasses in sports fields that demand for high quality or playable turf can be challenging during summer months, primarily due to heat stress. The optimal temperatures are ranged from 65 to 75° F for shoot growth and 55° F and 65° F, but temperature often exceeds the upper levels of the optimal temperature ranges in many areas, including temperate climatic regions. In addition, cool-season grass species require as much as 2-3 inches of water per week to maintain active growth during summer months. However, evaporation demands increase with rising temperatures and water availability for irrigation or from rainfall may decline during summer months, which all together can lead to drought stress. It is not uncommon that drought and heat stress may occur simultaneously during summer months. Summer stress combining heat and drought can cause grasses, such as Kentucky bluegrass, undergo dormancy and severe decline in turf quality and field playability.

▼ **Illustration of turf performance** of Kentucky bluegrass under different deficit irrigation regimes.

KENTUCKY BLUEGRASS

100% ET irrigation

80% ET irrigation

60% ET irrigation

40% ET irrigation

The question is how to maintain high quality turf of cool-season turfgrasses in sport fields during summer months with increasing temperature and declining water availability? This article describes characteristics of heat and drought damages in cool-season turfgrass species, and discusses some cultural practices that can be taken during spring months to prevent turfgrasses from suffering summer stress and those can be used during summer months to suppress or alleviate summer stress damages.

CHARACTERISTICS AND SYMPTOMS OF HEAT AND DROUGHT STRESS

Root systems are essential for water and nutrient uptake, as well as production of some plant hormones regulating plant growth and development. Root growth is more sensitive to rising temperatures in the summer than shoot growth, due to its lower optimal temperature requirements. Root growth decline or root dieback, therefore, typically precede turf quality decline. Turf quality decline caused by heat stress is characterized by leaf senescence or yellowing of leaves due to loss of chlorophyll (a green pigment for light absorption in photosynthesis). Without adequate chlorophyll pigments in leaves, plants cannot properly photosynthesize for carbohydrate production. Whole-plant tolerance of turfgrasses to heat stress or turf quality is highly correlated to the amount of green leaves or chlorophyll content in leaves. When leaf yellowing as the most visible symptom of heat damages appears, root damages may have already occurred. Restricted root growth or accelerated root dieback by heat stress inhibits rooting ability for water and nutrient uptake, and the synthesis of hormones, such as cytokinins that control leaf senescence.

Drought injury in turfgrass is characterized by leaf wilting or desiccation and reduction in cell enlargement and growth due to water deficit, although many physiological and morphological changes are induced. Under drought stress, water loss from stomatal pores on leaf surface (transpiration) increases while root growth and water uptake from the soil are limited. This results in water deficit and loss of cell turgor. Leaf wilting or rolling is a typical symptom of drought stress. Turf experience drought stress initially becomes bluish, dull green color and then turns to brown color as chlorophyll content decreases with stress progression.

Another symptom of summer stress in cool-season turfgrasses is dormancy, in which case turfgrass leaves turn brown in response to drought stress alone or in combination with heat stress, but the meristematic crowns and stem or rhizome nodes remain alive. Dormancy is a mechanism of turfgrass escape from drought stress such that dormant plants survive (without growth) for extended periods of drought stress and resume growth when soil moisture becomes available. In general, dormant turfgrasses, especially those with rhizomes (underground stems) such as Kentucky bluegrass, can survive without water for several weeks with limited damage at temperature near or below normal levels, but may survive in dormant conditions for a shorter period of time during the summer when temperature is elevated. Depending on the duration of dormancy, grasses may recovery to a certain extent or fully recovery when temperature drops to normal levels and rainfall or irrigation becomes available. Allowing turfgrasses to go dormant may lose the field playability, although it can result in significant water savings without loss of turfgrass. Kentucky bluegrass can withstand extended period of dormancy and recover, as it has extensive rhizomes that generate new roots and shoots once soil moisture is replenished. However, bunch-type turfgrasses such as perennial ryegrass, once the turf canopy becomes desiccated and thinned under non-irrigated conditions, are slow to recover to their full canopy upon rewatering.

Any cultural practices that can promote root growth or minimize root damages and that can alleviate leaf senescence or increasing photosynthesis capacity and carbohydrate accumulation during hot summer months would help to maintain healthy, green turf during hot summer. In addition, it is important to take measures to promote turfgrasses quickly recover from dormancy once temperature drops and water becomes available. Proper routine management practices, such as mowing, fertilization, irrigation, and soil cultivation, as well as selection of stress tolerance turfgrass species or cultivars are important for maintaining actively-growing turf and improving turfgrass tolerance to summer stress. In the following sections we will focus on the discussion of practicing infrequent or deficit irrigation and use of plant growth regulators (PGRs) and biostimulants to prevent or control summer stress damages in cool-season turfgrass species, as well as cultural practices to promote turfgrass recovery from summer dormancy.

PRE-CONDITIONING TURF WITH INFREQUENT OR DEFICIT IRRIGATION

Irrigation practices performed in the spring, when maximum growth of shoots and roots occurs for cool-season turfgrasses, may well dictate how well turf will perform in the summer. Irrigation frequency and quantity can affect root growth, shoot growth and the balance of roots to shoots, as well as other physiological processes, such as carbohydrate availability, thereby affecting plant tolerance to summer stress.

Allowing surface soil drying between irrigation or infrequent irrigation typically reduces water loss due to slower vertical shoot growth and stimulates root penetration into deeper soil profiles by promoting carbon allocation into roots and reducing carbohydrate consumption of the shoots. In contrast, frequently irrigated turfgrasses (soils that are kept wet constantly) use more water than turfgrasses that receive less frequent irrigation and also promotes shallow root systems, which limits water uptake from deeper soil profiles where water may be available. Deficit irrigation is applying water at the quantity lower than the maximum amount of water evapotranspired from the turf (often measured at ET rate) with little or no loss of aesthetic turfgrass quality or field playability. Deficit irrigation has been associated with increases in water use efficiency. The level of deficit irrigation, however, varies with turfgrass species, soil types, and climatic conditions. For example, some cultivars of Kentucky bluegrass were able to maintain acceptable turf quality with 80% ET irrigation while 60-80% ET irrigation was adequate for tall fescue during June-September in loamy soils in Manhattan, KS.

Either infrequent or deficit irrigation may induce mild water deficit, leading to pre-conditioning or enhancement of physiological hardiness of plants. Infrequent or deficit irrigation promotes deep rooting, facilitates water retention (osmotic adjustment) mechanisms, and activates antioxidant stress-defense systems. Such mechanisms have been found in various plant species, including Kentucky bluegrass. Therefore, infrequent or deficit irrigation may be practices in spring for effectively promoting summer stress tolerance of cool-season turfgrasses. Spring is the best time to pre-condition plants for combating summer stress.

