



Hello WTA Members:

Part of the Wisconsin Turfgrass Association's mission is to "Disseminate research findings to turfgrass professionals." With the many challenges that 2020 has brought to all of us, the WTA Board of Directors recently voted to have four (December thru March) supplemental newsletters that will focus on the research that our own University of Wisconsin-Madison professors conducted this year.

We have access to some of the world's leading turfgrass researchers at the University of Wisconsin-Madison. In partnering with these researchers, the WTA will be sending these research publications to our membership. These publications will include a plethora of information about new and existing products, turfgrass management strategies and agronomics. Look for these publications in your inbox and on our website. Thank you for your continued support of the WTA and enjoy the continued education!

Cheers,

Brad DeBels

WTA President



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Evaluation of Poa Cure SC for use in Sports Turf Management: Midterm Report

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Introduction: Poa Cure SC (25% methiozolin) is a newly registered pre- and post-emergence herbicide for selective control of annual bluegrass and rough bluegrass. It is labeled for use on golf turf in Wisconsin, but the label does not allow for use on sports turf. However, Poa Cure may be a useful tool in sports turf for control of annual bluegrass, and if the label is changes to allow for application to sports turf, it will be valuable to have research on its use. Poa Cure is intended for use on Kentucky bluegrass and perennial ryegrass (among several other species), which are the dominant species on Wisconsin athletic fields. However, because Poa Cure is a pre-emergent herbicide, it may not be a good choice for athletic fields that rely on overseeding.

The objective of this study is to evaluate the new herbicide Poa Cure on athletic fields (Kentucky bluegrass and perennially ryegrass) infested with annual bluegrass and subjected to regular traffic and over-seeding. We are evaluating the tolerance of Kentucky bluegrass and perennial ryegrass to the herbicide, observing the control of annual bluegrass while evaluating how overseeding is affected by the herbicide treatment.

Materials and Methods: This study is conducted at the O.J. Noer Turfgrass Facility in Madison, WI to evaluate the efficacy of different timings of Poa Cure herbicide on the control of annual bluegrass (Poa) and the effect on desired grass and bare soil. The study was designed as a randomized complete block design with two application timings of Poa Cure (two spring applications vs. two fall applications, see Table 1) and four replications. Individual plots measured 6 x 4 feet. The study is replicated on two sites at the O.J. Noer Facility, a Kentucky bluegrass field and a perennial ryegrass field, both mowed at 2.5 inches. The fields were fertilized with approximately 3 lbs of N per 1000 square feet of slow release N, split into two evenly sized applications in May and July. The study areas were irrigated three times per week and the runtimes were dependent upon evapotranspiration collected from a weather station.

Herbicide treatments were applied using a CO₂-powered backpack sprayer calibrated to deliver 86 gallons per acre. Applications were made following the label directions for air temperature (apply when average daily air temps are between 50 and 80 F) and re-application intervals (14-21 days). The product was immediately watered in following application with 0.2 inches of irrigation.

Data collection includes periodic evaluation of the composition of the plot area (percent cover of desired grass, Poa, broadleaf weeds, and bare soil), visual turfgrass quality. Spring applications were made on 1 and 14 June 2020, and fall applications were made on 10 and 24 September 2020. Traffic was applied by a Brinkman Traffic Simulator that simulated 6 NFL games weekly. Traffic occurred June through end of August. Unfortunately, mechanical issues prevented traffic from being applied in September and after. The issues have been corrected and traffic will resume in 2021. Overseeding was done at a rate of 7 lbs M⁻¹ of perennial rye biweekly on the alternate week in which data was taken. The seed was applied shortly before a traffic event so the trafficker could create seed to soil contact with the recently applied seed. Turfgrass visual reflectance (NDRE) was assessed by a Holland Scientific CS-45 reflectance meter. Treatment means were separated using Fisher's Least Significant Difference at alpha = 0.05.

Table 1. Treatments and application rates for the products used in the trial.

Treatment Description	Rate	Application Dates
	fl. oz. pr. / 1000 square feet	
Kentucky Bluegrass Field		
Poa Cure Spring	0.9	1, 14 June
Poa Cure Fall	0.9	10, 24 September
Control	n/a	n/a
Perennial Ryegrass Field		
Poa Cure Spring	0.9	1, 14 June
Poa Cure Fall	0.9	10, 24 September
Control	n/a	n/a

Preliminary Results: Because the study is evaluating spring and fall application timings, the results from the fall applications will not be apparent until the 2021 season. Therefore, the results presented here are preliminary, and only relevant for the spring timing. Fall applications were made in mid-September, and data collection paused for the year in October. Data collection will resume in Spring 2021.

The study areas were initially composed of approximately 70-80% desired grass, and 20-30% annual bluegrass and very little bare soil. Traffic simulation increased the amount of bare soil during the study period. Averaged over the season, spring applications of Poa Cure resulted a two to three-fold reduction in Poa population (Table 2) compared to the control treatment. There were few other significant effects, particularly for visual quality, color (NDRE), desired grass, and bare soil.

Table 2. Average desired grass, annual bluegrass, bare soil, quality, and broadleaf weeds through the study period. Different letters indicate statistically significant differences ($p = 0.05$).

Treatment	Desired Grass	Poa	Bare Soil	Weeds	Quality	Color (NDRE)
	----- % plot cover -----				1-9	Greater is greener
Kentucky Bluegrass Field						
Poa Cure Spring	78.1 a	3.2 b	16.5 a	5.8 a	4.3 a	0.300 a
Poa Cure Fall	70.2 a	10.4 a	17.6 a	4.8 ab	4.0 a	0.293 a
Control	69.9 a	12.4 a	16.3 a	3.8 b	4.5 a	0.307 a
Perennial Ryegrass Field						
Poa Cure Spring	81.4 a	6.8 b	11.4 a	1.3 b	4.5 a	0.265 a
Poa Cure Fall	76.8 a	13.5 a	8.8 a	2.2 a	4.4 a	0.273 a
Control	79.1 a	9.5 b	10.9 a	1.5 ab	4.5 a	0.266 a

Spring applications of Poa Cure resulted in significantly higher populations of the desired grass on the Kentucky bluegrass field by August 2020 compared to the control (Table 3 and Figure 1). No significant increase in desired grass was observed for the perennial ryegrass. This is likely because Kentucky bluegrass is a rhizomatous grass and was able to spread to the bare areas left behind by the dead Poa, while the bunch-type ryegrass was not. Because Poa Cure is a pre-emergent grass, we did not observe much or any germination of the overseeded grass in the Poa Cure treated plots.

