Wisconsin Turfgrass Field Day

July 26, 2016

O.J. Noer Turfgrass Research & Education Facility
2502 Hwy M, Verona, WI 53593

2016 Wisconsin Turfgrass Field Day

Morning Tour: General Turf Management (9:30 – 11:00 AM)

11:00-1:30pm- Lunch, Trade Show and Networking

Afternoon Tour: Golf Turf Research (1:30 – 3:00 PM)

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Editor's Note

We are grateful for and humbled by the tremendous industry support for the UW Turfgrass Program provided by the above sponsors. Without your help, our turfgrass research and educational program would be unable to function at our current and targeted level. While we strive for perfection and attempt to list all our supporters, if we accidentally missed you then you have our sincere apology; please let us know so we may correct the situation in the future. If you have any comment or suggestions for next year's program, please contact me at 608-263-3631 or djsoldat@wisc.edu. References to products in this booklet are intended to convey objective, unbiased information and do not imply an endorsement.

On behalf of the entire UW-Madison Turf Team, thanks again for your support, and we look forward to continuing to provide the industry with research and outreach programs that improve your turf, your bottom line, and the environment.

Sincerely,

Doug Soldat
Associate Professor and Extension Specialist

Protecting Pollinators When Making Turfgrass Pesticide Applications

Dr. R. Chris Williamson
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Pollinators including bees and other pollinating insects provide invaluable ecological and economic services to the urban horticulture system including landscapes, golf courses and other areas. More than 85% of the world's flowering plants depend on pollinators to reproduce, unfortunately the valuable services that pollinators provide have been declining at an alarming rate around the world. Such losses in population and biodiversity have been associated with a combination of several factors including: diseases, habitat loss, insecticide exposure and parasites. Consequently, identifying and implanting ways to promote and preserve pollinators is of great importance for homeowners and professionals including landscape managers, turfgrass managers and golf course superintendents. To help protect and conserve pollinators, there are several management practices that can be employed to maximize potential risks to pollinators.

Practice Pesticide Stewardship

Fungicides, herbicides and especially insecticide may have lethal effects on pollinators or they can induce non-lethal (sub-lethal, negative effects), such as memory loss, lowered immune systems, or even a loss of queen production. In any case, insecticides are designed to kill insects, and bees and most other pollinators are insects. Although, nearly all insecticides can harm bees, most of the attention has focused on the neonicotinoid class of insecticides. Neonicotinoids or "neonics" are the most widely used class of insecticides in turfgrass, ornamental and other agricultural systems. There are several different active ingredients in this class (Table 1). Neonics are largely used in the turfgrass system for preventive management of various white grub species.

Turfgrass areas that are treated with insecticides occasionally have flowering weeds such as white clover or dandelions present (Figures 1 and 2). Although such weeds are often considered a nuisance to homeowners and professional turfgrass managers, they serve as pollen and nectar resources for more than 50 different kinds of pollinating insects[1]. Therefore, it is critical to use pesticides appropriately and with caution, especially when weedy plants are present. For example, misapplications such as over spraying or inadvertently spraying flowering weeds with an insecticide could place many species of pollinators at risk. In order to mitigate such risk of exposure to pollinators, a couple of product stewardship practice can be employed:

1) When an abundance of blooming (flowering) weeds occur, it is necessary to apply a herbicide to circumvent the flowering of such weeds before an insecticide application is made. Turf areas that are mainly free of flowering weeds pose little risk to pollinators, even when a neonicotinoid insecticide is applied.
2) A second management option to mitigate the risk of insecticide applications to pollinators is to mow-off any flowers (i.e., such as clover) in the turf area immediately before spraying a liquid

formulation of an insecticide. Mowing typically removes > 90% of the flowers, consequently reducing the number of bees foraging in that area. Neonicotinoids are systemic insecticides that are absorbed by plant roots, but these residues are transferred to plant leaves rather than into nectar and pollen of flowering weeds in turf. As result, flowers that grow after mowing and application do not typically contain hazardous levels of neonicotinoids[2].

If it is not possible to control the flowering weeds in a turf area, consider using granular or pelleted (spreadable) insecticide formulations. Granular or pelleted products will move directly into the soil following irrigation or rainfall, leaving no insecticide residues in the flowering portion of the plant. Turfgrass managers can also consider using more "bee-friendly" types of insecticides including the anthranilic diamide Acelepryn© (chlorantraniliprole), it has been shown to have no adverse effects on pollinators that ingest this insecticide[3].

Everyone must make a concerted effort to protect pollinators, it is vital that the turfgrass industry consider and implement commonsense approaches to minimize potential hazards to bees. We must be proactive and employ simple, yet effective stewardship practices that safeguard pollinator health. As a result, we can ensure the likelihood that tools, insecticides including the neonicotinoids, that we currently have will be available to us for the foreseeable future.

Create Habitats for Pollinating Insects

Homeowners and professional turfgrass managers alike can help create habitats for pollinators by converting portions of turf landscapes into pollinator sanctuaries and floral resources. Golf courses are especially well suited for this as they may provide a large fraction of the green space in otherwise urbanized areas. To provide the best possible habitat for the bees and other pollinators in your area, it helps to plant a mixture of native flowering plants (Table 2 and Figure 3). These native areas help promote pollinators in two primary ways: 1) it ensures that pollinating insects with differing food preferences will have a variety of plants to choose from and 2) by having a mixture of flowering plants, various plants will be plants in bloom throughout the growing season to provide resources to pollinator species that may be present at different times of the year. The Pollinator Partnership offers free planting guides tailored to specific parts of the country (www.pollinator.org/guides).

References

Larson, Jonathan L., Adam J. Kesheimer, and Daniel A. Potter. "Pollinator assemblages on dandelions and white clover in urban and suburban lawns." *Journal of Insect Conservation* 18.5 (2014): 863-873.

Larson, Jonathan L., Carl T. Redmond, and Daniel A. Potter. "Mowing mitigates bioactivity of neonicotinoid insecticides in nectar of flowering lawn weeds and turfgrass guttation." *Environmental Toxicology and Chemistry* 34.1 (2015): 127-132.

Larson, Jonathan L., Carl T. Redmond, and Daniel A. Potter. "Assessing insecticide hazard to bumble bees foraging on flowering weeds in treated lawns." *PLoS One* 8.6 (2013): e66375.

Table 1. Neonicotinoid Insecticides and Acute (Dermal) Bee Toxicity.

Active Ingredient	**Brand Name**	**Acute Honey Bee Toxicity (Dermal) LD_{50} ng/bee***
clothianidin	Arena	21.8
dinotefuran	Zylam	75.0
imidacloprid	Merit, Bandit, Zenith, Mallet, others	17.9
thiamethoxam	Meridian	29.9

* LD_{50} ng/bee = Lethal dose (nanograms) required to kill 50% of a test population of honey bees; one nanogram = 1.0×10^{-9} grams

Table 2. Mixtures of Native Flowering Plants.

Common Name	Scientific Name
Cape Forget-Me-Not	Anchusa capensis
New England Aster	Aster novae-angliae
White Upland Aster	Aster ptarmicoides
China Aster	Callistephus chinensis
Siberian Wallflower	Cheiranthus allionii
Lance-leaved Coreopsis	Coreopsis lanceolata
Dwarf Sulphur Cosmos	Cosmos sulphureus
Chinese Forget-Me-Not	Cynoglossum amabile
Purple Prairie Clover	Dalea purpurea
Purple Coneflower	Echinacea purpurea
California Poppy	Eschscholzia californica
Blanketflower	Gaillardia aristata
Basil	Ocimum basilicum
Corn Poppy	Papaver rhoeas
Lacy Phacelia	Phacelia tanacetifolia
Scarlet Cinquefoil	Potentilla thurberi
Prairie Coneflower	Ratibida columnifera
Sweet Mignonette	Reseda odorata
French Marigold	Tagetes patula

This mixture consists of annual and perennial flowers that provide nectar and pollen to honeybees. These flowers are proven favorites of honeybees in gardens and will provide forage all season long. It is ideal for honeybee keepers and others interested in honeybee health. This mixture can be used in garden beds, borders, and other maintained areas.

Seeding Rate: ≈ Seeds/lb. = 492,000
Planting Rate: 6-12 lbs./Acre, 5 oz./1000 square feet
Planting Time: Optimal times to plant are spring, early summer and fall

Figure 1. Flowering White Clover in a Stand of Turf.

Figure 2. Flowering Dandelions in a Stand of Turf.

Figure 3. Mixtures of Native Flowering Plants.

Mowing Frequency Evaluation

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INTRODUCTION

One of the most basic rules of mowing turf is called the one-third (1/3) rule. This rule states that one should not remove more than one-third of the leaf tissue at any single mowing. For example if you mow you lawn at 2 inches, you should mow it before it reaches 3 inches. If you mow at 2.5 inches, then you should mow before it reaches 3.75 inches. This means that faster growing grasses must be mowed more frequently than slower growing grasses for optimal health. Tall fescue is among one of the fastest growing grasses, and fine fescue is among the slowest, with Kentucky bluegrass falling somewhere in between. However, the genetic diversity of Kentucky bluegrass is amazing, and different cultivars can have vastly different characteristics.

Bella bluegrass is a relatively new Kentucky bluegrass cultivar and unique in that it is only vegetatively propagated (no seed!). It has been touted for its slow growth habit, dark green color, and excellent density. However, few scientific evaluations of the grass have been conducted. The objective of this research is to evaluate the agronomic characteristics (including color, quality, density, shade tolerance, drought tolerance, and clipping production) of ‘Bella’ Bluegrass, against other high quality bluegrass blends (Turf Blue HGT and Turf Blue – both of Barenbrug) and Black Beauty Tall Fescue and a mixture of fine fescue species.

MATERIALS AND METHODS

The study will be conducted at the O.J. Noer Turfgrass Research and Education Facility in Verona, WI. The experiment consists of five turfgrasses planted by sod in May 2016 on a silt loam soil:

1. ‘Bella’ Kentucky bluegrass
2. ‘Black Beauty’ tall fescue
3. ‘HGT’ Kentucky bluegrass
4. Fine fescue blend (TBD)
5. Kentucky bluegrass blend (TBD)

The plots measure 10 x 12 feet and are arrayed in a randomized complete block design with four replications. The grasses are mowed at a height of 2.5 inches either once per week, twice a month, or monthly in strips 4 feet wide and 10 feet long. A sample of the grass clippings is collected and weighed at each mowing to estimate clipping production rates during the season. In addition, we measure the visual quality of each grass every other week using a 1-9 scale, with 9 representing the highest quality. The color of the turf is measured using a reflectance device.

Shade tolerance is being evaluated by wood frames holding 70% shade cloth on a 1 x 1 section of each plot (mown weekly). We will evaluate the density of the grass under the shade and full sun areas to determine which grasses performed better under the heavy shade. In August, the irrigation will be shut off to see which grasses retain green color the longest under drought conditions. In late September after the grasses have recovered from any drought stress, we will quantify the density of the grasses in sun and shade.

RESULTS

The results below are preliminary and only represent the growth from a single mowing event on July 1st, 2016. The full research report will be available in January 2017.