USE OF PLANT GROWTH REGULATORS AND BIOSTIMULANTS

Plant growth regulators are synthetic hormone-synthesizing inhibitors or other synthetic compounds that regulate plants growth and development at very low concentrations. Biostimulants contain various organic solutes, such as amino acids, sugars, antioxidants, and hormones, and many biostimulant products are extracts from seaweeds or kelps. Recently, PGRs and biostimulants have received increasing attention, and have been incorporated into the management programs in promoting turfgrass tolerance to stresses. However, most research information was obtained in golf turf management whereas field research on sports turf is limited in the study of using PGRs and biostimulants in stress management.

Among PGRs, trinexapac-ethyl (TE) is one of the most widely-used products as a foliar spay for suppressing vertical growth of shoots in turfgrasses, as it inhibits the synthesis of gibberellic acid that control cell elongation. Due to the growth inhibition effects, water demand of shoots is reduced; in addition, TE application has also been found to increase chlorophyll concentration and tiller density in warm-season and cool-season turfgrasses, including Kentucky bluegrass. The research information on TE regulation of root growth is inconsistent with no effects reported in perennial ryegrass and a reduction in root growth found in Kentucky bluegrass. As the consequences of growth and physiological regulation of shoot growth, TE is also effective in reducing water consumption and delaying drought stress or suppressing heat injury in various turfgrass species, including perennial ryegrass and Kentucky bluegrass. Ervin and Koski reported that application of TE (0.27 kg a.i. ha-1) three times per year at 6-week intervals reduced weekly evapotranspiration rate in Kentucky bluegrass in 5 out of a total of 34 weeks. Pre-stress conditioning of turf with TE seems to be more effective than applying TE at the onset or during drought stress. TE may be applied to turf at reduced rates more frequently before a dry period is anticipated or prior to reducing irrigation. How TE application may alleviate heat stress damages in cool-season sport turf are not well documented and the effective frequency and rates for improving turf performance during heat stress have yet to be determined. Further investigation is required before TE is adopted in the summer management program.

Biostimulant products contain a remarkable variety of ingredients. The effectiveness of those products can vary, depending on the mode of actions of the active ingredients. Seaweed-based biostimulants are most studied, which has been found to be effective for improving drought and heat tolerance in several cool-season turfgrasses, including Kentucky bluegrass. The positive effects of seaweed-based biostimulants are mainly due to the antioxidant activities of some compounds in the biostimulants that protect plant cells from oxidative damages induced by drought or heat stress. Proper dose and frequency are critical to the efficacy of the products. Multiple applications are often necessary to increase the effectiveness of the products in alleviating summer stress.

MANAGEMENT PRACTICE TO SUSTAIN SURVIVAL AND PROMOTE RECOVERY

Extended period of dormancy in cool-season turfgrasses, particularly bunch-type perennial ryegrass without watering can cause the plants to die. Light, frequent irrigation during summer may sustain the survival and prevent death of dormant plants. Small amount of irrigation just sufficient to moist the canopy will not be able to break the dormancy, but provides enough moisture to keep the meristems of crowns alive until weather becomes cooler and more water becomes available.

It is critical for dormant turf to quickly regenerate new shoots and roots when temperatures cool down in the fall. However, limited research information is available in management practices promoting recovery from summer dormancy. Applying irrigation to soak the crown and rhizomes, as well as the root zone will help to weaken the meristematic tissues for the regeneration of new shoots and roots. Quick-released or soluble fertilizers, including phosphorus and nitrogen may be incorporated in the fall recovery program, as P provides respiratory energy for the regeneration of new tissues and N promotes growth of newly-formed tissues. In addition, some growth promoting hormones, such as gibberellic acid, may be applied for promoting recovery from summer dormancy. In our studies, we found foliar application of GA was effective in promoting shoot regrowth and turf quality recovery in creeping bentgrass following summer stress. However, gibberellic acid effects on sports turf recovery, such as Kentucky bluegrass and perennial ryegrass are yet to be determined. The doses and application frequency can vary with turfgrass species and severity of summer dormancy. ■

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UNIVERSITY TURFGRASS RESEARCH UPDATE

Over the past 5 years we have periodically published reports from some leading turfgrass researchers in the US on their current studies. Here is our latest update on such research projects.

▲ **Above:** Colorant to improve color of dormant warm-season turfgrasses. **Top Right:** Response & recovery of DBG to severe drought. **Bottom Right:** Turf paint and glyphosate application timing effects on annual bluegrass control and zoysiagrass spring green-up

KANSAS STATE UNIVERSITY

Response and Recovery of Kentucky Bluegrass Cultivars to Severe Drought with No Irrigation. In a 2-year study, we subjected 28 cultivars of KBG and two hybrid bluegrasses to 81 days without irrigation in the first year and 61 days without irrigation in the second year; plots also received very little precipitation during these periods. Our goals were to evaluate the performance of these KBG cultivars during the dry downs and their recuperative abilities after being rewatered. All 30 of the bluegrasses went completely dormant in the first year and mostly dormant in the second year from prolonged drought stress. Remarkably, all 30 bluegrasses recovered in both years, although the recovery was slower after the first dry down because of longer exposure to drought. There were no consistent differences in the performance of the 30 bluegrasses. Given increasing pressure to conserve water when irrigating turf, and the possibility of total bans on turf irrigation in some areas, a viable strategy may be to adjust our expectations to allow for some dormancy of KBG during hot, dry summers. (Drs. Tony Goldsby, Dale Bremer, Jack Fry, Steve Keeley).

» Frequency-based irrigation cycles ran three times weekly regardless of precipitation amounts, and SMS applied water only when soils dried to a predetermined threshold.

Irrigation Management and N Fertilization Effects on Water Application Amounts and Nitrate Leaching in Turfgrass. Urbanization in the US has increased the area covered with turf, causing greater concern about water amounts used for irrigation and the potential for leaching from nitrogen (N) fertilization in urban watersheds. In a 2-year study on a silt loam soil, we compared differences in water applied between traditional frequency-based irrigation and irrigation controlled by soil moisture sensors (SMS) in tall fescue turfgrass. Frequency irrigation cycles ran three times weekly regardless of precipitation amounts, and SMS applied water only when soils dried to a predetermined threshold. Within each irrigation treatment, nitrate leaching was also measured in subplot treatments consisting of N applications of urea and polymer-coated urea, each at

122 and 244 kg N ha-1 yr-1, and no N (control). The SMS-based irrigation applied 32 to 70% less water than frequency-based irrigation. No differences in nitrate leaching occurred between irrigation treatments or among N sources and leaching levels did not exceed 0.6 mg L-1, which is well below EPA thresholds. All fertilized turf had acceptable quality throughout the study. Results indicate that on silt loam soils, SMS-based irrigation saves water compared to standard frequency-based irrigation while providing acceptable quality, and nitrate leaching is negligible. (Josh Chabon, M.S. and Drs. Dale Bremer and Jack Fry).