Interestingly, Poa Cure appeared to be more effective on the Kentucky bluegrass field than the perennial ryegrass field (Table 4 and Figure 2). The reasons for this are unclear. Using Poa Cure never

resulted in greater bare soil than the control for both fields (Table 5 and Figure 3). Poa Cure also had very little impact on the visual quality, color (NDRE), or populations of broadleaf weeds in on the two athletic fields (Table 6-8, Figure 4-5). In 2021, we will collect data to quantify the efficacy of the fall applications of Poa Cure on these two fields, and see how or if annual bluegrass populations rebound in the plots treated in spring 2020.

Weather was not atypical during the study period, with the exception of a cooler than normal spring (Figure 6).

Table 3. Visual estimate of desired grass at each rating date during the study. Different letters indicate statistically significant differences ($p = 0.05$) * indicates application date

Treatment	1 June*	15 June*	29 June	14 July	27 July
----- % plot cover -----					
Kentucky Bluegrass Field					
Poa Cure Spring	70.0 a	90.3 a	80.0 a	72.3 a	54.0 a
Poa Cure Fall	68.8 a	88.3 a	80.0 a	66.0 a	47.0 a
Control	77.5 a	87.0 a	77.5 a	61.0 a	48.5 a
Perennial Ryegrass Field					
Poa Cure Spring	73.8 a	82.5 a	82.5 a	89.0 a	78.8 a
Poa Cure Fall	68.8 a	80.5 a	78.8 a	85.3 a	72.8 a
Control	71.3 a	81.3 a	82.0 a	88.0 a	75.0 a

Table 3 cont. Visual estimate of desired grass at each rating date during the study. Different letters indicate statistically significant differences ($p = 0.05$) * indicates application date

Treatment	10 Aug	24 Aug	22 Sept	6 Oct
----- % plot cover -----				
Kentucky Bluegrass Field				
Poa Cure Spring	55.3 a	84.5 a	93.0 a	95.8 a
Poa Cure Fall	45.0 ab	69.5 b	80.0 c	85.8 b
Control	40.0 b	73.0 b	86.3 b	86.0 b
Perennial Ryegrass Field				
Poa Cure Spring	71.3 a	79.3 a	80.0 a	87.8 a
Poa Cure Fall	65.5 a	75.8 a	78.75 a	77.5 a
Control	67.0 a	76.0 a	73.0 a	90.3 a

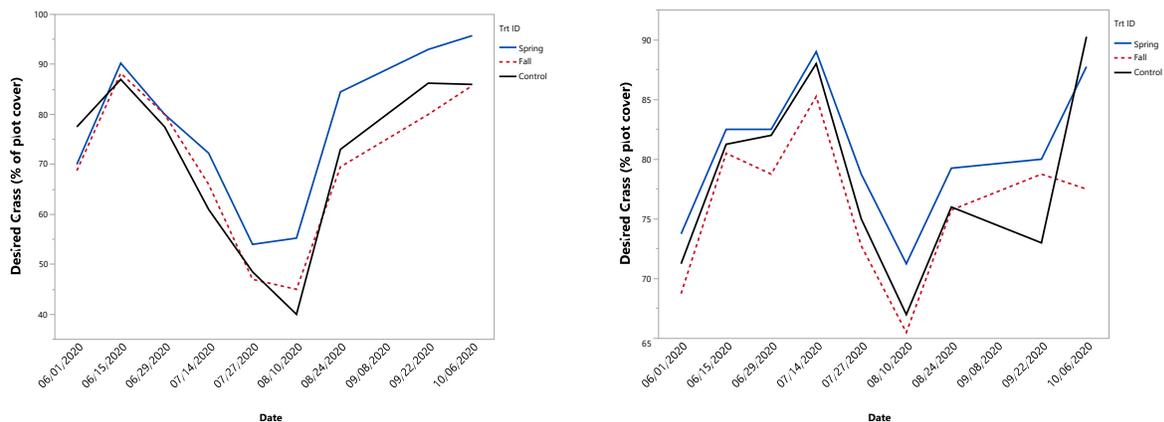


Figure 1. Visual estimate of percent desired grass cover for Kentucky bluegrass (left) and perennial ryegrass (right) during study period.

Table 4. Visual estimate of annual bluegrass at each rating date during the study. Different letters indicate statistically significant differences ($p = 0.05$) * indicates application date

Treatment	1 June*	15 June*	29 June	14 July	27 July
	----- % plot cover -----				
Kentucky Bluegrass Field					
Poa Cure Spring	30.0 a	6.3 a	6.3 b	2.8 b	1.0 b
Poa Cure Fall	31.3 a	8.8 a	13.8 ab	16.5 a	11.3 a
Control	22.5 a	8.8 a	16.3 a	15.3 a	11.5 a
Perennial Ryegrass Field					
Poa Cure Spring	21.3 a	13.8 a	10.0 b	1.8 b	3.0 b
Poa Cure Fall	27.5 a	16.3 a	16.3 a	9.3 a	15.0 a
Control	21.3 a	15.0 a	12.5 ab	2.8 b	6.0 ab

Table 4 cont. Visual estimate of annual bluegrass at each rating date during the study. Different letters indicate statistically significant differences ($p = 0.05$) * indicates application date

Treatment	10 Aug	24 Aug	22 Sept	6 Oct
	----- % plot cover -----			
Kentucky Bluegrass Field				
Poa Cure Spring	1.0 b	3.8 b	2.5 b	1.8 b
Poa Cure Fall	11.3 a	16.8 a	3.8 b	1.3 a
Control	11.3 a	15.0 a	10.0 a	11.3 a
Perennial Ryegrass Field				
Poa Cure Spring	3.8 a	1.8 a	12.5 a	7.5 a
Poa Cure Fall	17.5 a	9.0 a	13.8 a	11.3 a
Control	10.0 a	4.8 a	20.0 a	5.0 a

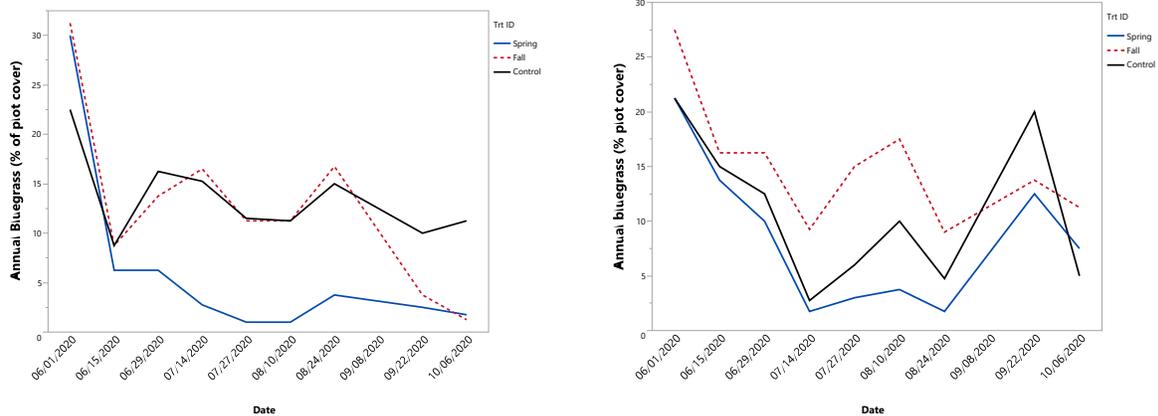


Figure 2. Visual estimate of percent annual bluegrass cover for Kentucky bluegrass (left) and perennial ryegrass (right) during study period.

