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.

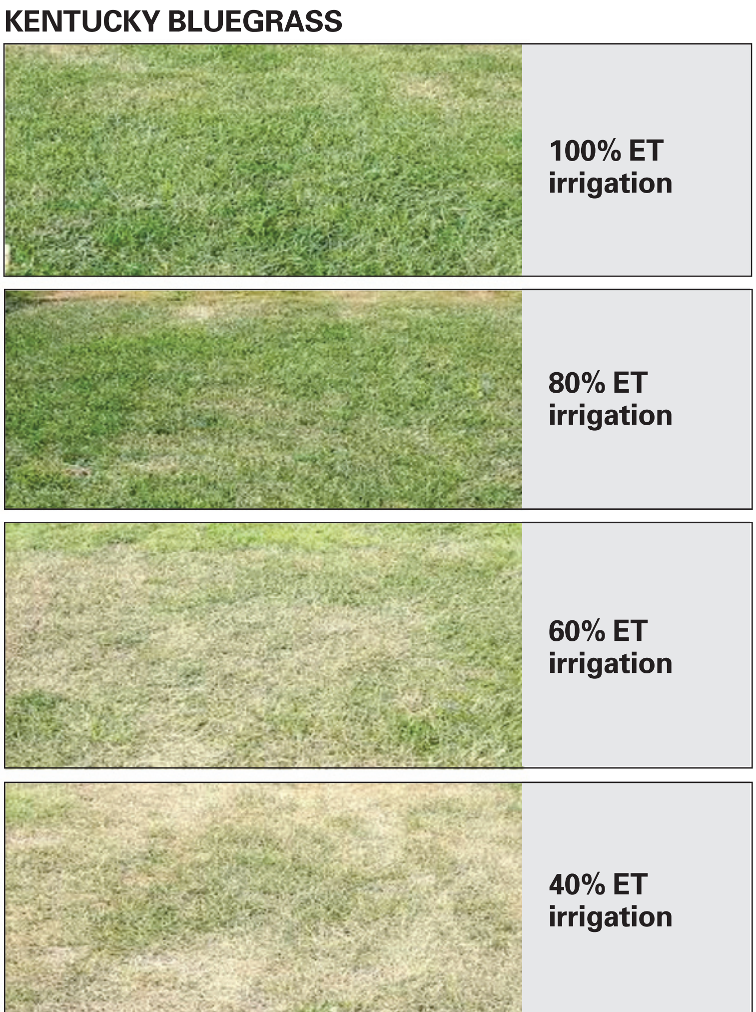
Football in New Jersey is a long season. It starts with heat and humidity and finishes with a mix of cold unpredictable weather. The best way to survive is to have a plan that you can communicate to coaches and administrators in order to provide the best possible playing surface for the athletes to use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

Rich Watson is Grounds Supervisor for the Pine Hill (NJ) School District. He won an STMA Founders Award last January when he was named recipient of the 2013 Dick Ericson Award for his contributions to the industry.

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.



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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John Mascaro's Photo Quiz

John Mascaro is President of Turf-Tec International

Can you identify this sports turf problem?

Problem: Snow cover on field on left and not on field on right **Turfgrass area:** Sports Complex
Location: Columbia, Tennessee **Grass Variety:** 419 bermudagrass base

Answer to John Mascaro's Photo Quiz on Page 33

Background illustration courtesy of istockphoto.com

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)

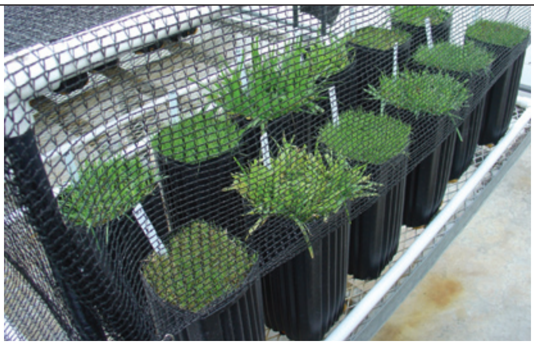
Turf Paint and Glyphosate Application Timing Effects on Annual Bluegrass Control and Zoysiagrass Spring Green-up. Turfgrass managers commonly apply glyphosate on dormant zoysiagrass to control winter annual weeds. More recently, turfgrass managers are using paints and pigments to color dormant zoysiagrass 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

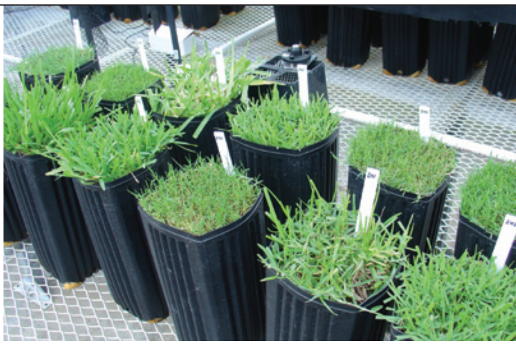
Daily Light Integral Requirements for 12 Warm-Season Turfgrasses. This study was conducted by Brian Glenn and Jason Kruse, PhD, University of Florida, Gainesville; and J. Bryan Unruh, PhD, University of Florida, Jay, FL.

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