▲ **Late-season bermudagrass** control with glyphosate, fluazifop and mesotrione combinations for spring renovations

Irrigation Management, Cutting Height, and Primo Effects on Mowing Requirements of Tall Fescue. In-ground irrigation systems are often mismanaged, resulting in excessive application of water. In this 2-year study, we evaluated mowing requirements of tall fescue irrigated using frequency-based irrigation and irrigation controlled by soil moisture sensors (SMS). Frequency-based irrigation cycles ran three times weekly regardless of precipitation amounts, and SMS applied water only when soils dried to a predetermined threshold. Within each irrigation treatment, we evaluated mowing at 5.1 cm or 8.9 cm, based upon the 1/3 rule, with or without monthly applications of Primo. In 2012, tall fescue mowed at 5.1 cm and treated with Primo required three fewer mowings than untreated turf mowed at 5.1 cm; at an 8.9 cm cutting height, only one fewer mowing resulted after Primo application. Mowing at 8.9 vs. 5.1 cm, or using Primo vs. not resulted in a 9% reduction in total mowings required in 2013. (Josh Chabon, M.S. and Drs. Dale Bremer and Jack Fry).

Nitrous Oxide Emissions and Carbon Sequestration in Turfgrass: Effects of Irrigation and N Fertilization. Nitrous oxide (N_2O) and carbon dioxide (CO_2) are important greenhouse gases that have been implicated in global climate change, and N_2O is the most important ozone-depleting substance in the atmosphere. Turfgrass covers ~50 million acres in the USA and is typically fertilized with nitrogen and irrigated, which may result in significant N_2O emissions. Turfgrass also has the capacity to sequester or emit CO_2 from/into the atmosphere. We are beginning a 3-year study to measure N_2O emissions and carbon sequestration from turfgrass when fertilized with different nitrogen (N) fertilizer types (urea and poly-coated N) and different irrigation regimes. The use of slow-release N fertilizer and deficit irrigation may mitigate N_2O emissions from turf, although deficit irrigation may also reduce carbon sequestration. Therefore, it is important to measure N_2O fluxes and carbon sequestration in turfgrass managed under various combinations of deficit irrigation and fertilized with urea or slow-release N. Our goal is to develop smarter management practices that may reduce N_2O emissions from turfgrass and enhance carbon sequestration in turf soils, which could help mitigate climate change and atmospheric ozone destruction. (Ross Braun, M.S. student, and Drs. Dale Bremer and Jack Fry).

Rough Bluegrass Physiology and Control. Rough bluegrass (RBG, *Poa trivialis* L.) is a difficult-to-control weed that commonly develops in cool-season turfgrasses due to vegetative propagation of stolons and contamination from seed lots. Rough bluegrass is less tolerant of heat stress than desirable cool-season species such as tall fescue (TF), and often declines during mid-summer due to biotic or abiotic stresses. The objectives of these 2011-2013 controlled environment and field studies were to 1) observe growth and physiological differences between 'Laser' and 'Pulsar' RBG and TF; 2) differentiate between physiological and pathological contributors to RBG decline; 3) determine the effects of TF seeding rate and mowing height on TF/RBG establishment when RBG is a seed contaminant; 4) evaluate herbicide combinations for selective RBG control; and 5) evaluate seasonal timing of glyphosate for nonselective RBG control. Tall fescue was less affected by elevated temperature than RBG. When subjected to 35°C, Laser and Pulsar experienced similar reductions in quality, gross photosynthesis, shoot and root biomass, and root length density compared to when grown at 23°C. Evaluation of RBG foliage and roots did not reveal a fungal pathogen associated with RBG decline. Still, repeated applications of strobilurin fungicides increased RBG quality and cover during summer compared to untreated RBG, possibly due to poorly understood non-target physiological effects of the fungicides. Mowing TF at 7.6 or 11.4 cm reduced RBG incidence up to 57% compared to mowing at 3.8 cm. Tall fescue seeding rate had no effect on RBG incidence. Several herbicides and herbicide combinations provided transient RBG control in the field, but Velocity was the only treatment that provided RBG control (16 to 92%) in Manhattan, KS; Hutchinson, KS; and Mead, NE. Spring-applied glyphosate resulted in the lowest RBG coverage (1 to 31%) among field studies in Manhattan and Mead, followed by late-summer applications (6 to 58%), and mid-summer applications (9 to 86%). (Drs. Cole Thompson, Jack Fry, and Megan Kennelly; Univ. of Nebraska Cooperators: Dr. Zac Reicher, Mr. Matt Sousek).

Using Colorants to Improve Color of Dormant Warm-Season Turfgrasses in the Transition Zone'Chisholm' zoysiagrass (*Zoysia japonica*) is a new cultivar that is well adapted to the transition zone, with low maintenance requirements, and good quality and drought resistance. However, some turf managers object to the brown color of dormant Chisholm. The objective of this experiment was to determine if turfgrass colorants or overseeding could enhance winter color. Field studies were conducted in Manhattan and Haysville, KS from October 2012 to May 2013. Treatments included the colorants Green Lawnger and Ultradwarf Super, applied once (autumn) or twice (autumn plus mid-winter), annual ryegrass overseeding, a tall fescue control, and an untreated control. For the fall application, colorants were applied at a dilution rate of 1:6 (colorant:water) at 1225 L/ha on 21 October (turf 5-10% green) in Manhattan and 31 October in Haysville. Mid-winter applications were done on 23 January in Manhattan and 5 February in Haysville. Prior to overseeding, turf was vertically mowed, then seeded with annual ryegrass at 488 kg/ha on 28 September in Manhattan and on 11 October in Haysville. Visual color was rated weekly on a 1 to 9 scale in which 1 = straw brown; 6 = acceptable color, and 9 = dark green. A single application of Green Lawnger provided acceptable color for 14 weeks after treatment (WAT) at both sites. At 14 WAT, a second application resulted in acceptable turf color until spring green up in early May. Ultradwarf Super applied once provided acceptable color for 6 WAT in Manhattan and 10 WAT in Haysville, resulting in an 8 and 4 week period, respectively, of unacceptable color until the second application. Overseeding provided 4 weeks of acceptable color beginning 4 weeks after seeding in Manhattan, but color was not acceptable in Haysville. Chisholm color was enhanced with colorant application, which could make this cultivar more desirable. (Ross Braun, M.S. student, and Drs. Jack Fry, Megan Kennelly, Dale Bremer, and Jason Griffin).