Table 5. Visual estimate of bare soil at each rating date during the study. Different letters indicate statistically significant differences ($p = 0.05$) * indicates application date

Treatment	1 June*	15 June*	29 June	14 July	27 July
----- % plot cover -----					
Kentucky Bluegrass Field					
Poa Cure Spring	0 a	3.5 a	13.8 a	25.0 a	37.5 a
Poa Cure Fall	0 a	3.0 a	6.3 b	17.5 a	36.3 a
Control	0 a	4.3 a	6.3 b	23.8 a	36.3 a
Perennial Ryegrass Field					
Poa Cure Spring	5.0 ab	3.8 a	7.5 a	9.3 a	17.3 a
Poa Cure Fall	3.8 b	3.3 a	5.0 a	5.5 a	11.3 a
Control	7.5 a	3.8 a	5.5 a	9.3 a	18.0 a

Table 5 cont. Visual estimate of bare soil at each rating date during the study. Different letters indicate statistically significant differences ($p = 0.05$) * indicates application date

Treatment	10 Aug	24 Aug	22 Sept	6 Oct
----- % plot cover -----				
Kentucky Bluegrass Field				
Poa Cure Spring	36.3 a	9.3 a	4.5 b	2.5 b
Poa Cure Fall	37.5 a	11.0 a	16.3 a	13.0 a
Control	43.8 a	9.3 a	3.8 b	2.8 b
Perennial Ryegrass Field				
Poa Cure Spring	23.8 a	17.5 a	7.5 a	4.8 a
Poa Cure Fall	15.0 a	11.8 a	7.5 a	11.3 a
Control	21.3 a	17.5 a	7.0 a	4.8 a

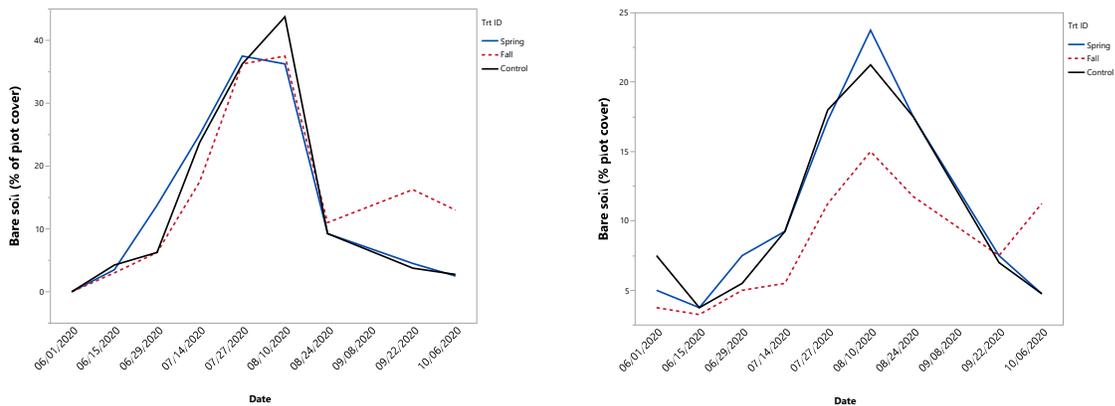


Figure 3. Visual estimate of percent bare soil cover for Kentucky bluegrass (left) and perennial ryegrass (right) during study period.

Table 6. Visual estimate of turfgrass quality at each rating date during the study. Different letters indicate statistically significant differences ($p = 0.05$) * indicates application date

Treatment	1 June*	15 June*	29 June	14 July	27 July
	----- 1-9, 1 is dead turf 9 is ideal -----				
Kentucky Bluegrass Field					
Poa Cure Spring	5.8 a	4.8 a	2.8 b	3.8 a	2.8 a
Poa Cure Fall	5.8 a	4.0 ab	4.3 a	4.3 a	3.3 a
Control	6.0 a	3.8 b	4.5 a	3.8 a	2.8 a
Perennial Ryegrass Field					
Poa Cure Spring	5.5 a	5.0 a	4.0 a	4.0 a	3.5 a
Poa Cure Fall	5.5 a	4.8 a	4.5 a	4.0 a	3.8 a
Control	5.3 a	4.5 a	4.8 a	4.3 a	3.5 a

Table 6 cont. Visual estimate of turfgrass quality at each rating date during the study. Different letters indicate statistically significant differences ($p = 0.05$) * indicates application date

Treatment	10 Aug	24 Aug	8 Sept	22 Sept	6 Oct
	----- 1-9, 1 is dead turf 9 is ideal -----				
Kentucky Bluegrass Field					
Poa Cure Spring	3.0 a	4.5 a	4.5 a	6.0 a	6.5 a
Poa Cure Fall	3.0 a	4.5 a	3.8 a	4.3 b	4.5 b
Control	3.3 a	4.8 a	4.5 a	6.3 a	6.8 a
Perennial Ryegrass Field					
Poa Cure Spring	3.8 a	3.8 a	No data	5.8 a	6.0 a
Poa Cure Fall	4.0 a	4.5 a	No data	5.5 a	4.5 b
Control	3.8 a	3.8 a	No data	5.5 a	6.0 a

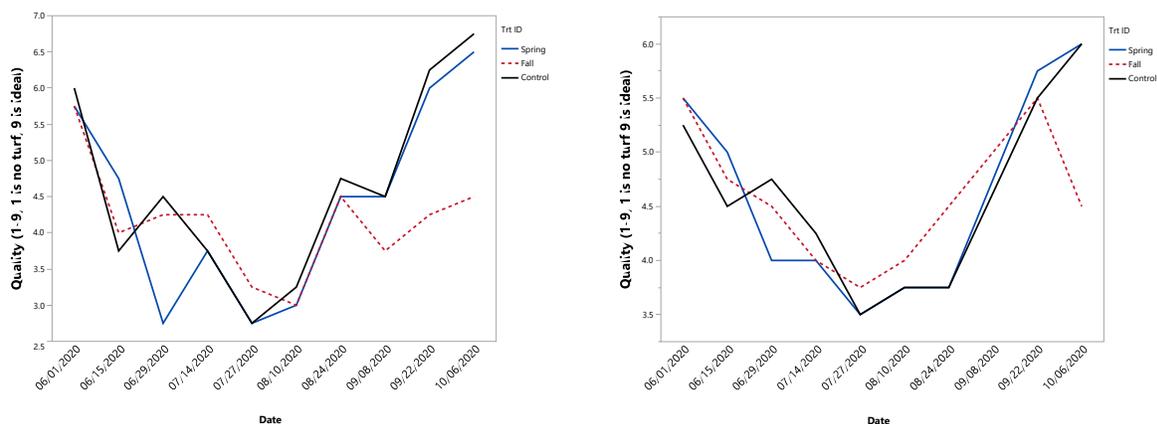


Figure 4. Visual estimate of turfgrass quality for Kentucky bluegrass (left) and perennial ryegrass (right) during study period.