One of the most interesting findings so far is that the more frequently these grasses were mowed, the less clippings they produced (Table 1). If growth rates were similar, we'd expect to get about 40 grams of grass clippings for the grasses mowed monthly. Instead we find about 70 g. This is a demonstration of compensatory growth. When grasses are scalped (or the 1/3 rule is not followed) the grass exhibits accelerated growth in response to losing a substantial amount of vegetation.

As expected, the tall fescue sod produced more clippings and was taller at the time of mowing than all other grasses (Table 1). The Turf Blue and Turf Blue HGT sod blends were next in terms of growth and height before mowing with the HGT variety being slightly more aggressive. Bella bluegrass was significantly slower growing than the other bluegrasses in the study. Fine fescue was the slowest growing grass in the study, but Bella had statistically similar growth as the fine fescue when being mowed at one or two week intervals. Only when four weeks went by between mowings was the slower growth of fine fescue evident (Table 3).

Table 1. Averages of clippings produced across all grasses as affected by mowing frequency. Different letters denote statistically significant differences.

Mowing Treatment	**Clipping Mass**
	g/plot
Every four weeks	71.1 A
Every two weeks	33.2 B
Weekly	10.2 C

Table 2. Clippings produced on July 1 and height of grass prior to mowing for all mowing frequencies. Different letters denote statistically significant differences.

Grass	Clipping Mass	Height Prior to Mowing
	g/plot	inches
Black Beauty	56.8 A	5.0 A
Turf Blue HGT	48.9 AB	4.5 B
Turf Blue	42.0 B	4.0 C
Bella Bluegrass	27.0 C	3.5 D
Fine Fescue	16.1 D	3.2 D

Table 3. Clippings and mowing height as affected by both grass type and mowing frequency. Percent of grass removed by mowing was calculated to determine if and when the 1/3 rule was violated. Different letters denote statistically significant differences.

Grass	Mowing Freq.	Clipping Mass	Height Prior to Mowing	Percent Removal	Passes 1/3 rule?
Black Beauty	Weekly	18.3 FG	3.5 FG	29%	Yes
	Every two weeks	51.1 CD	4.8 CD	48%	No
	Every four weeks	101.1 A	6.9 A	64%	No
Turf Blue HGT	Weekly	10.7 GH	3.4 FGH	26%	Yes
	Every two weeks	10.8 DE	4.4 DE	43%	No
	Every four weeks	68.6 B	5.6 B	55%	No
Turf Blue	Weekly	14.7 GH	3.1 GHI	19%	Yes
	Every two weeks	42.8 DE	3.9 EF	36%	No
	Every four weeks	48.6 B	5.1 BC	51%	No
Bella Bluegrass	Weekly	3.74 H	2.8 I	11%	Yes
	Every two weeks	17.4 FGH	3.3 GHI	24%	Yes
	Every four weeks	59.9 BC	4.4 DE	43%	No
Fine Fescue	Weekly	3.7 H	2.9 HI	14%	Yes
	Every two weeks	14.0 GH	3.2 GHI	22%	Yes
	Every four weeks	30.8 EF	3.6 FG	31%	Yes

Mosquito and Tick Control in the Residential Landscape

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INTRODUCTION

Both ticks and mosquitoes are capable of having significant impacts on human health and can be common in the landscape. With increasing requests for mosquito and tick control services from the general public, many lawn care and landscape companies are starting to offer these services to clients. This report reviews the important points about mosquito and tick biology and management.

MOSQUITOES

Mosquitoes can be a concern for human and animal health as they are capable of vectoring a number of diseases. In Wisconsin alone, nearly 60 species of mosquitoes can be found, although only a small portion of these are considered medically important to humans and animals by transmitting West Nile Virus, canine heartworm, and other diseases. Globally, mosquitoes pose very significant health threats due to their transmission of diseases such as: malaria, Zika Virus, Dengue Fever, Yellow Fever, and other conditions. In addition to spreading diseases, mosquitoes can be a major nuisance pest capable of disrupting outdoor events. For that reason, clients may enquire about mosquito control services.

Mosquito Biology: It typically takes mosquitoes ~2 weeks to go from egg to adults during the summer months and adults may live for a month or longer. Some mosquito species are capable of overwintering as adults, so mosquitoes can technically be found any time during the year. However, peak mosquito season in Wisconsin is typically during the frost-free periods of the year (May – September). The single most important factor affecting mosquito populations is rainfall**—***especially heavy rains that result in temporarily flooded areas, which are often the most important source of mosquitoes*. Permanent bodies of water (ponds and lakes with fish, rivers, and streams) are usually not important breeding sources.

Mosquito Control: When it comes to mosquito control tactics, cultural, physical, and chemical approaches can be used together as part of an Integrated Pest Management (IPM) program. Important considerations include eliminating mosquito-breeding sites in a given yard. Mosquitoes are capable of breeding in stagnant water that has collected in just about any natural or man-made item: hollow stumps, temporary puddles, clogged gutters, bird baths, neglected swimming pools, children's toys, sagging tarps, etc. Eliminating stagnant water from these spots will minimize mosquito breeding in the local area. In addition, inspecting homes and other buildings for broken, damaged, or improperly fitting screens, windows, and doors, will help ensure that the mosquitoes that are outside, *will stay outside*.

Chemical control (i.e., the use of insecticides) is also an option, but has its limitations. To commercially apply insecticides for mosquito control in Wisconsin, an applicator must be certified in Pest Control Category 5.0 (Aquatic and Mosquito). Certain insecticides (larvicides) can be used to target mosquito larvae (juveniles) in sources of water, such as ponds and reservoirs and may be able to provide long-term control. In some situations, permits may need to be obtained from the DNR to apply larvicides (i.e., applications to waters of the state). A good summary of mosquito control requirements can be found in the WI-DATCP "How to Comply Manual" for Category 5.0 [https://datcp.wi.gov/Documents/AquaticHowToComply.pdf].

Adult mosquitoes can also be targeted, but results tend to be very short lived. Fogging and Ultra-Low Volume (ULV) applications can be made to control adult mosquitoes. However, as soon as the insecticide has dissipated, additional mosquitoes could fly or get blown in from the nearby areas. Due to the short activity of these types of treatments, they are typically performed just prior to an upcoming outdoor event. Another type of treatment to target adult mosquitoes is to apply a residual insecticide to nearby vegetation. During the day, mosquitoes often land on plants to rest and would be killed upon contacting the treated vegetation. These types of treatments last longer (often several weeks), but do not provide the quick knockdown of the fogging/ULV treatments. A variety of active ingredients are available for both fogging/ULV applications and residual applications to vegetation.

For personal protection from mosquitoes while working outdoors, long sleeved clothing and repellents (DEET, picaradin, and similar) can be helpful, as well as staying indoors during peak mosquito times (dawn and dusk).

TICKS

While Wisconsin is home to over 15 different species of ticks, three species are encountered most often: the American dog tick (aka "Wood Tick"), the deer tick, and the lone star tick. Of these, the American dog tick is very common, but is primarily a nuisance species, as it does not pose significant health risks in the state. The lone star tick is a relatively new species and is spotted infrequently in the state; it is much more prevalent in southern parts of the US. The lone star tick can be associated with diseases such as Ehrlichiosis, and components of its saliva can also cause an allergic reaction to red meat. Like the American dog tick, the deer tick can be quite common in Wisconsin. Of our three main tick species, the deer tick poses the greatest risks to human health as it can transmit Lyme disease, Anaplasmosis, and Babesiosis. The Centers for Disease Control (CDC) has an excellent guide to tickborne diseases with additional information: www.cdc.gov/lyme/resources/tickbornediseases.pdf.

Tick Biology: Ticks are small arachnids (<1/4" long) and are related to spiders and mites; they possess 8 legs as adults and have flattened bodies. Our main tick species require two years to complete their life cycle, and they require a blood meal to go through the various stages of their life cycle. Each tick species has a slightly different appearance and an excellent, interactive tick identification chart can be found at the University of Rhode Island Tick Encounter website: www.tickencounter.org. Ticks are associated with vegetation and are often most common along the edges of wooded areas and mowed trails. In contrast, increased sunlight and airflow makes most turfgrass and mulched areas too dry and inhospitable for ticks to survive—*thus, these areas are not an important source of ticks*. Ticks do not jump or fall out of trees, but they are capable of crawling up onto low vegetation to grab onto animals or humans passing by.

Tick Control: Similar to mosquito control, cultural, physical, and chemical tactics can all complement each other as part of an Integrated Pest Management (IPM) program. Eliminating tall/weedy grass at the edges of yards and invasive shrubs (such as honeysuckle) can often help reduce potential tick habitat. In situations where ticks are known or suspected to be present in the nearby landscape, various residual insecticides can be applied to turfgrass areas to help with tick control. These treatments should be applied as a liquid application with enough volume to thoroughly soak the ground. Apply treatments as a band 10-20 feet wide to the turf where turfgrass contacts an area with denser vegetation (weedy/grassy area, wooded area, etc.) or along mowed or gravel paths. This type of treatment only needs to be applied once per year and should be applied in mid-Spring or in fall when there isn't as much vegetation to intercept the insecticide treatment. Most broad-spectrum insecticides labeled for turfgrass can be used in this manner to help with tick control.

For personal protection from ticks while working outdoors, long sleeved clothing and repellents (DEET, picaradin, permethrin clothing treatments and similar) can be helpful. In addition, conducting tick checks after working outdoors is another important step to minimize tick exposure.

Creating GDD Models for Plant Growth Regulators on Athletic Fields and Fairways

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INTRODUCTION

Previous research at UW demonstrated that growing degree day models can predict the performance of the plant growth regulator (PGR) trinexapac-ethyl (Primo Maxx). These models are effective because metabolism or degradation of PGRs was found to be directly related to air temperature. Relative clipping yield of turfgrasses treated with trinexapac-ethyl followed a sinewave model with a period of growth suppression followed by a period of growth enhancement, hereafter called rebound, with respect to non-treated cool-season putting greens. A recent poll found that nearly 50% of respondents now use GDD models to apply PGRs to their turfgrass despite the lack of GDD models for other anti-gibberellin PGRs.

The objectives of this research were to i) determine if GDD models could predict performance of other PGRs, ii) investigate the impact application rate on PGR performance, and iii) determine optimum GDD re-application intervals for each PGR on bentgrass fairways and Kentucky bluegrass at a relatively low mowing height.

METHODS

This research is being conducted on a creeping bentgrass fairway mowed at 3/8th inch and Kentucky bluegrass fairway/sports field mowed at 1 inch at the OJ Noer Facility in Madison and also at the University of Nebraska turfgrass research facility in Mead, NE. Diseases are controlled curatively with fungicides; DMI fungicides are not used. The experimental design is a RCBD with three replicate blocks. Plots measured 6’x4’ Treatments included commonly applied PGRs at various application rates and a non-treated control (Table 1). All PGR treatments are re-applied to previously untreated plots at the beginning of each month. The first applications were made in early June, the second in early July. Applications are made with a CO_2-powered backpack sprayer calibrated to 2.0 gal/1000 ft^2 at 40 psi.