Late-Season Bermudagrass Control with Glyphosate, Fluazifop and Mesotrione Combinations for Spring Renovation. Common non-selective bermudagrass removal recommendations include multiple applications of glyphosate, while bermudagrass is actively growing. This application results in non-aesthetically pleasing and non-functional turfgrass throughout the summer. Turfgrass managers do not always have the opportunity for this application timing. Two research trials were initiated in Fall of 2013 in Manhattan, KS to determine non-selective bermudagrass control with glyphosate, fluazifop and mesotrione combinations prior to winter dormancy. Individual and all possible combinations of glyphosate, fluazifop and mesotrione applications were conducted October 9, 2014. Any treatment containing glyphosate resulted in <25% green cover 7 days after application. By October 31, 2013 all treatments including the non-treated resulted in <5% green cover. Final results could potentially provide new herbicide combinations for Fall bermudagrass control for Spring renovation. (Drs. Jared Hoyle and Cole Thompson)

'Cody' Buffalograss Tolerance to Combination Post-Emergence Herbicides. With the increase pressure to reduce irrigation on turfgrass systems, a low-input turfgrass species, buffalograss, has become more widely accepted in the Mid-West. Although, options for sedge, broadleaf, and grass weed control in buffalograss are limited and applications have previously resulted in unacceptable buffalograss injury. Experiments were conducted in 2013, in Haysville, KS to evaluate 'Cody' buffalograss tolerance to various broad-spectrum postemergent herbicides. 'Cody' buffalograss was maintained at 7.6 cm and irrigated as needed. Not all herbicides used in this study are labeled for use on buffalograss. Rates of herbicides were either maximum labeled rate or maximum labeled rate for a labeled warm-season turfgrass. Herbicide treatments included Celsius, Katana, Q4Plus, Speed Zone, Surge, Trimec Classic, T-Zone, Drive XLR8, Battleship III, EndRun, Solitare, Dismiss, QuickSilver, Blindside, and SquareOne. Plots were treated with herbicides on July 1, 2013. No buffalograss injury was observed 7 DAT with Katana or QuickSilver. Slight buffalograss phytotoxicity (0 to10%) was observed 7 days after treatment (DAT) on research plots treated with Celsius, Q4Plus, Surge, Drive XLR8, Solitare, Dismiss, Blindside, and SquareOne. Applications of Speed Zone, Trimec Classic, T-Zone, Battleship and EndRun resulted in > 14% buffalograss phytotoxicity. By 28 DAT all herbicide treatments excluding SpeedZone (< 10%) and T-Zone (< 5%), resulted in no buffalograss phytotoxicity. With the increasing use of buffalograss in low-input turfgrass systems, combination herbicides may cause slight injury but are a viable option for weed control. (Dr. Jared A. Hoyle)

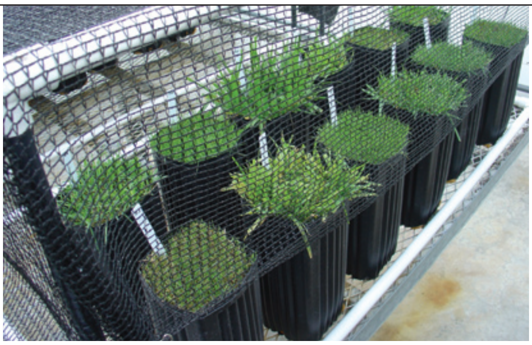
Turf Paint and Glyphosate Application Timing Effects on Annual Bluegrass Control and Zoysiagrass Spring Green-up. Turfgrass managers commonly apply glyphosate on dormant zoysiagrass to control winter annual weeds. More recently, turfgrass managers are using paints and pigments to color dormant zoysiagrass throughout the winter months. Glyphosate application on dormant zoysiagrass is well documented, but information about the interaction of glyphosate and paint applications is lacking. A field study was conducted to evaluate the effects of glyphosate and glyphosate + Endurant (Turfgrass Colorant) timing applications for annual bluegrass control and zoysiagrass spring green-up. Treatments included a non-treated, glyphosate and glyphosate + Endurant applications applied in November, December, January and February (9 total treatments). Initial results indicate that all glyphosate and glyphosate + Endurant applications, across all timings, reduced annual bluegrass populations. Previous research has shown that early applications of glyphosate on zoysiagrass when turf is not completely dormant can result in delayed spring green-up and injury. Initial zoysiagrass Spring green-up observations demonstrate that the addition of Endurant to glyphosate at early applications (November) may increase glyphosate safety on zoysiagrass. (Dr. Jared A. Hoyle and Mr. Jake Reeves)

UNIVERSITY OF FLORIDA

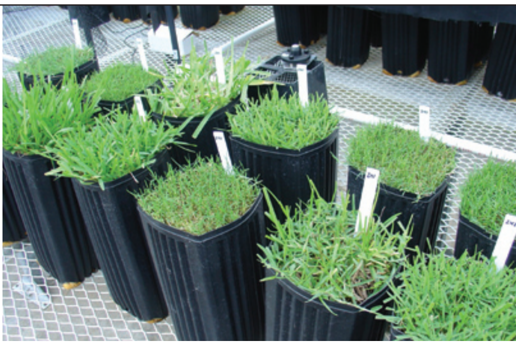
Daily Light Integral Requirements for 12 Warm-Season Turfgrasses. This study was conducted by Brian Glenn and Jason Kruse, PhD, University of Florida, Gainesville; and J. Bryan Unruh, PhD, University of Florida, Jay, FL.

If you have it, shade can cause turfgrass maintenance challenges on athletic fields. After water, temperature, and nutrition requirements are met, light interception is the growth-limiting factor for turfgrass. In many cases, shade on athletic fields can be caused by stadium superstructure resulting in various microclimates on the field as the sun moves across the sky. Stadiums that may experience these areas are increasing, as many sports are trying to improve game-day comforts using air conditioning and retractable roofs. Shade can be even more detrimental when using warm-season turfgrass, which require more sun for optimal growth (Figure 1). As these turfgrasses sense cues

▲ **Figure 1.** Shade on bermudagrass



▲ **Figure 2.** Twelve warm-season turfgrass species under 30% shade



▲ **Figure 3.** Twelve warm-season turfgrass species

associate with lower light, they begin to react and try to "grow out" of shaded conditions. This is usually seen as elongated, thin leaves, and can lead to unsightly scalping. If light levels are not increased, turfgrass quality will eventually begin to decline.

Daily light integral, or DLI, is a method of measuring light that quantifies total light intensity accumulated during the course of a day. It is measured in moles of light per meter squared per day (mol/m2/day). In the past, light has been reported in hours of full sun or percent shade. These are often vague as incoming solar radiation changes periodically due to sun movement, cloud cover, and changing shadows caused by objects such as buildings and trees. DLI is a more precise method to evaluate available light in a given location on the field, as it takes into account the dynamic nature of shade.

To put DLI into perspective, the average summer ranges are 40-45 moles in the eastern U.S., and can get as high as 60 moles in parts of the southwestern US. These ranges can fall significantly during the winter months. In certain areas where warm-season turfgrass is grown year-round, ranges can drop to as low as 15 moles. If these levels are already marginal for growing a specific turfgrass in your area, reductions in light caused by shade can further impact turf quality and growth.

By using some light-monitoring equipment, turfgrass managers can easily determine exactly how much light is falling on a particular site. The question becomes, how can this information be used to make more informed decisions about turfgrass management from a species standpoint? We set out to determine threshold light levels using DLI to maintain quality turfgrass. We also wanted to see how much temperature impacted these DLI requirements, so that managers could determine if the amount of light measured was adequate for their turf, no matter the time of the year.

Greenhouse trials were conducted at the Turfgrass Envirotron at the University of Florida over 2 years to evaluate minimum DLI requirements to maintain acceptable turfgrass quality for twelve warm-season turfgrasses (Figure 2). Four treatments (0%, 30%, 60% and 90% shade) were used to develop a light gradient to determine the point at which turfgrass quality becomes unacceptable (Figure 3). These grasses were shaded for a period of two months. All treatments simulated either summer or winter average temperatures in south Florida (87 F and 74 F, respectively).