Table 7. Turfgrass color reflectance (NDRE) at each rating date during the study. Different letters indicate statistically significant differences ($p = 0.05$) * indicates application date

Treatment	1 June*	15 June*	29 June	14 July	27 July
----- greater is greener -----					
Kentucky Bluegrass Field					
Poa Cure Spring	0.323 a	0.315 a	0.244 b	0.246 a	0.285 a
Poa Cure Fall	0.335 a	0.316 a	0.277 a	0.265 a	0.273 a
Control	0.317 a	0.304 a	0.265 ab	0.263 a	0.282 a
Perennial Ryegrass Field					
Poa Cure Spring	0.308 a	0.272 a	0.254 b	0.220 a	0.250 a
Poa Cure Fall	0.329 a	0.285 a	0.289 a	0.248 a	0.266 a
Control	0.311 a	0.274 a	0.273 ab	0.236 a	0.247 a

Table 7 cont. Turfgrass color reflectance (NDRE) at each rating date during the study. Different letters indicate statistically significant differences ($p = 0.05$) * indicates application date

Treatment	10 Aug	24 Aug	8 Sept	22 Sept	6 Oct
----- greater is greener -----					
Kentucky Bluegrass Field					
Poa Cure Spring	0.293 a	0.313 a	0.282 a	0.356 a	0.368 a
Poa Cure Fall	0.282 a	0.302 a	0.271 a	0.310 b	0.335 b
Control	0.292 a	0.328 a	0.285 a	0.354 a	0.386 a
Perennial Ryegrass Field					
Poa Cure Spring	0.250 a	0.279 a	0.247 a	0.309 a	0.307 a
Poa Cure Fall	0.249 a	0.282 a	0.257 a	0.289 b	0.293 a
Control	0.257 a	0.263 a	0.247 a	0.297 ab	0.305 a

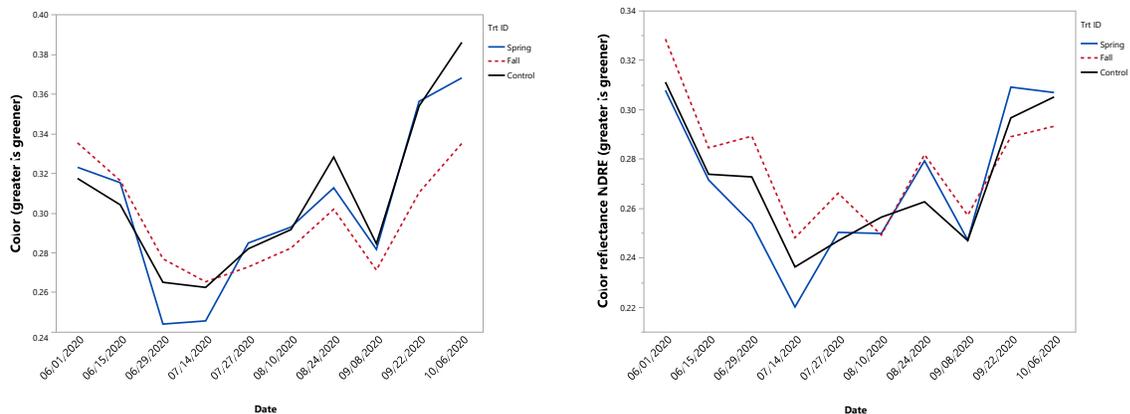


Figure 5. Turfgrass color reflectance (NDRE) for Kentucky bluegrass (left) and perennial ryegrass (right) during study period.

Table 8. Visual estimate of weeds at each rating date during the study. Different letters indicate statistically significant differences ($p = 0.05$) * indicates application date

Treatment	27 July	10 Aug	24 Aug
	----- % plot cover -----		
Kentucky Bluegrass Field			
Poa Cure Spring	7.5 a	7.5 a	2.5 a
Poa Cure Fall	5.5 ab	6.3 a	2.8 a
Control	3.8 b	5.0 a	2.8 a
Perennial Ryegrass Field			
Poa Cure Spring	1.0 a	1.3 a	1.5 a
Poa Cure Fall	1.0 a	2.0 a	3.5 a
Control	1.0 a	1.8 a	1.8 a



Figure 6. Average air temperature (blue line), daily precipitation total (bars), and 1 inch soil temperature (red line) at the O.J. Noer Turfgrass Research Facility in Verona, WI for the study period.

Title: Building a Better Growth Model to Optimize Nitrogen Applications to Bentgrass Putting Greens

Project Leaders: Doug Soldat, Qiyu Zhou (Ph.D. student in Soil Science)

Objectives: The objectives of this research are 1) to investigate the effects of weather variables, walking traffic, nitrogen application rate and soil moisture content on creeping bentgrass growth at putting green. 2) whether the potentially mineralized nitrogen (measured by the flush of CO₂ after rewetting of dried soil) determines bentgrass growth. 3) to develop a statistical growth model for creeping bentgrass that can be useful for making short-term nitrogen management decisions. 4) compare the statistical model with other nitrogen estimation model on nitrogen management

Summary Points:

1. Temperature, relative humidity and evapotranspiration are key weather factors determining bentgrass growth
2. Foot traffic, nitrogen rate and soil moisture are weakly correlated with bentgrass growth. However, model accuracy substantially increased when these variables were included.
3. Potentially mineralizable nitrogen in the top 5 cm of soil was positively correlated with bentgrass clipping production.
4. A data-driven statistical model using the random forest machine learning algorithm can accurately predict bentgrass yield. However, the model was only effective for the location where the model was built, suggesting that individual golf courses should build a customized growth prediction models to manage nitrogen adaptively.