Clippings are collected approximately twice a week by mowing one pass down the center of each pass. Clippings are then dried, cleaned of sand debris, and weighed. To calculate relative clipping production, mean dry clipping weights for each PGR treatment was divided by the mean dry clipping weight of the non-treated control for each collection date.

Table 1. The growth regulators and rates evaluated.

Plant Growth Regulator	Active Ingredients	Green Rate*	Fairway Rate	Athletic Field Rate
	%	oz/A	oz/A	oz/A
Anuew	Prohexadione-Ca (27.5%)	2	7	15
Anuew	Prohexadione-Ca (27.5%)	-	15	24
Cutless MEC	Flurprimidol (16%)	2	25	25
Cutless MEC	Flurprimidol (16%)	8	49	49
Legacy	Flurprimidol (13.26%) Trinexapac-ethyl (5.00%)	5	10	10
Legacy	Flurprimidol (13.26%) Trinexapac-ethyl (5.00%)	10	20	30
Musketeer	Flurprimidol (5.6%) Paclobutrazol (5.6%) Trinexapac-ethyl (1.4%)	12	18	18
Musketeer	Flurprimidol (5.6%) Paclobutrazol (5.6%) Trinexapac-ethyl (1.4%)	22	30	30
Primo MAXX	Trinexapac-ethyl (11.3%)	-	11	11
Primo MAXX	Trinexapac-ethyl (11.3%)	-	33	33
Trimmit 2SC	Paclobutrazol (22.9%)	5.5	16	16
Trimmit 2SC	Paclobutrazol (22.9%)	11	32	32

RESULTS

The following results are highly preliminary and based on only a few months of data collection. However, some interesting trends have been observed. First it is apparent that the growth regulators are much more effective on the taller cut bentgrass compared to the shorter putting green height. Most products gave at least 50% growth suppression for 500 GDD on the fairway areas compared to less than 30% suppression over 300 GDD for the greens. Interestingly, very low growth suppression was observed on the low mow Kentucky bluegrass athletic field. Products containing fluprimidol had almost no efficacy at all. Best suppression was observed for Trimmit, Primo Maxx, and Anuew but even with these products growth suppression was typically less than 50% and lasted 400 GDD or less.

More data is needed to confirm these findings, however, it appears that plant growth regulators are less effective in turf areas that are mown low or below their ideal height. This may be because turf mown short exhibiteds accelerated growth, which likely affects the normal GA production cycle. We hope to continue investigating the physiology of growth regulators to better understand how to get the most out of these products.

Table 2. Length of growth suppression and percent of maximum growth suppression for the growth regulators tested on three different turf areas in Wisconsin and Nebraska. The bentgrass green data was replicated at the Univ. of Nebraska only.

Plant Growth Regulator	Active Ingredients	Bentgrass Green Interval and Suppression	Bentgrass Fairway Interval and Suppression	Athletic Field Interval and Suppression
Anuew	Prohexadione-Ca (27.5%)	280 GDD 35%	550 GDD 50%	400 GDD 30%
Anuew	Prohexadione-Ca (27.5%)	-	550 GDD 50%	400 GDD 40%
Cutless MEC	Flurprimidol (16%)	210 GDD 12%	500 GDD 25%	0 GDD 0%
Cutless MEC	Flurprimidol (16%)	270 GDD 18%	500 GDD 50%	0 GDD 0%
Legacy	Flurprimidol (13.26%) Trinexapac-ethyl (5.00%)	270 GDD 20%	400 GDD 40%	0 GDD 0%
Legacy	Flurprimidol (13.26%) Trinexapac-ethyl (5.00%)	300 GDD 27%	500 GDD 60%	0 GDD 0%
Musketeer	Flurprimidol (5.6%) Paclobutrazol (5.6%) Trinexapac-ethyl (1.4%)	290 GDD 25%	400 GDD 50%	400 GDD 20%
Musketeer	Flurprimidol (5.6%) Paclobutrazol (5.6%) Trinexapac-ethyl (1.4%)	290 GDD 35%	400 GDD 50%	400 GDD 20%
Primo MAXX	Trinexapac-ethyl (11.3%)	-	500 GDD 50%	400 GDD 30%
Primo MAXX	Trinexapac-ethyl (11.3%)	-	500 GDD 60%	400 GDD 50%
Trimmit 2SC	Paclobutrazol (22.9%)	280 GDD 30%	600 GDD 75%	400 GDD 20%
Trimmit 2SC	Paclobutrazol (22.9%)	300 GDD 30%	700 GDD 75%	400 GDD 50%

Reduced-Risk Weed Management

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OBJECTIVE

To determine the efficacy of various reduced-risk herbicides primarily for the control of various broadleaf weeds in a lawn.

MATERIALS AND METHODS

The study was conducted at the O.J. Noer Turfgrass Research and Education Facility in Madison, WI on lawn height Kentucky bluegrass/perennial ryegrass mixture with heavy weed infestations. The individual plots measured 3 ft X 10 ft 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 CO_2 pressurized boom sprayer equipped with XR Teejet AI8004 VS nozzles. All fungicides were agitated by hand and applied in the equivalent of 1.5 gallons of water per 1000 ft^2, except for Adios herbicide, which was applied in 4.5 gallons of water per 1000 ft^2. One herbicide application was initiated on 10/30/2015, while the rest were initiated in the spring of 2016 on various dates with various reapplications according to label directions. Weed counts were conducted 3 times in spring/summer of 2016. Results were subjected to an analysis of variance and means were separated using Fisher's LSD ($P = 0.05$). Results are displayed in Tables 1 and 2.

RESULTS AND DISCUSSION

Weed infestations were very high when the trial was initiated, and all treatments on at least one rating date were significantly better than the untreated control (Table 1). On the May 9th rating date, only 4 of the 8 herbicides performed better than the control. Larger differences were observed on the June 9th rating date with 7 of the 8 herbicides performing better than the control., with Trimec 1000 and Defendor-Spring performing the best. On the July 12th rating date, creeping charlie made a resurgence and weed percentages went back up from the previous rating date. Only 5 of the 8 herbicides performed better than the control on July 12th, with Trimec 1000 averaging 5.56%, while Defendor-Spring, Defendor-Fall, Turflon Ester Ultra, and Adios ranged from 24-44% weeds. Quicksilver, Tenacity, Fiesta, and the control averaged from 48-66% weeds.

On the first rating date, significant differences were observed in how many dandelions were present and how many of those dandelions were blooming (Table 2). While the majority of treatments had many blooming dandelions (average of 163 per plot), Defendor-Fall and Defendor-Spring averaged very close to zero blooming dandelions. Defendor-Fall also suppressed unbloomed dandelions very close to zero. Defendor-Spring averaged 70.8 unbloomed dandelions per plot, but still contained less total dandelions than all other treatments.

Table 1. Mean percent weeds per treatment at the OJ Noer Turfgrass Research and Education Facility in Madison, WI in 2016.

	Treatment	Rate	Application Date	Percent Weeds[a]		
				May 9	Jun 9	Jul 12
1	Non-treated control			77.08a	61.11a	66.67a
2	Fiesta	25.2 fl oz/1000 ft2	4/29, 5/19	45.83b	33.33c	51.39ab
3	Tenacity	5 fl oz/A	4/29, 5/19	76.39a	13.89d	48.61ab
4	Quicksilver	2 fl oz/A	4/29, 5/19	48.61b	43.75bc	48.61ab
5	Adios	192 fl oz/1000 ft2	5/2, 5/19, 5/31	64.58a	48.61ab	44.45b
6	Defendor-Spring	4 fl oz/A	4/12, 5/19	38.89b	13.88d	24.31c
7	Defendor-Fall	4 fl oz/A	10/30	34.72b	38.89bc	34.72bc
8	Turflon Ester Ultra	0.5 qts/A	4/29, 5/31	72.92a	37.50bc	34.03bc
9	Trimec 1000	1.5 fl oz/1000 ft2	4/29, 5/31	64.59a	18.75d	5.56d

[a]Weeds were visually assessed using a 36-point grid and tallying weeds at each point per plot. Means in each column followed by the same letter do not significantly differ (P=.05, Fisher LSD).

Table 2. Mean bloomed and unbloomed dandelion counts per treatment at the OJ Noer Turfgrass Research and Education Facility in Madison, WI in 2016.

	Treatment	Rate	Application Date	Dandelion Counts[a]	
				Bloomed	Unbloomed
1	Non-treated control			196.8a	11.9b
2	Fiesta	25.2 fl oz/1000 ft2	4/29, 5/19	109.8b	14.4b
3	Tenacity	5 fl oz/A	4/29, 5/19	185.8a	8.3b
4	Quicksilver	2 fl oz/A	4/29, 5/19	168.5ab	16.5b
5	Adios	192 fl oz/1000 ft2	5/2, 5/19, 5/31	171.0ab	26.7ab
6	Defendor-Spring	4 fl oz/A	4/12, 5/19	0.0c	70.8a
7	Defendor-Fall	4 fl oz/A	10/30	0.3c	0.6c
8	Turflon Ester Ultra	0.5 qts/A	4/29, 5/31	153.8ab	28.2ab
9	Trimec 1000	1.5 fl oz/1000 ft2	4/29, 5/31	160.3ab	17.9ab

[a]Dandelion counts were visually assessed on 5/9/16. Means in each column followed by the same letter do not significantly differ (P=.05, Fisher LSD).

Different Nitrogen Sources get Different Results

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INTRODUCTION

Turfgrass species varies throughout Wisconsin. There are many different fertility management plans for every type of facility. The major nutrient in all these programs is Nitrogen. How much to apply and which product to by? The choices seem endless but how to choose. Which Nitrogen source or blend of sources to apply? The answer will be based on what the result you expect. Are you attempting to improve turfgrass health, are you maintaining a good stand of turfgrass, are weeds or crabgrass an issue, are you seeing disease issues? All these can affect the Nitrogen source you choose.

We will discuss the basics of Nitrogen sources and what to expect out of each source. How do we blend these sources and what are the expect results in turfgrass growth. What are expected the benefits of each Nitrogen source. Are there benefits to changing sources and percentages of a Nitrogen source in your blend and will that change throughout the year.

We will also talk briefly about weed control in newly seeded turfgrass. What works?

Effect of pH on Fungicide Efficacy

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OBJECTIVE

To determine the effect of pH on the efficacy of two commonly used fungicides for dollar spot control.

MATERIALS AND METHODS

The study was conducted at the O. J. Noer Turfgrass Research and Education Facility in Madison, WI on a stand of creeping bentgrass (*Agrostis stolonifera* 'Penncross') 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 p.s.i. using a CO_2 pressurized boom sprayer equipped with two XR Teejet AI8004 VS nozzles. All fungicides were agitated by hand and applied in the equivalent of 1.5 gallons of water per 1000 ft^2. All treatments were initiated on July 7th and only the Daconil treatments were applied 14 days later. The pH of each bottle was either lowered using LpH Chemstik, a pH buffer, or raised using one pellet of potassium hydroxide (KOH), or left unchanged. Disease severity (number of dollar spot foci per plot) and turfgrass quality (1-9, 9 being excellent, 6 acceptable, and 1 bare soil) were assessed. Turf quality and disease severity were subjected to an analysis of variance and means were separated using Fisher's LSD (P = 0.05). Results of the disease severity and turfgrass quality ratings can be found in table 1 and 2, respectively.