When DLI requirements were calculated after the trials were completed, there was a substantial difference between the summer and winter ranges (Table 1). The highest requirement from the grasses that were included was 22 moles, where that number dropped down to around 11 moles during lower temperatures. Turfgrasses in both temperatures were actively growing, but the samples in the cooler environment seemed to tolerate shade better. The answer can most likely be attributed to lower energy demands on the turf with lower temperatures, allowing the plant to maintain quality without as much light.

▲ **Figure 4.** DLI100 Light Meter from Spectrum Technologies.

Many of the results when comparing grasses were expected based on past research and observations. Bermudagrass had the highest light requirements, while the zoysiagrasses had the lowest. Some of the species that were selected for the studies are marketed for their "shade tolerance," including Celebration and TifGrand bermudagrasses.

Now that we have an idea of the relative light requirements for different grasses, how can they be used? With the right tools, this information can help turfgrass managers establish a starting point when dealing with shade on their fields. One instrument that can be used is a small light sensor that measures DLI over a 24 hour period (Figure 4). After a few days of monitoring, the average DLI can be determined for the site. Multiple units can be used across a field if various microclimates exist. If the DLI is below the requirement for the given season and declines in turf quality have been observed, a different turfgrass species with a lower DLI requirement may be recommended.

These values are an approximation for each of the species tested, but different factors can potentially alter DLI requirements for a specific grass. Low mowing heights could lead to unacceptable turfgrass quality, even with an acceptable amount of light. Using a plant growth regulator (PGR) could lead to higher quality under lower light levels. Minimum acceptable quality may also not be acceptable on high profile sports turf, so these requirements may need to be adjusted according to expectations. When used for comparison purposes, these values can help managers determine if quality issues are a product of shade or if another possibility should be considered.

Research using DLI is ongoing, including determining the effect of different mowing heights on DLI requirements within the same species. New information using DLI could potentially help managers account for the effects of low light on turfgrass growth. Raising mowing heights, applying PGRs, and other cultural practices could be proactively altered to maximize turfgrass health and minimize negative effects due to shade and other reductions in light. ■


▶ Dimple seeding

▲ **Adding** ≤ inch of topdressing


▲ **First day** of mowing 20 days after seeding


▲ The organic layer

FROM SEED TO PLAYING IN 35 DAYS

JUST 35 MILES NORTHWEST OF WASHINGTON, DC, sits an athletic oasis. Each year, thousands of athletes from around the world visit the Maryland SoccerPlex, a 600-acre park consisting of 22 pitches. The facility includes 16 native soil pitches (9 cool season, 7 bermudagrass), three sand-based pitches (1 cool season, 2 bermudagrass), and three synthetic fields. The Soccerplex has hosted everything from MLS Open Cup matches to the University of Maryland rugby team.

In the heart of the facility sits the Maureen Hendricks Field. In 2012, our crew decided that even though the stadium pitch was good, it could be better. The end goal of our thinking was for the pitch to be able to sustain more use while requiring less water and fungicides.

To make the pitch the best that it could be it needed to be renovated due to three main reasons: to remove the built-up organic layer, to eradicate the inherited *Poa annua* population, and to return the pitch to its original grade.

The pitch consisted of a 4-inch heavy organic layer. This layer was comprised of 11/2-inch thick cut sod and 21/2 inches of organic build-up that was consistent with all fields in our complex over a 12-year span. Clippings and the use of low-quality organic compost caused this organic layer. By removing the 4-inch heavy organic layer, it would increase drainage capacity and air movement and reduce the compaction potential. The original pitch also had stability fibers mixed into the soil profile, but with the existing 4-inch layer, those fibers were not being used. By removing the layer, the grass roots would be able to wrap around those fibers to give the pitch a more durable playing surface, allowing it to handle more traffic.

Removing the inherited*Poa* infestation would make the field more aesthetically pleasing and be able to sustain more traffic. It would also reduce the stress tolerance of the pitch and the water use. Not only would the pitch use fewer pesticides, but would also be less susceptible to winter injury.

The third reason for the renovation was to return the field to its original grade, which is essential for a successful pitch. Due to the inconsistent grade, there were major drainage issues, such as puddling and unhealthy turf. Getting back to the original grade would allow for an ideal drainage pattern, allowing the water to move smoothly across the surface grade and to filter into the soil.

Factors	Seed	Sod
Cost (approximate)	Ft^2=$17.77 Total Seed Cost=$1,600	Ft^2=$833.33 Sod/Trucking =$60,000 Sod Install=$$15,000 Total Sod Cost=$75,000
Timeline	Variable grow-in times Newer seed technologies boast faster germination and establishment	"Quick Fix" Playable in 1-2 weeks
Layer Issue	No layer created from immediate seed-to-soil contact	Virtually impossible to match sand of the sod to the sand of your existing profile Creates inevitable layering problems, drainage and air exchange issues

Growth Chart

Renovation Process	
1. Cut out existing field	8. Roll second time
2. Topdress 3/4" 100% sand	9. Initial granular fertilizer
3. Laser Grade	10. Topdress 1/4" (85% sand 15% peat)
4. Recycle Dress	11. Apply paper mulch
5. Mesh Drag	12. Water
6. Roll	13. Foliar fertilize
7.Seed	14. Mowing

Revovation Process Chart

After the issues of the existing pitch were determined, the problem solving stage came next. Would there be a full renovation to cut out the existing field and replace it, or would there be gradual amendments used, such as core aerification, topdressing and overseeding? Because the organic layer was too large and the *Poa* infestation was too severe to reduce without the use of chemical control, the gradual amendment option was thrown out.

When deciding to go with a full renovation there were two options, sod or seed. Below is a chart of the factors that went into determining whether we should seed or sod the pitch:

European influence also had an impact on the decision making process. Many premier pitches in Europe renovate annually and are considered to be some of the best in the world. They are all almost exclusively done with seed. When our crew talked to a European field expert, he asked us, "Why would we sod when we had this open window of time to seed?" Seeding is the "norm" across the pond, and they simply could not understand why we debated between the two.

Not only were we looking at all options, but we also wanted to challenge ourselves in the whole process. The general consensus was that we had to sod. We heard doubt from all angles when we proposed growing a stable Kentucky bluegrass stand and prepare it for use in just 35 days. Our different ways of thinking pushed us past the "norm," and our crew began to think that this would be a great opportunity to push the envelope and test the newest grass genetic technologies out there.

The final decision was to go ahead and seed the field because using the European-style renovation that many top-level clubs have used interested us. There was also an up-front savings that was too large to ignore, and growing from seed would eliminate any potential sod layer. Choosing this option defied the perception that seeding could not be done. A 35-day grow-in was achievable with the new grass genetics, and it would also challenge us professionally. When deciding to seed, the renovation process was then planned out completely.

The existing field was cut out on the first pass at a 2-inch depth. This removed the top 2 inches of the sod layer. After the first initial cut out was done, the second pass was started, removing the remaining organic layer and exposing the original sand/stability fiber mix.