Summary Text:

Nitrogen is usually the most limiting nutrient for turfgrass growth. Therefore, a manager with a growth target could use the estimation between actual and desired growth to determine an appropriate nitrogen fertilizer rate. While the PACE Turf growth model has been used for this purpose, the model uses only temperature and is not specific to any particular species. Therefore, a more accurate method to help turf managers to make reasonable nitrogen application decisions would be valuable. To better understand turf growth and nitrogen demand, we need to identify the key factors influencing turfgrass growth and use the knowledge to build a growth model that could be used for bentgrass nitrogen management on golf course putting green.

METHODS

To investigate the interactions among soil, turfgrass, environment and management practices, this study was conducted on four ‘Focus’ bentgrass sand putting greens that vary in soil organic matter content and quality. The study was conducted in 2018-2020 at the O. J. Noer Turfgrass Research and Education Facility, Madison WI. In 2018 and 2019 (the work in 2018 was done prior to funding), we investigated the factors that influenced daily bentgrass growth and used the collected data to develop a growth prediction model. Generally, N fertilizer treatments were applied at 0, 0.1 and 0.2 lbs N/1000 square feet every two weeks, footwear traffic was applied by walking on the green wearing golf shoes. In 2018, traffic was maintained at high, medium and low level which represent the golf course received 3600 rounds/week, 1800 rounds/week and 0 rounds/week; In 2019, traffic levels were decreased and maintained at 1400 rounds/week, 700 rounds/week and 0 rounds/week. We additionally investigated the effect of soil moisture content on bentgrass growth on one of the greens. Treatments were maintained at high (25-27% volumetric water content), medium (18-20% volumetric water content), and low (8-13% volumetric water content) moisture levels in the top 3 inches during periods without precipitation. Turf visual quality was measured every two weeks and NDRE was measured before each clipping collection event. Soil samples were collected each month for estimating potentially mineralizable nitrogen -- a fraction of soil organic matter that can be easily converted to plant-available nitrogen. We measured the flush of CO₂ following rewetting dried soil after a 24-hour incubation at 25 °C.

All clipping data collected from 2018 and 2019 were used to build a statistical growth model. To build the bentgrass growth model, several different weather factors were selected as input variables, including air temperature, evapotranspiration, relative humidity, precipitation and wind speed. Weather data were used from online weather data (Weather Underground). Moreover, soil moisture content, historical nitrogen rate, walking traffic level and proximal sensing data (NDRE) were used to develop the model. The growth model was built with the “scikit-learn” random forest package from Python.

In 2020, the growth prediction model built based on 2018 and 2019’s data was validated and put to use by making nitrogen application decisions. Nitrogen application decisions were made according to biweekly accumulated predicted growth multiply leaf tissue nitrogen content. We compared the model with three other nitrogen management methods that include 1) the Pace Turf Growth Potential Model which estimates growth (and therefore N use) based on air temperature; 2) the experience method where 0.2 lbs N/1000 ft² were applied every other week; and 3) a modification of the experience method where N was applied at 0.2 lbs N/1000 ft² only if the treatment fell below a proximal sensing measurement (NDRE) threshold. Clippings were collected three times a week, tissue was analyzed for N content, and soil moisture content and NDRE were collected before each mowing event.

PRELIMINARY RESULTS

Impact of management practices and soil potentially mineralizable nitrogen on bentgrass growth

Bentgrass growth rate overall was greatest on the plots contained the highest soil moisture content. Research plots receiving relatively high traffic levels produced significantly lower clipping yields than the plots receiving lower traffic. However, the difference in growth caused by traffic was not significant across more realistic levels of traffic. Least surprisingly, bentgrass fertilized with higher levels of nitrogen produced higher yields. However, individually, all of these relationships were fairly weakly correlated with bentgrass growth and using these factors as model inputs will not accurately predict bentgrass growth rate.

It is well known that soil N is a major source of N to the turf, yet soil N is rarely measured. In this study, potentially mineralizable nitrogen (PMN) of the soil at 0-5 cm had a strong positive relationship with bentgrass growth ($R^2 = 0.73$), while there was no correlation between PMN and growth at the 5-10 cm depth (Figure 1). Soil microbial biomass and labile organic nitrogen were more likely accumulated at the shallower depth of soil. Tracing and recording the potentially mineralizable nitrogen on the different putting greens could help turf managers adjust nitrogen rate and also be an important input for a growth prediction model.

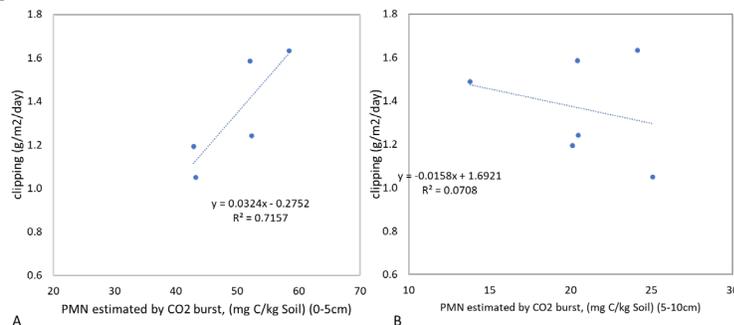


Figure 1. The correlation between potentially mineralizable nitrogen with bentgrass clipping production at top 5cm soil (A), at the soil depth of 5-10 cm (B)

Random Forest Model Performance

Both 2018 and 2019 data were used for building several random forest models, in search of one that was both simple and accurate. The full model included the entire suite of growth variables including soil moisture content, NDRE, traffic level, N application rate and weekly weather data (min, max and average of air temperature, precipitation, evapotranspiration, wind speed and min, max and average of relative humidity). We also tested two sets of simplified models by using subsets of the input: 1. without NDRE and soil moisture content input; 2. using only weekly weather data input. These reduced models

focus on the variables that are most easily available or obtained by the end-user. Figure 2 shows the correlation between predicted clipping and actual clipping data for each model. These results suggest that excellent growth predictions can be made from readily available and easily obtained data, although using only weather data appears to be far less accurate than including management information and soil factors.