RESULTS AND DISCUSSION

Dollar spot pressure has been very low up to this point on this plot and all treatments have reduced dollar spot severity compared to the untreated controls. No clear effects of pH on fungicide efficacy have been observed.

Table 1. Mean number of dollar spot foci per treatment at the OJ Noer Turfgrass Research and Education Facility in Madison, WI during 2016.

	Treatment	pH	Rate	Application Interval	Dollar Spot Severity[a]
					Jul 15
1	Non-treated control				3.8a
2	Banner MAXX	6.15	2 fl oz/1000 ft2	Single App	1.3b
3	Banner MAXX	7.28	2 fl oz/1000 ft2	Single App	0.0b
4	Banner MAXX	9.54	2 fl oz/1000 ft2	Single App	0.0b
5	Daconil Weatherstik	6.09	5.5 fl oz/1000 ft2	14 day	0.5b
6	Daconil Weatherstik	7.11	5.5 fl oz/1000 ft2	14 day	1.0b
7	Daconil Weatherstik	9.34	5.5 fl oz/1000 ft2	14 day	1.3b

[a]Dollar spot severity assessed as number of dollar spot infection centers per plot. Means followed by the same letter do not significantly differ (P=.05, Fisher's LSD).

Table 2. Mean turfgrass quality at the OJ Noer Turfgrass Research and Education Facility in Madison, WI during 2016.

	Treatment	pH	Rate	Application Interval/pH	Turfgrass Quality[a]
					Jul 15
1	Non-treated control				7.5a
2	Banner MAXX LpH Chemstik	6.15	2 fl oz/1000 ft2 6 ml/bottle	Single App	7.5a
3	Banner MAXX	7.28	2 fl oz/1000 ft2	Single App	7.8a
4	Banner MAXX KOH	9.54	2 fl oz/1000 ft2 1 pellet/bottle	Single App	7.3a
5	Daconil Weatherstik LpH Chemstik	6.09	5.5 fl oz/1000 ft2 5 ml/bottle	14 day	7.3a
6	Daconil Weatherstik	7.11	5.5 fl oz/1000 ft2	14 day	7.5a
7	Daconil Weatherstik KOH	9.34	5.5 fl oz/1000 ft2 1 pellet/bottle	14 day	7.5a

[a]Turfgrass 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).

Dollar Spot Model Fungicide Test

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OBJECTIVE

To compare control of dollar spot caused by the fungus *Sclerotinia homoeocarpa* using various fungicides with different application intervals sprayed on a calendar basis and using the Smith-Kerns dollar spot prediction model.

MATERIALS AND METHODS

The study was conducted at the O. J. Noer Turfgrass Research and Education Facility on a stand of creeping bentgrass (*Agrostis stolonifera* 'Penncross') fairway 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 CO_2 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 $ft^{2.}$ All treatments were initiated June 1^{st}, 2016 and half of the treatments were subsequently applied at 14, 21, and 28 day intervals depending on label recommendations. The other half of the treatments used the Smith-Kerns dollar spot prediction model to determine application timings. Dollar spot infection centers and turf quality (1-9, 9 being excellent and 6 acceptable) were visually assessed and subjected to an analysis of variance and means were separated using Fisher's LSD (P = 0.05). Results of the disease severity and turfgrass quality ratings can be found in table 1 and 2, respectively.

RESULTS AND DISCUSSION

Dollar spot pressure has been low to moderate up to this point in the season with nontreated controls averaging 56.5 dollar spot foci per plot. All treatments significantly lowered dollar spot severity, but trt 3 had some breakthrough on the last rating date. Treatment 4 has been applied four times, treatments 2, 3, and 5 have been applied three times, and treatments 6 and 7 have been applied twice.

Table 1. Mean number of dollar spot infection centers per treatment at the OJ Noer Turfgrass Research Facility in Madison, WI in 2016.

	Treatment	Rate	Application Interval	Dollar Spot Severity[a]		
				Jun 16	Jun 27	Jul 11
1	Non-treated control			5.3a	20.3a	56.5a
2	Banner MAXX	2 fl oz/1000 ft2	21 days	0.5a	0.0b	0.0b
3	Banner MAXX	2 fl oz/1000 ft2	20 % risk	0.3a	4.8b	15.8b
4	Secure	0.5 fl oz/1000 ft2	14 days	0.3a	0.0b	0.0b
5	Secure	0.5 fl oz/1000 ft2	20% risk	0.0a	0.0b	0.8b
6	Xzemplar	0.26 fl oz/1000 ft2	28 days	0.0a	1.8b	0.0b
7	Xzemplar	0.26 fl oz/1000 ft2	20% risk	0.3a	0.5b	0.0b

[a]Dollar spot severity assessed as number of dollar spot infection centers per plot. Means followed by the same letter do not significantly differ (P=.05, Fisher's LSD).

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 2016.

	Treatment	Rate	Application Interval	Turfgrass Quality[a]		
				Jun 16	Jun 27	Jul 11
1	Non-treated control			7.0a	6.8a	5.5d
2	Banner MAXX	2 fl oz/1000 ft2	21 days	7.3a	7.0a	6.8ab
3	Banner MAXX	2 fl oz/1000 ft2	20 % risk	7.0a	7.0a	6.0cd
4	Secure	0.5 fl oz/1000 ft2	14 days	7.0a	7.0a	7.0a
5	Secure	0.5 fl oz/1000 ft2	20% risk	7.0a	7.0a	6.8ab
6	Xzemplar	0.26 fl oz/1000 ft2	28 days	7.3a	7.0a	7.0a
7	Xzemplar	0.26 fl oz/1000 ft2	20% risk	7.0a	7.0a	7.0a

[a]Turfgrass 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 Probability Model

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OBJECTIVE

To determine the accuracy of the Smith-Kerns dollar spot prediction model for use in controlling dollar spot caused by the fungus *Sclerotinia homoeocarpa*.

MATERIALS AND METHODS

The study was conducted at the O. J. Noer Turfgrass Research and Education Facility in Madison, WI on a stand of creeping bentgrass (*Agrostis stolonifera* 'Penncross') 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 p.s.i. using a CO_2 pressurized boom sprayer equipped with two XR Teejet AI8004 VS nozzles. The only fungicide used was Banner MAXX II, which was agitated by hand and applied in the equivalent of 1.5 gallons of water per 1000 ft^2. Treatment 2 was applied on a 21-day interval initiated on June 1st, 2016, while the remaining treatments were applied based on various probabilities produced by the Smith-Kerns dollar spot model. Number of dollar spot foci 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 the 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 pressure has been fairly high this year with nontreated controls averaging 183 dollar spot foci per plot. All treatments have significantly reduced dollar spot severity compared to the control. Treatments 2 and 3 have the highest turf quality ratings while treatments 4, 5, 6, and 7 have significantly lower quality scores. Treatments 2, 3, 4, and 5 have been applied 3 times, and treatments 6 and 7 have been applied three times.

Table 1. Mean number of dollar spots per treatment at the OJ Noer Turfgrass Research Facility in Madison, WI in 2016.

	Treatment	Rate	Application Interval/Model Prob.	Dollar Spot Severity[a]		
				Jun 15	Jun 28	Jul 11
1	Non-treated control			79.3a	132.0a	183.8a
2	Banner MAXX II	2.0 FL OZ/1000 FT2	21 Day	8.3b	1.8e	6.5c
3	Banner MAXX II	2.0 FL OZ/1000 FT2	10%	6.5b	10.5de	10.3c
4	Banner MAXX II	2.0 FL OZ/1000 FT2	15%	7.3b	23.8bcd	37.5bc
5	Banner MAXX II	2.0 FL OZ/1000 FT2	20%	5.0b	19.8cd	37.8bc
6	Banner MAXX II	2.0 FL OZ/1000 FT2	25%	7.8b	37.8b	58.5b
7	Banner MAXX II	2.0 FL OZ/1000 FT2	30%	6.3b	35.0bc	45.3bc

[a]Dollar spot severity assessed as number of dollar spot infection centers per plot. Means followed by the same letter do not significantly differ (P=.05, Fisher's LSD).

Table 2. Turfgrass quality at the OJ Noer Turfgrass Research Facility in Madison, WI in 2016.

	Treatment	Rate	Application Interval/Model Prob.	Turfgrass Quality[a]		
				Jun 15	Jun 28	Jul 11
1	Non-treated control			5.8b	5.0c	5.0c
2	Banner MAXX II	2.0 FL OZ/1000 FT2	21 Day	7.3a	7.0a	7.3a
3	Banner MAXX II	2.0 FL OZ/1000 FT2	10%	7.0a	7.0a	7.3a
4	Banner MAXX II	2.0 FL OZ/1000 FT2	15%	7.3a	6.3b	5.8bc
5	Banner MAXX II	2.0 FL OZ/1000 FT2	20%	7.3a	6.8ab	6.3b
6	Banner MAXX II	2.0 FL OZ/1000 FT2	25%	7.0a	6.5ab	6.0b
7	Banner MAXX II	2.0 FL OZ/1000 FT2	30%	7.0a	6.8ab	5.5bc

[a]Turfgrass 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).

Impact of Nitrogen on Dollar Spot

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OBJECTIVE

The objective of this study is to determine the effect of nitrogen has on the production of oxalic acid by *Sclerotinia homoeocarpa* by looking at the nitrogen source and rate. The long term aim is to create an optimal fertility program that alters pH in foliar tissue of turfgrass with an aim of reducing oxalic acid production.

INTRODUCTION

Dollar spot which is caused by the pathogen *Sclerotinia homoeocarpa* is one of the most common diseases found on golf courses in North America. Recent research has shown that *S. homoeocarpa* produces oxalic acid which may influence the development of dollar spot symptoms. Production of oxalic acid is inhibited when the pathogen is cultured at a lower pH.

Dollar spot has long been recognized as a low nitrogen disease but the nitrogen sources could provide further insight into controlling the disease. Applications of various nitrogen sources have shown potential control options outside of traditional fungicide programs. Analyzing foliar pH may provide more information into the control of the pathogen. By utilizing nitrogen sources which each have a different effect on pH, the foliar pH may be affected as well.

MATERIALS AND METHODS

Field trials are being conducted at O.J. Noer Turfgrass Research Facility and at North Shore Country Club in Glenview, Illinois. These trials were initiated in June of 2015. Currently, there are two trials being conducted at each site analyzing nitrogen rate, and nitrogen source on green height turf. The trials at North Shore Country club are being conducted on a push up based nursery that is mowed at 0.115 inch cutting height using a Toro Greensmaster 1000. Trials taking place at the O.J Noer facility are grown on a sand based root zone maintained at a height of .125" using a Toro Greensmaster 3150. Individual plots measured 6 ft X 4 ft 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 CO_2 pressurized boom sprayer equipped with XR Teejet AI8004 nozzles. All fungicides were agitated by hand and applied in the equivalent of 2.0 gallons of water per 1000 ft^2. Turfgrass quality (1-9, 9 being excellent, 6 being acceptable, and 1 bare soil) are visually assessed every 2 weeks. The number of dollar spot foci and percent disease cover are visually assessed every 2 weeks. Clippings are collected from each plot and then analyzed each month for foliar pH and foliar nitrogen content.