Using a Speedresser, the pitch was topdressed with 3/4-inch with USGA spec 100% sand. The pitch was then laser graded, which removed all accumulated material and exposed the original grade.

Once the laser grading was complete, a recycling dresser was used to incorporate the new 100% sand with the existing sand, which contained the fiber mix. This process refreshed the existing sand with the new material and combined the new sand with the fibers.

A mesh drag was then used to break up the clumps and bunches of soil and fibers. Following that, a three-ton double-drum roller was used on the pitch. By doing this, we created a stable base for the seeding and topdressing equipment.

▲ **These photos** were taken on day 8 of the process. The picture on the left was taken at 10 am; after that photo, a package of biostimulants was applied to the field. The picture on the right was taken at 2 pm of that same day.

Next came the most important part of the renovation, seeding. All seed that was applied had a Germinex seed coating powder. Three separate varieties of Kentucky bluegrass were used at 5 lb/M. The new genetics in Kentucky bluegrass allows for rapid germination, aggressiveness, disease tolerance, and early spring green-up. The seed was applied with a tractor-mounted dimple seeder. Because of a heavy rainstorm that was going to hit the Maryland area later in the week, a new variety of Perennial ryegrass was applied to the pitch with a rotary walk-behind spreader at 1 lb/M. This was applied because of its quick germination and stolon production, which accelerated stabilization.

The pitch was then ready for the second roll using the same three-ton double-drum roller as before. When seeding, the dimple seeder loosened the soil when it created the seedbed. By rolling, it stabilized the material and promoted maximum seed-to-soil contact. Seed-to-soil contact is the key to a fast, successful grow-in.

As soon as the field was cut off, a soil test was conducted. We wanted to make sure that we kept our fertilization program simple and gave the plant exactly what it needed. The first granular fertilizer application was on the first sign of germination. A 19-0-19 50% slow release was applied for the plant to have a base and equal ratio of nitrogen (N) and potassium (K). We also wanted the roots to have a consistent diet. On day 5 after germination, an 18-24-12 was applied to add phosphorus (P) to promote root growth. On day 10, another soil test was taken because of the amount of water that had been put on the pitch to promote seed germination. This test showed that the pitch was still lacking P and was deficient in magnesium (Mg), so on day 14, Crystal Green 5-28-0 10% Mg was applied. On day 21, a 19-0-19 50% slow release was applied.

The second topdressing pass consisted of ¾-inch 85% sand and 15% peat mix. Using the small amount of peat helped to hold moisture for the seed to germinate and establish.

▼ **10 weeks** after seeding for ACC Men's Championship Game.

Paper-based biodegradable mulch was then put out over the pitch by using a topdresser. This was used because the area was anticipating a heavy rainfall event. This material aided in preventing seed from washing away.

Initially, the water program was very heavy. The water needed to "set-in" the profile and break the seed coat, which also promotes germination of the seed. After the initial germination, there were continual cycles of water, keeping seed moist through the germination and establishment process. Gradually the water was backed off, forcing the plant to push roots.

Foliar fertilization allowed us to give the plant what it needed at the exact moment in time. A package of biostimulants that was prescribed specifically for each growth stage was applied. Biostimulants are organic products (plant hormones, carbohydrates, amino acids, and anti-oxidants) that assist the plant in the respiration and photosynthesis process. By using these hormones, the pitch could be grown in an efficient, healthy way. If only N was mostly used, the shoot growth would have been pushed. We were more concentrated on root mass/growth and strong cell walls to aid the plant to withstand heavy traffic.

During post-germination, the pitch was sprayed on a 4-day cycle. This provided the plant with what it needed, without expending the energy to create it. The package of biostimulants was to acclimate the plant and to make it wake up. This is equivalent to humans waking up and drinking a cup of coffee in the morning, or taking daily vitamins.

The first cut of the pitch was 20 days after seeding with a Denis Pedestrian mower until day 30, when a triplex mower replaced it. We cut the pitch every 2-3 days at 1 inch and then worked our way down to 9/16 inch where the height stayed the rest of the 2012 and 2013 season. This height was maintained to force the plant to grow sideways.

It was evident after 20 days with the amount of growth and density already visible on the pitch, that a 35-day grow-in was possible. With great seedbed preparation, water use, consistent mowing, and a foliar fertilization plan that was focused on healthy plant growth and root development, a playable, dense and tight playing surface was on its way to being fully developed. This process not only made us learn about new technologies in our industry, but it also taught us that going against the "norm" can lead to an outcome that could change our way of thinking forever. Like all projects and renovations, we learned many lessons. Looking back, there are two things that we would do differently, if the pitch were to be renovated to this extent again. The pitch would not have had the Perennial ryegrass spread out. The Kentucky bluegrass would have withstood the rainstorm that we had expected that week. It also would have received a second topdressing that consisted of 100% sand instead of the ¾-inch mixture of 85% sand and 15% peat mix. By mixing in the 15% peat, a minor layer was created on the pitch. To fix this problem, the stadium pitch was fraze mowed at ¼ inch in the fall of 2013 after withstanding 167 events in 6 months.

In the past two years, our industry has had new technology and new grass genetics introduced. Because of this, seeding is possible! Thinking outside the box can turn impossibility into possibility. Thanks to using new technologies, plant feeding, and soil stabilization, 11 weeks after seeding, the Maureen Hendricks Field held 20 events in 14 days, including the ACC Men's Soccer Championships.

Each season and field provides new lessons to all of us, but with creative thinking, extensive research, and trial and error, all problems can be solved. It is important to keep an open line of communication with directors, players, and coaches, which will allow everyone to be comfortable with the renovation at hand. Most importantly, it helps to have a positive mindset through the good and the bad. You must believe in what you are doing because if you don't, why should anyone else? If a problem arises, learn from it and move on in order to fix that problem. It is so important to meet old challenges with new creative and energized attitudes.

M.C. Escher once said, "Only those who attempt the absurd, will achieve the impossible." It is up to each and every one of us to continue to improve fields and open the minds of others to the idea that grass fields can and will take more traffic. ■

Presented at the 2014 STMA by Julie Adamski, director of retail and professional development for Sod Solutions, Inc., and Ryan Bjorn, director of grounds and environmental management at the Maryland SoccerPlex..

POST-EMERGENT HERBICIDE Q&A

Cor an overview of post-emergence weed control, including herbicide selection and overall application strategies *SportsTurf* recently sought the insights of Ken Hutto, technical service manager at FMC Professional Solutions.

SportsTurf: Have there been noticeable changes in post-emergent control results since MSMA was banned?

Hutto: MSMA was a valuable tool for postemergence weed control. It provided effective control of annual and perennial grass weeds, but could also be used for nutsedge, kyllinga, and certain broadleaf weeds.

The biggest void created when MSMA restrictions were issued was getting effective postemergence perennial grass control, most notably of dallisgrass. Since then, controlling dallisgrass has changed dramatically, not only because of the products now available, but because of when those products are applied. MSMA was solely used in the summer months, but some of the newer products are recommended for use in the fall and early summer for effective dallisgrass control. It is a change in application philosophy.