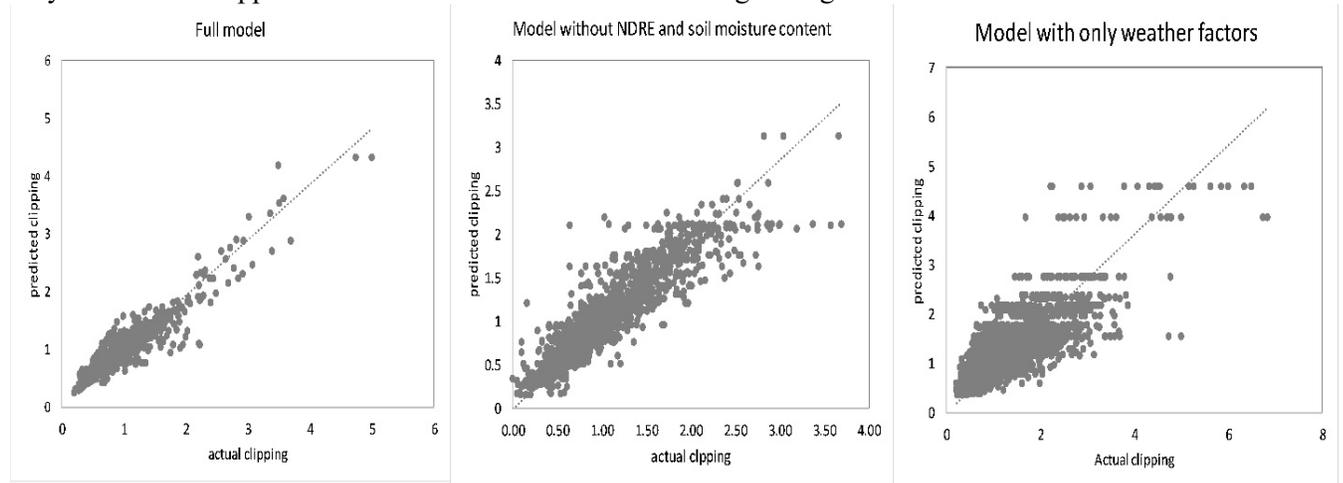


Figure 2. The scatter plot of predicted clipping and actual clipping from full model and reduced models.

Figure 3 shows the most important variables for each of the three random forest models. Generally, the most important management practices included N application rate, soil moisture content and traffic. The most important weather variables included relative humidity, evapotranspiration, and air temperature. Of the difficult to obtain measurements, NDRE and soil potentially mineralizable nitrogen increased model accuracy. We also observed that the frequency of mowing the grass influenced the bentgrass growth rate and grass that was mowed more frequently would be expected to have a higher daily clipping yield than infrequently mowed grass.

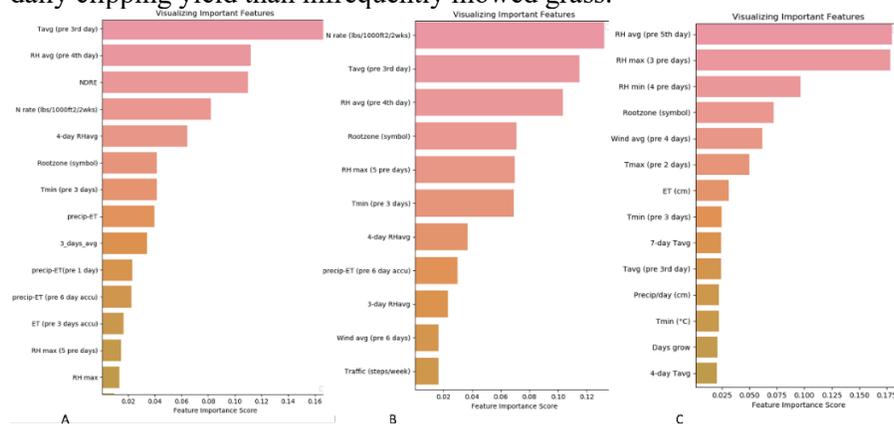


Figure 3. Important features for two sets of prediction models (A) full model; (B) model without NDRE and soil moisture content; (C) model with only weather variables input.

We compared growth models built using weather and nitrogen application data from two golf courses and compared those predictions along with the predictions of the PACE Turf Growth Potential model to actual growth data. Figure 4 shows the Random Forest model improved upon the predictions of the Pace Turf model which uses average air temperature. This suggests that individual golf courses could build a customized growth prediction models. We are confident that with more variables added to the model (besides N and weather), the model accuracy would be greatly improved.

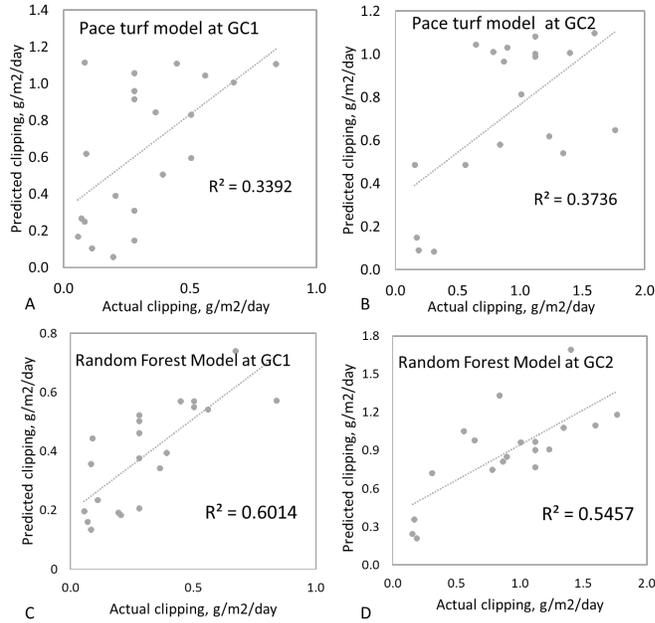


Figure 4. Model performance using different growth prediction models on two golf courses. (A) Pace Turf model performance on golf course 1. (B) Pace Turf model performance on golf course 2. (C) Random Forest model performance on golf course 1. (D) Random Forest model performance on golf course 2.

In 2020, we evaluated the use of various N management strategies on putting greens in Madison, WI (Figure 5). Overall, the PACE Turf model resulted in the greatest nitrogen fertilizer application, greatest overall clipping yield and highest visual quality. The experience method and the PACE Turf method were quite similar. The nitrogen program decided by our random forest model used only half of the nitrogen as the PACE Turf model; however, there were no significant differences in visual quality between these two models. The modified experience method resulted in the least N applied, but also showed lower turfgrass quality. In summary, it appears that growth models can be relied upon for helping turfgrass managers manage N more sustainably and adaptively.

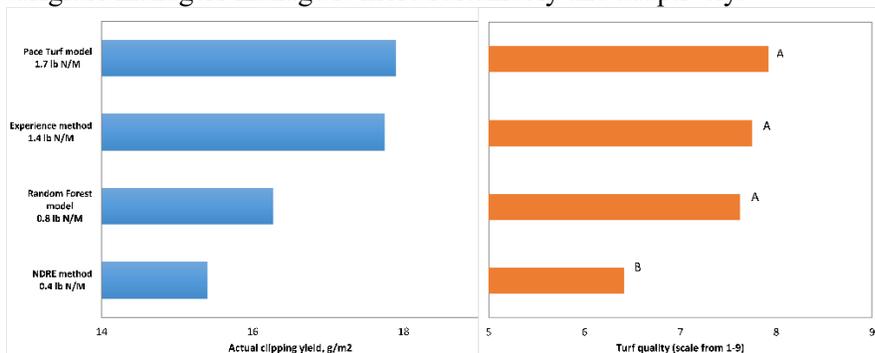


Figure 5. Three-month (May-August) bentgrass overall growth responses to nitrogen programs decided by different nitrogen prediction model (left) and its corresponding turfgrass average visual quality (right) (scale from 1-9, 1 represents bare soil, 9 represents best turf quality, 6 is acceptable).