RESULTS AND DISCUSSION

Nitrogen Rate

Dollar Spot Pressure is slowly starting to increase at both sites. Compared to the data from last year dollar spot pressure at the O.J Noer this year has been much lower. Infection centers this time last year peaked at 600 centers per plot, compared to 60 this season. Looking at table 2 we see that the nitrogen rates begin to separate from one another. There is significant difference (*P*=0.05) between treatment 5 (0.6lbsN/1000ft^2) compared to the untreated check. We also see that as nitrogen rates increase disease severity is reduced.

Table 1. Area under disease progress curve (AUDPC) for all treatments in located at OJ Noer Turfgrass Research Facility in Madison WI during 2015.

	Treatment	Rate	Application Interval	AUDPC (Infection Centers)
1	Non-treated control			3536.6 A[a]
2	Urea	0.1 LB N/1000 FT2	14 Day	3124.2 AB
3	Urea	0.2 LB N/1000 FT2	14 Day	3097.3 AB
4	Urea	0.4 LB N/1000 FT2	14 Day	2473.4 AB
5	Urea	0.6 LB N/1000 FT2	14 Day	1804.7 AB
6	Xzemplar Banner MAXX II Secure Xzemplar Secure Iprodione Secure Banner MAXX II	0.26 FL OZ/1000 FT2 1.5 FL OZ/1000 FT2 0.5 FL OZ/1000 FT2 0.26 FL OZ/1000 FT2 0.5 FL OZ/1000 FT2 3.0 FL OZ/1000 FT2 0.5 FL OZ/1000 FT2 1.5 FL OZ/1000 FT2	14 Day	1652.2 B

[a]Area under the disease progress curve (AUDPC) assessed as number of dollar spot infection centers per plot. Means followed by the same letter do not significantly differ (P=0.05).

Table 2. Area under disease progress curve (AUDPC) for all treatments in located at North Shore Country Club in Glenview IL during 2015.

	Treatment	Rate	Application Interval	AUDPC (Infection Centers)
1	Non-treated control			3043.8 A[a]
2	Urea	0.1 LB N/1000 FT2	14 Day	2297.1 AB
3	Urea	0.2 LB N/1000 FT2	14 Day	2294.8 AB
4	Urea	0.4 LB N/1000 FT2	14 Day	1770.3 AB
5	Urea	0.6 LB N/1000 FT2	14 Day	1273.1 BC
6	Xzemplar Banner MAXX II Secure Xzemplar Secure Iprodione Secure Banner MAXX II	0.26 FL OZ/1000 FT2 1.5 FL OZ/1000 FT2 0.5 FL OZ/1000 FT2 0.26 FL OZ/1000 FT2 0.5 FL OZ/1000 FT2 3.0 FL OZ/1000 FT2 0.5 FL OZ/1000 FT2 1.5 FL OZ/1000 FT2	14 Day	0 C

[a]Area under the disease progress curve (AUDPC) assessed as number of dollar spot infection centers per plot. Means followed by the same letter do not significantly differ (P=0.05).

Table 3. Dollar Spot severity for all treatments in located at North Shore Country Club in Glenview IL and OJ Noer in Madison WI during 2015.

	Treatment	Rate	Application Interval	NSCC Infection Sites	OJ Noer Infection Sites
1	Non-treated control			216 A	274.09 A[a]
2	Urea	0.1 LB N/1000 FT2	14 Day	159.44 B	243.25 A
3	Urea	0.2 LB N/1000 FT2	14 Day	157.79 B	241.64 A
4	Urea	0.4 LB N/1000 FT2	14 Day	123.38 B	200.25 AB
5	Urea	0.6 LB N/1000 FT2	14 Day	60.63 C	150.73 B
6	Xzemplar Banner MAXX II Secure Xzemplar Secure Iprodione Secure Banner MAXX II	0.26 FL OZ/1000 FT2 1.5 FL OZ/1000 FT2 0.5 FL OZ/1000 FT2 0.26 FL OZ/1000 FT2 0.5 FL OZ/1000 FT2 3.0 FL OZ/1000 FT2 0.5 FL OZ/1000 FT2 1.5 FL OZ/1000 FT2	14 Day	0 D	139.93 B

[a]Dollar spot severity assessed as number of dollar spot infection centers per plot. Means followed by the same letter do not significantly differ (P=0.05).

Nitrogen Source

This summer we see that dollar spot pressure is lower compared to last summer. Dollar spot pressure is starting to intensify on both sites and is providing good data. Looking at the data from last year we did not see any significant differences between nitrogen sources for reducing dollar spot severity. Looking at the tables below we see slight differences between some of the nitrogen sources but these differences are not significant. Interestingly we see from table 4 that all nitrogen sources reduced dollar spot severity when compared to the untreated check.

Table 4. Area under disease progress curve (AUDPC) for all treatments in located at OJ Noer Turfgrass Research Facility in Madison WI during 2015.

	Treatment	Rate	Application Interval	AUDPC (Infection Centers)
1	Non-treated control			4503.2 A[a]
2	Calcium Nitrate	0.2 LB N/1000 FT2	14 Day	3201.7 AB
3	Ammonium Sulfate	0.2 LB N/1000 FT2	14 Day	3471.8 A
4	Ammonium Nitrate	0.2 LB N/1000 FT2	14 Day	3206.9 AB
5	Xzemplar Banner MAXX II Secure Xzemplar Secure Iprodione Secure Banner MAXX II	0.26 FL OZ/1000 FT2 1.5 FL OZ/1000 FT2 0.5 FL OZ/1000 FT2 0.26 FL OZ/1000 FT2 0.5 FL OZ/1000 FT2 3.0 FL OZ/1000 FT2 0.5 FL OZ/1000 FT2 1.5 FL OZ/1000 FT2	14 Day	1448.6 B

[a]Area under the disease progress curve (AUDPC) assessed as number of dollar spot infection centers per plot. Means followed by the same letter do not significantly differ (P=0.05).

Table 5. Area under disease progress curve (AUDPC) for all treatments in located at North Shore Country Club in Glenview IL during 2015.

	Treatment	Rate	Application Interval	AUDPC (Infection Centers)
1	Non-treated control			2944.9 A[a]
2	Calcium Nitrate	0.2 LB N/1000 FT2	14 Day	2095.2 A
3	Ammonium Sulfate	0.2 LB N/1000 FT2	14 Day	2332.4 A
4	Ammonium Nitrate	0.2 LB N/1000 FT2	14 Day	2145.1 A
5	Xzemplar Banner MAXX II Secure Xzemplar Secure Iprodione Secure Banner MAXX II	0.26 FL OZ/1000 FT2 1.5 FL OZ/1000 FT2 0.5 FL OZ/1000 FT2 0.26 FL OZ/1000 FT2 0.5 FL OZ/1000 FT2 3.0 FL OZ/1000 FT2 0.5 FL OZ/1000 FT2 1.5 FL OZ/1000 FT2	14 Day	0 B

[a]Area under the disease progress curve (AUDPC) assessed as number of dollar spot infection centers per plot. Means followed by the same letter do not significantly differ (P=0.05).

Table 6. Dollar Spot severity for all treatments in located at North Shore Country Club in Glenview IL and OJ Noer in Madison WI during 2015.

	Treatment	Rate	Application Interval	NSCC Infection Centers	OJ Noer Infection Centers
1	Non-treated control			211.27 A	337.64 A[a]
2	Calcium Nitrate	0.2 LB N/1000 FT2	14 Day	149.27 B	249.95 B
3	Ammonium Sulfate	0.2 LB N/1000 FT2	14 Day	165.92 B	266.59 B
4	Ammonium Nitrate	0.2 LB N/1000 FT2	14 Day	154.06 B	249 B
5	Xzemplar Banner MAXX II Secure Xzemplar Secure Iprodione Secure Banner MAXX II	0.26 FL OZ/1000 FT2 1.5 FL OZ/1000 FT2 0.5 FL OZ/1000 FT2 0.26 FL OZ/1000 FT2 0.5 FL OZ/1000 FT2 3.0 FL OZ/1000 FT2 0.5 FL OZ/1000 FT2 1.5 FL OZ/1000 FT2	14 Day	0 C	124.36 C

[a]Dollar spot severity assessed as number of dollar spot infection centers per plot. Means followed by the same letter do not significantly differ (P=0.05).

Reduced-Risk Dollar Spot Management

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OBJECTIVE

To determine the efficacy of various reduced-risk programs primarily for the control of dollar spot on creeping bentgrass maintained as a golf course fairway and putting green.

MATERIALS AND METHODS

The study was replicated at 3 locations: the O.J. Noer Turfgrass Research and Education Facility in Madison, WI and the 14th and 18th holes at University Ridge Golf Course in Madison, WI. At the O.J. Noer site the study was conducted on creeping bentgrass (*Agrostis stolonifera* 'Pencross') maintained at a 0.125 inch cutting height. At the University Ridge sites the study was conducted on creeping bentgrass (*Agrostis stolonifera* 'Penncross') maintained at a 0.5 inch cutting height. The individual plots measured 6 ft X 10 ft 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 CO_2 pressurized boom sprayer equipped with XR Teejet AI8004 VS nozzles. All fungicides were agitated by hand and applied in the equivalent of 1.5 gallons of water per 1000 ft^2. Four fungicide programs were tested in addition to the non-treated control. One was a conventional fungicide program based off the program of a local golf course, the second based the application timing on the Smith-Kerns dollar spot prediction model using conventional fungicides, the third based application timing on the Smith-Kerns dollar spot model but used exclusively fungicides labeled as reduced risk by the Environmental Protection Agency, and the fourth based application timing on the Smith-Kerns dollar spot model and used low rates of conventional fungicides tank-mixed with Civitas Pre-M1xed. Number of dollar spot infection centers per plot, turfgrass quality (1-9, 9 being excellent, 6 acceptable, and 1 bare soil) were assessed every two weeks. Results were subjected to an analysis of variance and means were separated using Fisher's LSD (P = 0.05). Disease severity and turfgrass quality from each location can be found in the following tables.

RESULTS AND DISCUSSION

Dollar spot pressure has varied greatly between the three study locations. Non-treated controls are averaging 300, 62, and 11 dollar spot foci per plot at the OJ Noer, 14th, and 18th hole locations, respectively. All four programs have produced acceptable turf quality ratings at each location. All treatements at the OJ Noer and 14th hole have reduced dollar spot severity, but the 18th hole has had low pressure up to this point and no differences between treatments have been observed. Treatment 2 has been applied four times and treatments 3, 4 and 5 have been applied three times.