SportsTurf: Please share your general post-emergent herbicide strategies for cool-season and warm-season athletic turf.

Hutto: Establishing a competitive turf is a must for successful long-term weed control. A close second is correct weed identification. What looks like crabgrass may not be crabgrass! Many grasses without a seedhead look like crabgrass. If you do not know what you are dealing with, how will you know what products are most effective?

Not all grass herbicides control all grasses. Likewise, some broadleaf weed materials will control prostrate knotweed better than others. In general, postemergence herbicides are most effective when the target weeds are in young growth stages. Depending on the sport, turf type and weed, sports turf managers may not be able to make postemergence treatments during this life cycle stage due to play. If possible, delay mowing events one day on each side of the application to ensure maximum herbicide absorption into the target weed.

Resistant weeds are becoming more and more prevalent, so rotating modes-of-action is important if other options are labeled for use in the desired turf. When interseeding, be aware of seeding restrictions on herbicide labels, as some postemergence herbicides may negatively impact new seedling establishment if applied too early in seedling development.

Lastly, don't forget about cultural practices! Aerifying high traffic areas to alleviate compacted areas will aid in reducing environments conducive to goosegrass.

SportsTurf: Are there different products and/or strategies for post-emergence control of grassy weeds and broadleaf weeds?

Hutto: There are probably more broadleaf weed herbicide options than grass herbicide options. Choosing the right postemergence herbicide will depend upon what weed spectrum you are dealing with.

Your most common three-way postemergence broadleaf weed herbicides can be used in most cool and warm-season turf and can be very effective. However, having such a wide range of turf tolerance is not always the case for postemergence grass herbicides.

For example, Solitare herbicide can be used for postemergence crabgrass, broadleaf, and nutsedge control in both cool and warm-season turf. Some sulfonylurea herbicides can be used for goosegrass control, but only in warm-season turf. Some of the newer "bleaching" herbicides are primarily labeled for cool-season turfgrass use.

Understanding your weed spectrum and what products are available for use in your specific turfgrass will be a big part in developing an effective weed-control strategy.

SportsTurf: Are there any new post-emergent herbicides near market that you can discuss?

Hutto: FMC is always working diligently to bring the next customer driven innovation to market. Our goal is to help turfgrass managers be more efficient in their weed-control programs. ■

Hutto joined FMC in 2007. He received a Bachelor of Science degree in Microbiology from Auburn University and Master of Science and Doctorate degrees in Weed Science specializing in Turfgrass Weed Management from Mississippi State University. After receiving his PhD, he worked at the University of Florida as a post-doctoral research associate at the West Florida Research and Education Center, conducting research in turfgrass science.

◄ Ken Hutto, PhD

POST-EMERGENT HERBICIDE Q&A

For an overview of post-emergence weed control, including herbicide selection and overall application strategies *SportsTurf* recently sought the insights of Dean Mosdell, PhD, field technical manager — west, at Syngenta Lawn & Garden.

SportsTurf: Have there been noticeable changes in post-emergent control results since MSMA was banned?

Mosdell: Weed control strategies have changed slightly. MSMA provided an inexpensive solution for many monocot weeds. Strategies may have greater emphasis on making pre-emergence more effective, such as timing or split/multiple applications. There are several post-emergence herbicides available for warm and cool-season turf, but are narrow in spectrum and/or safety on various turf species. The biggest gap in weed control without MSMA is dallisgrass control in cool-season turf.

SportsTurf: Please share your general post-emergent herbicide strategies for cool-season and warm-season athletic turf.

Mosdell: Selection is based on weeds present and turf type. Any strategy would need to consider turf type, weed targets and best timing for weed control that works into the use schedule and maintenance program of the athletic field.

SportsTurf: In general, what is the best strategy for post-emergence weed control?

Mosdell: Again, strategy would be based on weeds present and turf type. Dicot weeds can be controlled with pre-mixes of growth-regulating-type herbicides such as 2,4-D, dicamba, triclopyr, MCPA and others. There are numerous mixes that vary in ratios and components of these herbicides to improve the safety on certain turf types. There are fewer options to control grass weeds post-emergence. The most common summer annual grass is crabgrass. Options for control include products that contain quinclorac, or Tenacity and Acclaim herbicides. On warm-season turf, other options include ALS-inhibiting herbicides such as Monument or pre-mixes of several of these ALS herbicides. Older triazine chemistry is still used on warm-season turfgrasses. It's important to read the label for safety on turf species as they vary widely and mixtures may further reduce labeled turf species.

SportsTurf: Are there different products and/or strategies for post-emergence control of grassy weeds and broadleaf weeds?

Mosdell: Yes, with few exceptions most post-emergence herbicides are effective on either dicots or monocot weed species. Tenacity herbicide, with pre- and post-emergence activity, will control crabgrass as well as dandelion, oxalis and speedwells. In the herbicide screening process it is difficult to select for a broad spectrum grass herbicide to control a grass weed in turfgrasses since their physiology is similar. An effective strategy is to use a pre-emergence herbicide and treat any escapes of grass weeds with a post-emergence. There are man y effective post-emergence herbicides to control dicot weeds. Best strategy is to maintain a healthy turf stand and control any dicot weeds that pop-up with a broadleaf herbicide. There are many to choose from depending on weed species and turf type.

» I think in the near term there will be mixtures of post-emergence herbicides, similar to the broadleaf herbicide products, to improve spectrum, efficacy and turf safety. With the loss of MSMA in several markets, opportunities exist for new post-emergence grass herbicides.

SportsTurf: Are there any new post-emergent herbicides near market that you can discuss?

Mosdell: I think in the near term there will be mixtures of post-emergence herbicides, similar to the broadleaf herbicide products, to improve spectrum, efficacy and turf safety. With the loss of MSMA in several markets, opportunities exist for new post-emergence grass herbicides. ■

Dean Mosdell, Ph.D. is field technical manager <dash> west, for the Syngenta Lawn & Garden. His responsibilities include product stewardship, field testing and technical support of Syngenta products in turf markets for the western United States. Mosdell has more than 25 years of experience in developing plant growth regulating products for application on turfgrasses, including the introduction of the first PGR for fine turf. He holds both a BS and an MS degree in Agronomy (Turfgrass Specialty), from Virginia Tech in Blacksburg, Va., and a Ph.D from Purdue University in West Lafayette, Ind.

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SALT SOURCES IN IRRIGATION WATER

Nearly all waters contain trace levels of salts, which dissolve into water as a result of mineral weathering in the earth's surface. In addition, water runoff from urban and agricultural lands during storm and irrigation events can also impact water quality. Salinity, or the presence of salts, within irrigation water can impact plant growth and soil structure. The salinity of water sources vary (Table 1) as do the influence of various trace elements that combine with salts to make up the total salinity or salt presence within your water source.

» **Storm surge related flooding could directly induce salinity problems** in land previously free of such issues via storm water runoff.