Iron Sulfate Interactions for Dollar Spot Control

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OBJECTIVE

To determine how applications of iron sulfate interact with the Smith-Kerns dollar spot prediction model for controlling dollar spot caused by the fungus *Claviceps dactyloides* on a creeping bentgrass fairway.

MATERIALS AND METHODS

The study was conducted at the O. J. Noer Turfgrass Research and Education Facility in Madison, WI on a stand of Penncross creeping bentgrass (*Agrostis stolonifera*) maintained at 0.5 inches. Individual plots measured 3 feet by 10 feet and were arranged in a randomized complete block design with four replications. Treatments were applied at a nozzle pressure of 40 psi using a CO₂-pressurized boom sprayer equipped with two XR Teejet AI8004VS nozzles. Iron sulfate was applied as Extreme Green 20 (Simplot), and all treatments were agitated by hand and applied in the equivalent of 1.5 gallons of water per 1000 ft². All treatments were initiated on May 27, 2020 and subsequent applications were made at 7-, 14-, or 28-day intervals. Treatments 4 and 5 were applied on a 7-day interval while also using the Smith-Kerns model threshold of 20% with the Clarke Correction (i.e increasing model numbers over a 3-day period). Number of dollar spot foci per plot and turfgrass quality (1-9, 9 being excellent, 6 acceptable, and 1 bare soil) were visually assessed every 2 weeks. Turf quality and disease severity were subjected to an analysis of variance and means separated using Fisher's LSD (P = 0.05). Results of disease severity and turfgrass quality ratings can be found in tables 1 and 2, respectively.

RESULTS AND DISCUSSION

Dollar spot severity was high in early July and stayed high through early September. The 7-day calendar iron sulfate treatments resulted in 15 applications over the course of the study while the dollar spot model iron sulfate treatments resulted in 13 applications. Most of the treatments had significant breakthrough under high disease pressure. Only the standard fungicide treatment (Xzemplar) controlled dollar spot to acceptable levels in July and August. Treatments 4 and 5 did not result in better control of dollar spot by using the Smith-Kerns dollar spot prediction model relative to the calendar-based method. No phytotoxicity was observed with any treatments.

Table 1. Mean number of dollar spots per treatment at fairway height at the OJ Noer Turfgrass Research Facility in Madison, WI during 2020.

Treatment	Rate	Application Interval	Application Code ^a	Dollar Spot Severity ^b		
				Jul 8	Aug 5	Sep 2
1 Non-treated control				130.3a	355.3a	535.0ab
2 Extreme Green 20	4.5 oz/1000 ft ²	7 day	BCDEFGHIJKLMNOP	41.5cd	116.5cd	179.8e
3 Extreme Green 20	6.0 oz/1000 ft ²	7 day	BCDEFGHIJKLMNOP	53.8cd	157.5c	156.3e
4 Extreme Green 20	4.5 oz/1000 ft ²	7 day SK 20% CC	BCDEFGHIJKLMN	67.0bc	271.0ab	381.0cd
5 Extreme Green 20	6.0 oz/1000 ft ²	7 day SK 20% CC	BCDEFGHIJKLMN	57.5c	202.3bc	327.0d
6 Xzemplar	0.26 oz/1000ft ²	28 day	BFJN	3.3d	23.8d	23.8f
LSD P=0.05				50.72	105.83	107.27

^aApplication Code B = May 27, C (trt 2, 3, 7) = Jun 2, C (trt 4, 5) = Jun 4, D = Jun 9, E = Jun 16, F (trt 4, 5) = Jun 22, F (trt 2, 3, 6, 7, 8) = Jun 23, G (trt 4, 5) = Jun 29, G (trt 2, 3, 7) = Jun 30, H = Jul 7, I = Jul 14, J (trt 2, 3, 6, 7, 8) = Jul 21, J (trt 4, 5) = Jul 24, K = Jul 28, L = Aug 4, M (trt 4, 5) = Aug 10, M (trt 2, 3, 7) = Aug 11, N (trt 2, 3, 6, 7, 8) = Aug 18, N (trt 4, 5) = Aug 21, O = Aug 25, P = Sep 1

^bDollar spot rated as number of dollar spot infection centers. Means followed by the same letter do not significantly differ (P=.05, Fisher's LSD).

Table 2. Mean turfgrass quality per treatment at fairway height at the OJ Noer Turfgrass Research Facility in Madison, WI during 2020.

Treatment	Rate	Application Interval	Application Code ^a	Turfgrass Quality ^b		
				Jul 8	Aug 5	Sep 2
1 Non-treated control				4.8cd	4.0c	4.0d
2 Extreme Green 20	4.5 oz/1000 ft ²	7 day	BCDEFGHIJKLMNOP	5.3bc	5.5b	5.0b
3 Extreme Green 20	6.0 oz/1000 ft ²	7 day	BCDEFGHIJKLMNOP	5.3bc	5.3b	5.0b
4 Extreme Green 20	4.5 oz/1000 ft ²	7 day SK 20% CC	BCFGHIJMN	5.3bc	5.0b	4.0d
5 Extreme Green 20	6.0 oz/1000 ft ²	7 day SK 20% CC	BCFGHIJMN	5.5b	5.0b	4.5c
6 Xzemplar	0.26 oz/1000ft ²	28 day	BFJN	7.0a	7.0a	5.8a
LSD P=0.05				0.69	0.59	0.38

^aApplication Code B = May 27, C (trt 2, 3, 7) = Jun 2, C (trt 4, 5) = Jun 4, D = Jun 9, E = Jun 16, F (trt 4, 5) = Jun 22, F (trt 2, 3, 6, 7, 8) = Jun 23, G (trt 4, 5) = Jun 29, G (trt 2, 3, 7) = Jun 30, H = Jul 7, I = Jul 14, J (trt 2, 3, 6, 7, 8) = Jul 21, J (trt 4, 5) = Jul 24, K = Jul 28, L = Aug 4, M (trt 4, 5) = Aug 10, M (trt 2, 3, 7) = Aug 11, N (trt 2, 3, 6, 7, 8) = Aug 18, N (trt 4, 5) = Aug 21, O = Aug 25, P = Sep 1

^bTurfgrass quality was rated visually on a 1 – 9 scale with 6 being acceptable. Means followed by the same letter do not significantly differ (P=.05, Fisher's LSD).