Table 1. Mean number of dollar spot infection centers per treatment at the OJ Noer Turfgrass Research and Education Facility in Madison, WI in 2016.

		Treatment	Rate	Application Date/Interval	Dollar spot severity[a]		
					Jun 14	Jun 27	Jul 12
1		Non-treated control			150.8a	224.8a	300.5a
2	Conventional Program	Emerald (A)	0.18 OZ/1000 FT2	May 20	5.8b	2.5b	6.8b
		Torque (B)	0.6 FL OZ/1000 FT2	June 17			
		Daconil WStik (C)	3.2 FL OZ/1000 FT2	July 8			
		Banner MAXX II (C)	1.0 FL OZ/1000 FT2	July 8			
		Subdue MAXX (C)	1.0 FL OZ/1000 FT2	July 8			
		Chipco 26GT (D)	3.0 FL OZ/1000 FT2	July 21			
		Subdue MAXX (D)	1.0 FL OZ/1000 FT2	July 21			
		Daconil WStik (E)	3.2 FL OZ/1000 FT2	August 4			
		Torque (F)	0.6 FL OZ/1000 FT2	August 4			
		Curalan (G)	1.0 OZ/1000 FT2	September 1			
		Chipco 26GT (H)	3.0 FL OZ/1000 FT2	September 22			
3	Smith-Kerns model: Conventional	Emerald (A)	0.18 OZ/1000 FT2	28 Days	4.3b	8.0b	10.3b
		Banner MAXX II (B)	1.0 FL OZ/1000 FT2	14 Days			
		Daconil WStik (B)	3.2 FL OZ/1000 FT2	14 Days			
		Chipco 26GT (C)	2.0 FL OZ/1000 FT2	14 Days			
		Daconil WStik (C)	3.2 FL OZ/1000 FT2	14 Days			
		Banner MAXX II (D)	1.0 FL OZ/1000 FT2	14 Days			
		Daconil WStik (D)	3.2 FL OZ/1000 FT2	14 Days			
		Emerald (E)	0.18 OZ/1000 FT2	28 Days			
		Banner MAXX II (F)	2.0 FL OZ/1000 FT2	21 Days			
4	Smith-Kerns model: Reduced Risk	Emerald (A)	0.18 OZ/1000 FT2	28 Days	1.5b	5.3b	2.3b
		Velista (B)	0.5 OZ/1000 FT2	21 Days			
		Secure (B)	0.5 FL OZ/1000 FT2	21 Days			
		Emerald (C)	0.18 OZ/1000 FT2	28 Days			
		Heritage TL (C)	2.0 FL OZ/1000 FT2	28 Days			
		Compass (D)	0.25 OZ/1000 FT2	21 Days			
		Velista (D)	0.5 OZ/1000 FT2	21 Days			
		Secure (D)	0.5 FL OZ/1000 FT2	21 Days			
		Emerald (E)	0.18 OZ/1000 FT2	28 Days			
		Velista (F)	0.5 OZ/1000 FT2	21 Days			
		Secure (F)	0.5 FL OZ/1000 FT2	21 Days			
5	Smith-Kerns model: Low Rate Convent.+Civitas	Emerald (A)	0.13 OZ/1000 FT2	28 Days	2.0b	4.3b	22.5b
		Civitas Pre-M1xed (A)	17 FL OZ/1000 FT2	28 Days			
		Banner MAXX (B)	0.5 FL OZ/1000 FT2	14 Days			
		Civitas Pre-M1xed (B)	8.5 FL OZ/1000 FT2	14 Days			
		Chipco 26 GT (C)	2 FL OZ/1000 FT2	14 Days			
		Civitas Pre-M1xed (C)	8.5 FL OZ/1000 FT2	14 Days			
		Banner MAXX (D)	0.5 FL OZ/1000 FT2	14 Days			
		Civitas Pre-M1xed (D)	8.5 FL OZ/1000 FT2	14 Days			
		Emerald (E)	0.13 OZ/1000 FT2	28 Days			
		Civitas Pre-M1xed (E)	17 FL OZ/1000 FT2	28 Days			
		Banner Maxx (F)	1 FL OZ/1000 FT2	21 Days			
		Civitas Pre-M1xed (F)	12.5 FL OZ/1000 FT2	21 Days			

[a]Dollar spot was visually assessed as number of dollar spot infection centers per plot. Means followed by the same letter do not significantly differ (P=.05, Fisher's LSD).

Table 2. Mean turf quality ratings per treatment at the OJ Noer Turfgrass Research and Education Facility in Madison, WI in 2016.

		Treatment	Rate	Application Date/Interval	Turfgrass Quality[a] Jun 14	Jun 27	Jul 12
1		Non-treated control			5.3b	4.8b	4.3b
2	Conventional Program	Emerald (A)[b]	0.18 OZ/1000 FT2	May 20	7.0a	7.3a	7.3a
		Torque (B)	0.6 FL OZ/1000 FT2	June 17			
		Daconil WStik (C)	3.2 FL OZ/1000 FT2	July 8			
		Banner MAXX II (C)	1.0 FL OZ/1000 FT2	July 8			
		Subdue MAXX (C)	1.0 FL OZ/1000 FT2	July 8			
		Chipco 26GT (D)	3.0 FL OZ/1000 FT2	July 21			
		Subdue MAXX (D)	1.0 FL OZ/1000 FT2	July 21			
		Daconil WStik (E)	3.2 FL OZ/1000 FT2	August 4			
		Torque (F)	0.6 FL OZ/1000 FT2	August 4			
		Curalan (G)	1.0 OZ/1000 FT2	September 1			
		Chipco 26GT (H)	3.0 FL OZ/1000 FT2	September 22			
3	Smith-Kerns model - Conventional	Emerald (A)	0.18 OZ/1000 FT2	28 Days	6.8a	7.5a	7.0a
		Banner MAXX II (B)	1.0 FL OZ/1000 FT2	14 Days			
		Daconil Wstik (B)	3.2 FL OZ/1000 FT2	14 Days			
		Chipco 26GT (C)	2.0 FL OZ/1000 FT2	14 Days			
		Daconil Wstik (C)	3.2 FL OZ/1000 FT2	14 Days			
		Banner MAXX II (D)	1.0 FL OZ/1000 FT2	14 Days			
		Daconil WStik (D)	3.2 FL OZ/1000 FT2	14 Days			
		Emerald (E)	0.18 OZ/1000 FT2	28 Days			
		Banner MAXX II (F)	2.0 FL OZ/1000 FT2	21 Days			
4	Smith-Kerns model – Reduced Risk	Emerald (A)	0.18 OZ/1000 FT2	28 Days	7.0a	7.8a	7.3a
		Velista (B)	0.5 OZ/1000 FT2	21 Days			
		Secure (B)	0.5 FL OZ/1000 FT2	21 Days			
		Emerald (C)	0.18 OZ/1000 FT2	28 Days			
		Heritage TL (C)	2.0 FL OZ/1000 FT2	28 Days			
		Compass (D)	0.25 OZ/1000 FT2	21 Days			
		Velista (D)	0.5 OZ/1000 FT2	21 Days			
		Secure (D)	0.5 FL OZ/1000 FT2	21 Days			
		Emerald (E)	0.18 OZ/1000 FT2	28 Days			
		Velista (F)	0.5 OZ/1000 FT2	21 Days			
		Secure (F)	0.5 FL OZ/1000 FT2	21 Days			
5	Smith-Kerns model: Low Rate Convent.+ Civitas	Emerald (A)	0.13 OZ/1000 FT2	28 Days	7.5a	8.0a	7.3a
		Civitas Pre-M1xed (A)	17 FL OZ/1000 FT2	28 Days			
		Banner MAXX (B)	0.5 FL OZ/1000 FT2	14 Days			
		Civitas Pre-M1xed (B)	8.5 FL OZ/1000 FT2	14 Days			
		Chipco 26 GT (C)	2 FL OZ/1000 FT2	14 Days			
		Civitas Pre-M1xed (C)	8.5 FL OZ/1000 FT2	14 Days			
		Banner MAXX (D)	0.5 FL OZ/1000 FT2	14 Days			
		Civitas Pre-M1xed (D)	8.5 FL OZ/1000 FT2	14 Days			
		Emerald (E)	0.13 OZ/1000 FT2	28 Days			
		Civitas Pre-M1xed (E)	17 FL OZ/1000 FT2	28 Days			
		Banner Maxx (F)	1 FL OZ/1000 FT2	21 Days			
		Civitas Pre-M1xed (F)	12.5 FL OZ/1000 FT2	21 Days			

[a]Turfgrass quality was visually assessed on 1-9 scale, with 9 being excellent, 6 being acceptable, and 1 bare dirt. Means followed by the same letter do not significantly differ (P=.05, Fisher's LSD).

Table 3. Mean number of dollar spot infection centers per treatment on the 14th fairway at University Ridge GC in Madison, WI during 2016.

		Treatment	Rate	Application Date/Interval	Dollar spot severity[a]		
					Jun 14	Jun 27	Jul 12
1		Non-treated control			6.5a	16.3a	62.3a
2	Conventional Program	Emerald (A)[b]	0.18 OZ/1000 FT2	May 20	0.3b	0.5b	0.0b
		Torque (B)	0.6 FL OZ/1000 FT2	June 17			
		Daconil WStik (C)	3.2 FL OZ/1000 FT2	July 8			
		Banner MAXX II (C)	1.0 FL OZ/1000 FT2	July 8			
		Subdue MAXX (C)	1.0 FL OZ/1000 FT2	July 8			
		Chipco 26GT (D)	3.0 FL OZ/1000 FT2	July 21			
		Subdue MAXX (D)	1.0 FL OZ/1000 FT2	July 21			
		Daconil WStik (E)	3.2 FL OZ/1000 FT2	August 4			
		Torque (F)	0.6 FL OZ/1000 FT2	August 4			
		Curalan (G)	1.0 OZ/1000 FT2	September 1			
		Chipco 26GT (H)	3.0 FL OZ/1000 FT2	September 22			
3	Smith-Kerns model: Conventional	Emerald (A)	0.18 OZ/1000 FT2	28 Days	1.0b	3.0b	2.0b
		Banner MAXX II (B)	1.0 FL OZ/1000 FT2	14 Days			
		Daconil Wstik (B)	3.2 FL OZ/1000 FT2	14 Days			
		Chipco 26GT (C)	2.0 FL OZ/1000 FT2	14 Days			
		Daconil Wstik (C)	3.2 FL OZ/1000 FT2	14 Days			
		Banner MAXX II (D)	1.0 FL OZ/1000 FT2	14 Days			
		Daconil WStik (D)	3.2 FL OZ/1000 FT2	14 Days			
		Emerald (E)	0.18 OZ/1000 FT2	28 Days			
		Banner MAXX II (F)	2.0 FL OZ/1000 FT2	21 Days			
4	Smith-Kerns model: Reduced Risk	Emerald (A)	0.18 OZ/1000 FT2	28 Days	0.3b	0.8b	0.0b
		Velista (B)	0.5 OZ/1000 FT2	21 Days			
		Secure (B)	0.5 FL OZ/1000 FT2	21 Days			
		Emerald (C)	0.18 OZ/1000 FT2	28 Days			
		Heritage TL (C)	2.0 FL OZ/1000 FT2	28 Days			
		Compass (D)	0.25 OZ/1000 FT2	21 Days			
		Velista (D)	0.5 OZ/1000 FT2	21 Days			
		Secure (D)	0.5 FL OZ/1000 FT2	21 Days			
		Emerald (E)	0.18 OZ/1000 FT2	28 Days			
		Velista (F)	0.5 OZ/1000 FT2	21 Days			
		Secure (F)	0.5 FL OZ/1000 FT2	21 Days			
5	Smith-Kerns model: Low Rate Convent.+Civitas	Emerald (A)	0.13 OZ/1000 FT2	28 Days	0.0b	0.0b	0.8b
		Civitas Pre-M1xed (A)	17 FL OZ/1000 FT2	28 Days			
		Banner MAXX (B)	0.5 FL OZ/1000 FT2	14 Days			
		Civitas Pre-M1xed (B)	8.5 FL OZ/1000 FT2	14 Days			
		Chipco 26 GT (C)	2 FL OZ/1000 FT2	14 Days			
		Civitas Pre-M1xed (C)	8.5 FL OZ/1000 FT2	14 Days			
		Banner MAXX (D)	0.5 FL OZ/1000 FT2	14 Days			
		Civitas Pre-M1xed (D)	8.5 FL OZ/1000 FT2	14 Days			
		Emerald (E)	0.13 OZ/1000 FT2	28 Days			
		Civitas Pre-M1xed (E)	17 FL OZ/1000 FT2	28 Days			
		Banner Maxx (F)	1 FL OZ/1000 FT2	21 Days			
		Civitas Pre-M1xed (F)	12.5 FL OZ/1000 FT2	21 Days			