The total salinity of a water source is contributed by cations and anions. Common elements that contribute to salinity include calcium (Ca^{2+}), magnesium (Mg^{2+}), sodium (Na^{+}), potassium (K^{+}), chloride (Cl^{-}), bicarbonate (HCO_3^-), carbonate (CO_3^{2-}), sulfate (SO_4^{2-}), and others.

NATURAL WEATHER PATTERNS

Salts are commonly found in coastal area soils and water bodies. Fluctuating tides influence fresh surface water sources and soils with shallow groundwater levels. Natural saline aquifers can also be close enough to the surface that it is very tricky to determine proper well depth. Further inland are deeper saline aquifers (commonly found out west) that are used alone, and or blended with fresher water for irrigation purposes.

Rainfall contains few salts, and is nature's way to remediate soil salt accumulation. Humid regions that are inland from the coast, receive plenty of rainfall and thus the soils do not experience any long-term salt accumulation. Arid climates, where evapotranspiration (ET) demand far exceeds rainfall, are another hot spot for salt issues. As water is lost from the soil via ET, the salts accumulate in the soil profile and near the soil surface.

Grasses that naturally grow in arid conditions or in coastal environments are adapted to living under moderate to high salt conditions. For example, bermudagrass, zoysiagrass, and buffalograss all have leaf glands that excrete excess salts.

▼ **Table 1.** Salinity values of various water sources reported for total dissolved salts in parts per thousand (ppt) and parts per million (ppm), and as electrical conductivity (EC) in uS/cm, and mS/cm.

	ppt	ppm (mg/L)	µS/cm (µmhos/cm)	mS/cm (mmhos/cm, dS/m)
Most freshwater streams	< 1	< 1000	100-2000	0.1 – 2.0
Distilled water			0.5 -3.0	0.0005 – 0.003
Water supply limit	0.5	500	782	0.782
US salt concentration limits in drinking water	1	1000	1560	1.56
Melted snow			2- 42	0.002 – 0.042
Typical limit for irrigation	2	2000	3130	3.13
Brackish: mild	1 - 5	1000 - 5000	1560 - 7810	1.56 – 7.81
Brackish: moderate	5 - 10	5000 - 10,000	7810 -15,600	7.81 – 15.6
Brackish: heavily	10 - 35	10,000 - 35,000	15,600 – 54,700	15.6 – 54.7
Sea water	> 35	> 35,000	55,000	55
Brine	> 50	> 50,000	78,100	78.1

Certain regions also experience the opposite of a salinity issue, in that some water sources do not have *enough* salts. Many inland regions of the U.S. have ground and surface water that is so low in salts that remedial actions are needed to alleviate the "salt-less" condition.

Hurricanes and extreme storm events also introduce salts into soil and aquifers. Storm surge related flooding could directly induce salinity problems in land previously free of such issues via storm water runoff. Saltwater intrusion into subsoil and groundwater aquifers can increase when storms produce differential hydrologic heads. Salt removal can occur naturally, aided by rainfall and leaching, but extended dry periods following such storm events often intensify negative salt effects on plants.

Seasonal weather patterns (dry summers) may also induce temporary salt issues. During this period, salts may accumulate in the soil profile if not properly irrigated to leach the salts. Fortunately, this is an issue only in extreme cases, due to the returning rains in fall.

ANTHROPOGENIC SOURCES OF SALTS IN IRRIGATION WATER

Groundwater drawdown by urban and agricultural water use has contributed to saltwater intrusion into the underlying aquifer. Fresh water bodies that are influenced by tides are susceptible to saltwater intrusion occurring further upstream than normal as freshwater uses increase in urban areas. When this water is used for irrigation, it contributes to the salt levels in landscaped areas.

Parameter (units)	# of samples analyzed	Range	Average
	ESSENTIAL NUTRIENTS		
Nitrate-N (ppm)	14	6.8 - 18	13.0
Ortho-P (ppm)	14	1.2 - 3.7	2.5
Potassium (ppm)	12	10.3 - 25.0	12.7
Calcium (ppm)	14	42.3 – 70.7	54.6
Magnesium (ppm)	12	3.5 – 4.0	3.8
Sulfate (ppm)	12	26 - 40	30.5
Sodium (ppm)	14	56 – 79	63.4
Chloride (ppm)	14	55.5 – 80.9	66.6
	INDICATORS AND OTHER CONSTITUENTS		
pH	12	6.9 – 7.7	7.2
TDS (ppm)	12	384 - 467	418.8
EC (mmhos cm-1)	14	0.58 -0.73	0.65
SAR	12	1.9 – 3.1	2.3
Bicarbonates (meq L-1)	14	0.01 – 1.80	1.05
Carbonates (meq L-1)	14	0 – 0.33	0.05
RSC (calculated)	12	0.00007 - .008	0.005

▲ **Table 2.** Mineral values in reclaimed water (treated effluent) used for irrigation from the Myrtle Beach Wastewater Treatment Plant.

In the future, reclaimed water (treated effluent) from municipal wastewater treatment plants may become the prevalent irrigation source for turfgrasses and landscapes. Many golf courses already use treated effluent as a primary irrigation source. Large planned communities also use treated effluent to irrigate municipal parks and sports fields, commercial areas, and residential lawns. Examples include Tradition Hilton Head in South Carolina, which uses storm water as well as treated effluent for irrigating turfgrass areas. Treated effluent from the Michelson Water Reclamation Plant in Irvine, California is used to irrigate school playfields, athletic fields, parks and other turfgrass areas. Many ball fields, school yards, and parks in St. Petersburg, FL are irrigated with reclaimed water. Many other examples exist, yet treated effluent is not the most common water source for sports fields. This is primarily due to the lack of infrastructure to pipe treated wastewater to the end user. However, as freshwater demands increase, it is likely that treated effluent will become the MVP in the irrigation game.

One of the main issues with using treated effluent for irrigation is that disinfection residuals, typically chlorinators (e.g. chlorine gas and bleach (sodium hypochlorite)) may remain in treated solution. Low concentrations of chlorine and sodium can be problematic when used to irrigate plants. Emerging water treatment techniques use less of these disinfectants; however, the newer technologies require retrofitting or installation of new infrastructure, and thus are costly and will be implemented slowly. Although treated effluent may have a higher salt content, they typically also have a higher nutrient content, which can (and should) be considered into a facility's fertility program (Table 2). For example, treated effluent from the Myrtle Beach Waste Water Plant (Table 2) will most likely supply adequate levels of phosphorus, potassium, and calcium for maintaining highly managed turfgrass.

Although limited to those areas of the country that receive snow, it is noteworthy to comment on the salts contained in storm water runoff from roads deiced during winter storm events. The most commonly used deicers applied to roads are salt. Salts lower the melting point of water, causing the snow to melt in temperatures under which it would not typically melt. If the storm water runoff from our highway systems drains into a pond used for irrigation, the salts may concentrate over the winter making the water quite salty.

What does this all mean? Knowing your water source(s) is the first step to managing salts. In the next installment of this series, we will investigate what makes salts (or the lack of) such a problem for growing plants. ■

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