Smith-Kerns Dollar Spot Model - Upper Limit

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OBJECTIVE

To determine whether tighter spray intervals are required when an upper limit is reached on the Smith-Kerns dollar spot prediction model.

MATERIALS AND METHODS

The study was conducted at the O. J. Noer Turfgrass Research and Education Facility in Madison, WI on a stand of 'Penncross' creeping bentgrass (*Agrostis stolonifera*) maintained at 0.5 inches. The individual plots measured 3 feet by 10 feet and were arranged in a randomized complete block design with four replications. Individual treatments were applied at a nozzle pressure of 40 p.s.i. using a CO₂ -pressurized boom sprayer equipped with two XR Teejet AI8004 nozzles. All fungicides were agitated by hand and applied in the equivalent of 1.5 gallons of water per 1000 ft². Treatments 2 and 3 were initiated on May 27th, 2020 and subsequent applications were made at 28- or 21-day intervals, respectively. Treatments 4-8 were also initiated on May 27th, 2020 and were applied using the Smith-Kerns model at a 28-day interval when the model was 20% or higher. When the model reached 30%, 40%, 50%, or 60%, treatments 5, 6, 7, and 8 switched to a 21-day interval, respectively. Number of dollar spot foci per plot and turfgrass quality (1-9, 9 being excellent, 6 acceptable, and 1 bare soil) were visually assessed every 2 weeks. Disease severity and turf quality were subjected to an analysis of variance and means separated using Fisher's LSD ($P = 0.05$). Results of disease severity and turfgrass quality ratings can be found in table 1 and 2, respectively.

RESULTS AND DISCUSSION

Dollar spot developed in the experimental area during July and remained steady for the rest of the study. All fungicide treatments reduced dollar spot severity significantly when compared to the non-treated control. Despite intricate variations in when these fungicide treatments were applied, relatively minor differences were observed between treatments. However, a significant jump in disease was observed using the 60% cutoff, indicating that tightening intervals once the model surpasses 50% may be an effective control strategy. Further research is needed to discern whether tighter intervals are required when certain upper limits are met on the Smith-Kerns dollar spot prediction model.

Table 1. Mean dollar spot severity per treatment on creeping bentgrass maintained at fairway height at the OJ Noer Turfgrass Research Facility in Madison, WI during 2020.

Treatment	Rate	Application Code ^b	App Rule	Dollar Spot Severity ^a		
				Jul 22	Aug 5	Sep 16
1	Non-treated control			71.3a	171.5a	125.5a
2	Banner Maxx	2.0 FL OZ/1000 FT2	BFJNR 28 day	30.0a	6.0b	17.3c
3	Banner Maxx	2.0 FL OZ/1000 FT2	BEHKNQ 21 day	7.8cd	29.8b	2.0d
4	Banner Maxx	2.0 FL OZ/1000 FT2	BFJNR 28 d-20%	34.0b	5.5b	21.8c
5	Banner Maxx	2.0 FL OZ/1000 FT2	BFILOR 28 d-20% 21 d-30%	2.3d	14.3b	4.3d
6	Banner Maxx	2.0 FL OZ/1000 FT2	BFIMP 28 d-20% 21 d-40%	1.3d	16.3b	4.0d
7	Banner Maxx	2.0 FL OZ/1000 FT2	BFIMQ 28 d-20% 21 d-50%	8.8cd	1.3b	5.8d
8	Banner Maxx	2.0 FL OZ/1000 FT2	BFJMR 28 d-20% 21 d-60%	22.0bc	5.0b	37.0b
LSD P=.05				18.37	47.7	11.11

^aDollar spot rated as number of dollar spot infection centers per plot. Means followed by the same letter do not significantly differ (P=.05, Fisher's LSD).

^bApplication code B=May 27, E=Jun 16, F(trt 5)=Jun 22, F(trt 6)=Jun 23, F(trt 2, 4, 7, 8)=Jun 24, H=Jul 7, I(trt 5)=Jul 13, I(trt 6)=Jul 14, I(trt 7)=Jul 16, J(trt 8)=Jul 20, J(trt 2, 4)=Jul 22, K=Jul 28, L=Aug 3, M(trt 6, 7)=Aug 10, M(trt 8)=Aug 11, N=Aug 18, O=Aug 24, P = Aug 31, Q(trt 7)=Sep 7, Q(trt 3)=Sep 11, R = Sep 14

Table 2. Mean turfgrass quality per treatment on creeping bentgrass maintained at fairway height at the OJ Noer Turfgrass Research Facility in Madison, WI during 2020.

Treatment	Rate	Application Code ^b	App Rule	Turfgrass Quality ^a		
				Jul 22	Aug 5	Sep 16
1	Non-treated control			4.3d	4.3d	4.3c
2	Banner Maxx	2.0 FL OZ/1000 FT2	BFJNR 28 day	5.5c	6.3ab	6.0b
3	Banner Maxx	2.0 FL OZ/1000 FT2	BEHKNQ 21 day	5.5c	5.3c	7.0a
4	Banner Maxx	2.0 FL OZ/1000 FT2	BFJNR 28 d-20%	5.0cd	6.3ab	5.8b
5	Banner Maxx	2.0 FL OZ/1000 FT2	BFILOR 28 d-20% 21 d-30%	6.5ab	5.8bc	6.8a
6	Banner Maxx	2.0 FL OZ/1000 FT2	BFIMP 28 d-20% 21 d-40%	6.8a	5.8bc	7.0a
7	Banner Maxx	2.0 FL OZ/1000 FT2	BFIMQ 28 d-20% 21 d-50%	5.8bc	6.5a	7.0a
8	Banner Maxx	2.0 FL OZ/1000 FT2	BFJMR 28 d-20% 21 d-60%	5.3c	5.8bc	5.5b
LSD P=.05				0.81	0.55	0.52

^aTurfgrass quality was rated visually on a 1 – 9 scale with 6 being acceptable. Means followed by the same letter do not significantly differ (P=.05, Fisher's LSD).

^bApplication code B=May 27, E=Jun 16, F(trt 5)=Jun 22, F(trt 6)=Jun 23, F(trt 2, 4, 7, 8)=Jun 24, H=Jul 7, I(trt 5)=Jul 13, I(trt 6)=Jul 14, I(trt 7)=Jul 16, J(trt 8)=Jul 20, J(trt 2, 4)=Jul 22, K=Jul 28, L=Aug 3, M(trt 6, 7)=Aug 10, M(trt 8)=Aug 11, N=Aug 18, O=Aug 24, P = Aug 31, Q(trt 7)=Sep 7, Q(trt 3)=Sep 11, R = Sep 14