[a]Dollar spot was visually assessed as number of dollar spot infection centers per plot. Means followed by the same letter do not significantly differ (P=.05, Fisher's LSD).

Table 4. Mean turf quality ratings per treatment on the 14th fairway at University Ridge GC in Madison, WI during 2016.

		Treatment	Rate	Application Date/Interval	Turfgrass Quality[a] Jun 14	Turfgrass Quality[a] Jun 27	Turfgrass Quality[a] Jul 12
1		Non-treated control			7.5a	7.3b	5.3b
2	Conventional Program	Emerald (A)[b]	0.18 OZ/1000 FT2	May 20	7.5a	7.8ab	7.0a
		Torque (B)	0.6 FL OZ/1000 FT2	June 17			
		Daconil WStik (C)	3.2 FL OZ/1000 FT2	July 8			
		Banner MAXX II (C)	1.0 FL OZ/1000 FT2	July 8			
		Subdue MAXX (C)	1.0 FL OZ/1000 FT2	July 8			
		Chipco 26GT (D)	3.0 FL OZ/1000 FT2	July 21			
		Subdue MAXX (D)	1.0 FL OZ/1000 FT2	July 21			
		Daconil WStik (E)	3.2 FL OZ/1000 FT2	August 4			
		Torque (F)	0.6 FL OZ/1000 FT2	August 4			
		Curalan (G)	1.0 OZ/1000 FT2	September 1			
		Chipco 26GT (H)	3.0 FL OZ/1000 FT2	September 22			
3	Smith-Kerns model - Conventional	Emerald (A)	0.18 OZ/1000 FT2	28 Days	7.3a	6.5c	6.8a
		Banner MAXX II (B)	1.0 FL OZ/1000 FT2	14 Days			
		Daconil Wstik (B)	3.2 FL OZ/1000 FT2	14 Days			
		Chipco 26GT (C)	2.0 FL OZ/1000 FT2	14 Days			
		Daconil Wstik (C)	3.2 FL OZ/1000 FT2	14 Days			
		Banner MAXX II (D)	1.0 FL OZ/1000 FT2	14 Days			
		Daconil WStik (D)	3.2 FL OZ/1000 FT2	14 Days			
		Emerald (E)	0.18 OZ/1000 FT2	28 Days			
		Banner MAXX II (F)	2.0 FL OZ/1000 FT2	21 Days			
4	Smith-Kerns model – Reduced Risk	Emerald (A)	0.18 OZ/1000 FT2	28 Days	7.5a	8.0a	7.0a
		Velista (B)	0.5 OZ/1000 FT2	21 Days			
		Secure (B)	0.5 FL OZ/1000 FT2	21 Days			
		Emerald (C)	0.18 OZ/1000 FT2	28 Days			
		Heritage TL (C)	2.0 FL OZ/1000 FT2	28 Days			
		Compass (D)	0.25 OZ/1000 FT2	21 Days			
		Velista (D)	0.5 OZ/1000 FT2	21 Days			
		Secure (D)	0.5 FL OZ/1000 FT2	21 Days			
		Emerald (E)	0.18 OZ/1000 FT2	28 Days			
		Velista (F)	0.5 OZ/1000 FT2	21 Days			
		Secure (F)	0.5 FL OZ/1000 FT2	21 Days			
5	Smith-Kerns model: Low Rate Convent.+Civitas	Emerald (A)	0.13 OZ/1000 FT2	28 Days	7.8a	7.3b	7.3a
		Civitas Pre-M1xed (A)	17 FL OZ/1000 FT2	28 Days			
		Banner MAXX (B)	0.5 FL OZ/1000 FT2	14 Days			
		Civitas Pre-M1xed (B)	8.5 FL OZ/1000 FT2	14 Days			
		Chipco 26 GT (C)	2 FL OZ/1000 FT2	14 Days			
		Civitas Pre-M1xed (C)	8.5 FL OZ/1000 FT2	14 Days			
		Banner MAXX (D)	0.5 FL OZ/1000 FT2	14 Days			
		Civitas Pre-M1xed (D)	8.5 FL OZ/1000 FT2	14 Days			
		Emerald (E)	0.13 OZ/1000 FT2	28 Days			
		Civitas Pre-M1xed (E)	17 FL OZ/1000 FT2	28 Days			
		Banner Maxx (F)	1 FL OZ/1000 FT2	21 Days			
		Civitas Pre-M1xed (F)	12.5 FL OZ/1000 FT2	21 Days			

[a]Turfgrass quality was visually assessed on 1-9 scale, with 9 being excellent, 6 being acceptable, and 1 bare dirt. Means followed by the same letter do not significantly differ (P=.05, Fisher's LSD).

Table 5. Mean number of dollar spot infection centers per treatment on the 18th fairway at University Ridge GC in Madison, WI during 2016.

		Treatment	Rate	Application Date/Interval	Dollar spot severity[a]		
					Jun 14	Jun 27	Jul 12
1		Non-treated control			0.5a	2.0a	11.3a
2	Conventional Program	Emerald (A)[b]	0.18 OZ/1000 FT2	May 20	0.0a	1.5a	4.5a
		Torque (B)	0.6 FL OZ/1000 FT2	June 17			
		Daconil WStik (C)	3.2 FL OZ/1000 FT2	July 8			
		Banner MAXX II (C)	1.0 FL OZ/1000 FT2	July 8			
		Subdue MAXX (C)	1.0 FL OZ/1000 FT2	July 8			
		Chipco 26GT (D)	3.0 FL OZ/1000 FT2	July 21			
		Subdue MAXX (D)	1.0 FL OZ/1000 FT2	July 21			
		Daconil WStik (E)	3.2 FL OZ/1000 FT2	August 4			
		Torque (F)	0.6 FL OZ/1000 FT2	August 4			
		Curalan (G)	1.0 OZ/1000 FT2	September 1			
		Chipco 26GT (H)	3.0 FL OZ/1000 FT2	September 22			
3	Smith-Kerns model: Conventional	Emerald (A)	0.18 OZ/1000 FT2	28 Days	0.0a	2.3a	0.3a
		Banner MAXX II (B)	1.0 FL OZ/1000 FT2	14 Days			
		Daconil Wstik (B)	3.2 FL OZ/1000 FT2	14 Days			
		Chipco 26GT (C)	2.0 FL OZ/1000 FT2	14 Days			
		Daconil Wstik (C)	3.2 FL OZ/1000 FT2	14 Days			
		Banner MAXX II (D)	1.0 FL OZ/1000 FT2	14 Days			
		Daconil WStik (D)	3.2 FL OZ/1000 FT2	14 Days			
		Emerald (E)	0.18 OZ/1000 FT2	28 Days			
		Banner MAXX II (F)	2.0 FL OZ/1000 FT2	21 Days			
4	Smith-Kerns model: Reduced Risk	Emerald (A)	0.18 OZ/1000 FT2	28 Days	0.0a	0.5a	0.0a
		Velista (B)	0.5 OZ/1000 FT2	21 Days			
		Secure (B)	0.5 FL OZ/1000 FT2	21 Days			
		Emerald (C)	0.18 OZ/1000 FT2	28 Days			
		Heritage TL (C)	2.0 FL OZ/1000 FT2	28 Days			
		Compass (D)	0.25 OZ/1000 FT2	21 Days			
		Velista (D)	0.5 OZ/1000 FT2	21 Days			
		Secure (D)	0.5 FL OZ/1000 FT2	21 Days			
		Emerald (E)	0.18 OZ/1000 FT2	28 Days			
		Velista (F)	0.5 OZ/1000 FT2	21 Days			
		Secure (F)	0.5 FL OZ/1000 FT2	21 Days			
5	Smith-Kerns model: Low Rate Convent.+Civitas	Emerald (A)	0.13 OZ/1000 FT2	28 Days	0.0a	1.0a	1.5a
		Civitas Pre-M1xed (A)	17 FL OZ/1000 FT2	28 Days			
		Banner MAXX (B)	0.5 FL OZ/1000 FT2	14 Days			
		Civitas Pre-M1xed (B)	8.5 FL OZ/1000 FT2	14 Days			
		Chipco 26 GT (C)	2 FL OZ/1000 FT2	14 Days			
		Civitas Pre-M1xed (C)	8.5 FL OZ/1000 FT2	14 Days			
		Banner MAXX (D)	0.5 FL OZ/1000 FT2	14 Days			
		Civitas Pre-M1xed (D)	8.5 FL OZ/1000 FT2	14 Days			
		Emerald (E)	0.13 OZ/1000 FT2	28 Days			
		Civitas Pre-M1xed (E)	17 FL OZ/1000 FT2	28 Days			
		Banner Maxx (F)	1 FL OZ/1000 FT2	21 Days			
		Civitas Pre-M1xed (F)	12.5 FL OZ/1000 FT2	21 Days			

[a]Dollar spot was visually assessed as number of dollar spot infection centers per plot. Means followed by the same letter do not significantly differ (P=.05, Fisher's LSD).

Table 6. Mean turf quality ratings per treatment on the 18th fairway at University Ridge GC in Madison, WI during 2016.

