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)

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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