		Treatment	Rate	Application Date/Interval	Turfgrass Quality[a]		
					Jun 14	Jun 27	Jul 12
1		Non-treated control			7.8a	8.3a	6.5a
2	Conventional Program	Emerald (A)	0.18 OZ/1000 FT2	May 20	7.8a	8.0a	6.8a
		Torque (B)	0.6 FL OZ/1000 FT2	June 17			
		Daconil WStik (C)	3.2 FL OZ/1000 FT2	July 8			
		Banner MAXX II (C)	1.0 FL OZ/1000 FT2	July 8			
		Subdue MAXX (C)	1.0 FL OZ/1000 FT2	July 8			
		Chipco 26GT (D)	3.0 FL OZ/1000 FT2	July 21			
		Subdue MAXX (D)	1.0 FL OZ/1000 FT2	July 21			
		Daconil WStik (E)	3.2 FL OZ/1000 FT2	August 4			
		Torque (F)	0.6 FL OZ/1000 FT2	August 4			
		Curalan (G)	1.0 OZ/1000 FT2	September 1			
		Chipco 26GT (H)	3.0 FL OZ/1000 FT2	September 22			
3	Smith-Kerns model - Conventional	Emerald (A)	0.18 OZ/1000 FT2	28 Days	7.8a	7.8a	7.0a
		Banner MAXX II (B)	1.0 FL OZ/1000 FT2	14 Days			
		Daconil Wstik (B)	3.2 FL OZ/1000 FT2	14 Days			
		Chipco 26GT (C)	2.0 FL OZ/1000 FT2	14 Days			
		Daconil Wstik (C)	3.2 FL OZ/1000 FT2	14 Days			
		Banner MAXX II (D)	1.0 FL OZ/1000 FT2	14 Days			
		Daconil WStik (D)	3.2 FL OZ/1000 FT2	14 Days			
		Emerald (E)	0.18 OZ/1000 FT2	28 Days			
		Banner MAXX II (F)	2.0 FL OZ/1000 FT2	21 Days			
4	Smith-Kerns model – Reduced Risk	Emerald (A)	0.18 OZ/1000 FT2	28 Days	8.0a	8.0a	7.3a
		Velista (B)	0.5 OZ/1000 FT2	21 Days			
		Secure (B)	0.5 FL OZ/1000 FT2	21 Days			
		Emerald (C)	0.18 OZ/1000 FT2	28 Days			
		Heritage TL (C)	2.0 FL OZ/1000 FT2	28 Days			
		Compass (D)	0.25 OZ/1000 FT2	21 Days			
		Velista (D)	0.5 OZ/1000 FT2	21 Days			
		Secure (D)	0.5 FL OZ/1000 FT2	21 Days			
		Emerald (E)	0.18 OZ/1000 FT2	28 Days			
		Velista (F)	0.5 OZ/1000 FT2	21 Days			
		Secure (F)	0.5 FL OZ/1000 FT2	21 Days			
5	Smith-Kerns model: Low Rate Convent.+Civitas	Emerald (A)	0.13 OZ/1000 FT2	28 Days	8.0a	7.8a	7.3a
		Civitas Pre-M1xed (A)	17 FL OZ/1000 FT2	28 Days			
		Banner MAXX (B)	0.5 FL OZ/1000 FT2	14 Days			
		Civitas Pre-M1xed (B)	8.5 FL OZ/1000 FT2	14 Days			
		Chipco 26 GT (C)	2 FL OZ/1000 FT2	14 Days			
		Civitas Pre-M1xed (C)	8.5 FL OZ/1000 FT2	14 Days			
		Banner MAXX (D)	0.5 FL OZ/1000 FT2	14 Days			
		Civitas Pre-M1xed (D)	8.5 FL OZ/1000 FT2	14 Days			
		Emerald (E)	0.13 OZ/1000 FT2	28 Days			
		Civitas Pre-M1xed (E)	17 FL OZ/1000 FT2	28 Days			
		Banner Maxx (F)	1 FL OZ/1000 FT2	21 Days			
		Civitas Pre-M1xed (F)	12.5 FL OZ/1000 FT2	21 Days			

[a]Turfgrass quality was visually assessed on 1-9 scale, with 9 being excellent, 6 being acceptable, and 1 bare dirt. Means followed by the same letter do not significantly differ (P=.05, Fisher's LSD).

Determining Soil Potassium Requirements of Sand-Based Putting Greens

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INTRODUCTION

Potassium is an essential primary macronutrient required in relatively large quantities by turfgrass plants. Potassium does not have any structural role in the plant, but plays important roles in regulating osmotic pressure and facilitating enzymatic reactions. Potassium fertilization is thought to reduce many environmental stresses including heat, cold, and drought stress. It has also been associated with both increased and decreased disease pressure. Despite all these claims and associations, very few research studies have carefully examined how the soil and tissue levels of potassium influence turfgrass quality, growth, and disease pressure. The handful of studies that have addressed these topics often do not report soil test levels or tissue potassium content. In addition, many potassium studies are conducted over short time-scales (< 2 years) and do not quantify the long-term effects of various potassium fertilization strategies.

Because of the lack of quality data, turfgrass managers have hedged their bets and often apply large doses of potassium to turfgrass (>6 lbs per thousand square feet) – particularly to putting greens. However, with more accurate information, we feel that turfgrass managers will be able to confidently reduce their potassium applications, thus saving time and money, while not reducing and possibly enhancing the quality of the turfgrass they manage. The objective of this research is to evaluate putting green quality, growth, and disease incidence over a wide range of soil test and tissue potassium levels.

MATERIALS AND METHODS

This project was initiated in 2011 at the O.J. Noer Turfgrass Research Facility in Madison, WI on a USGA putting green with ‘A4’ creeping bentgrass. The experiment is a randomized complete block design with four replications. The treatments include five different levels of biweekly liquid potassium sulfate at rates ranging from zero to 0.6 lbs/M every two weeks (~ 0 – 8 lbs K2O/M annually depending on the exact start and stop dates of the applications). Paired soil and plant tissue samples are collected monthly along with measurements of clipping yield. The soil samples are taken to a depth of 7 cm, and the plant tissue is collected by a walking greens mower, dried at 60°C, cleaned of debris (sand) and then dry weight is recorded. The dried turfgrass tissue is then analyzed for mineral nutrient content (N, P, K, S, Ca, Mg, Fe, Mn, Zn, Cu, and B) using a C/N/S analyzer and sulfuric acid digestion followed by inductively coupled plasma atomic emission spectroscopy. The soil samples are air dried, then analyzed for available nutrients using the Mehlich-3 method. Turfgrass color is evaluated biweekly using a reflectance meter that measures wavelengths corresponding to chlorophyll reflectance (CM-1000, spectrum technologies). Visual turfgrass quality is also evaluated biweekly using the standard NTEP rating scale of 1-9, where 1 represents completely brown or dead turf, 6 represents the minimally acceptable turf quality, and 9 represents the greatest possible quality. Finally, because we are interested in how potassium may affect common diseases, we apply fungicides only rarely –

usually in cases where we are concerned about losing the entire stand. In fact, only one fungicide has been applied during the past four years – a dollar spot control application was made last summer after a prolonged outbreak. Disease incidence is quantified by counting infection centers and by the grid intersection method, where an 81 point grid is placed on the plot and the presence/absence of the disease is recorded directly under each intersection.

RESULTS

In 2015, we began to see visual signs of potassium deficiency for the first time since the study began in 2011. As shown in Table 1, the season average for color and quality were lowest in the control treatment (no K), significantly lower than treatments receiving K in most cases. Color and quality ratings for individual dates showed that the lower color and quality were most apparent in the first part of the growing season (data not shown). Clipping data show that no significant differences were detected among treatments on all of the collection dates, with the exception of August sampling when the control had significantly more clippings than the 0.2 lbs K/M treatment. This exception does not seem to correspond to any clear treatment effect.

Soil samples are taken monthly and the Mehlich-3 soil test results for potassium are show in Tables 2. The monthly soil samples show clear trends in differences in soil K values, and the differences closely follow the fertility treatments. Turfgrass tissue samples are collected and analyzed for nutrients monthly (one the same date as the soil sampling). Tissue concentrations of K are reported in Tables 3. These data show that the potassium fertilizer treatments strongly influenced the potassium in the leaf. The K ranges from below 1.0% in the no K treatment in June to over 2.0% in the high K treatment in July, demonstrating that our treatment applications have been successful in creating conditions suitable for testing the impact of K on turfgrass responses.

Potassium treatments affected pink snow mold severity, but not dollar spot (Table 4). The three treatments receiving potassium fertilizer had greater amounts of snow mold damage. This effect has been consistent for the last several years of the study. The 2016 season will provide more data on the impact of potassium fertilization, soil concentrations, and tissue potassium levels on turfgrass visual responses and disease pressure.

Table 1. Average turfgrass color, quality and daily clipping mass for the 2015 season. Color is measured using the Spectrum CM-1000 on a scale from 1-999 (greenest) and quality is rated using the NTEP scale of 1-9 (best). Results followed by different letters within each column are statistically different (alpha=0.05).

Treatment	Color	Quality	Clippings
	1-999	1-9	g/plot
0.2 lb Ca/M (gypsum)	178 AB	4.1 BC	1.8 A
Control (no application)	172 B	4.0 C	1.7 A
0.1 lb K2O/M (K2SO4)	182 A	4.4 AB	1.6 A
0.2 lb K2O/M (K2SO4)	182 A	4.3 ABC	1.6 A
0.6 lb K2O/M (K2SO4)	181 A	4.5 A	1.8 A

Table 2. Mehlich-3 soil test potassium levels during the 2015 season. Results followed by different letters within each column are statistically different (alpha=0.05).

Treatment	May	June	July	August	September	October
	------------------------------ K mg/kg ------------------------------					
0.2 lb Ca/M (gypsum)	16.4 c	19.6 c	19.2 b	20.9 c	20.4 b	20.7 c
Control (no application)	16.0 c	19.1 c	18.6 b	20.3 c	23.9 b	20.4 c
0.1 lb K2O/M (K2SO4)	19.9 bc	27.4 bc	24.5 b	27.5 b	25.8 b	25.7 bc
0.2 lb K2O/M (K2SO4)	24.2 b	30.9 b	35.1 a	33.5 a	22.5 b	29.9 b
0.6 lb K2O/M (K2SO4)	33.5 a	49.4 a	42.0 a	39.2 a	38.1 a	42.0 a

Table 3. Potassium concentration in turf tissue during the 2015 season. Results followed by different letters within each column are statistically different (alpha=0.05).

Treatment	May	June	July	August	September	October
	-------------------------- % K in tissue -----------------------------					
0.2 lb Ca/M (gypsum)	0.62 b	0.96 c	1.37 d	1.14 c	1.55 c	1.16 c
Control (no application)	0.50 b	0.96 c	1.39 d	1.05 c	1.54 c	1.18 c
0.1 lb K2O/M (K2SO4)	0.63 b	1.30 b	1.64 c	1.34 b	1.76 b	1.45 b
0.2 lb K2O/M (K2SO4)	0.95 a	1.37 b	1.86 b	1.54 a	1.93 a	1.51 a
0.6 lb K2O/M (K2SO4)	1.16 a	1.52 a	2.06 a	1.65 a	1.90 a	1.65 a

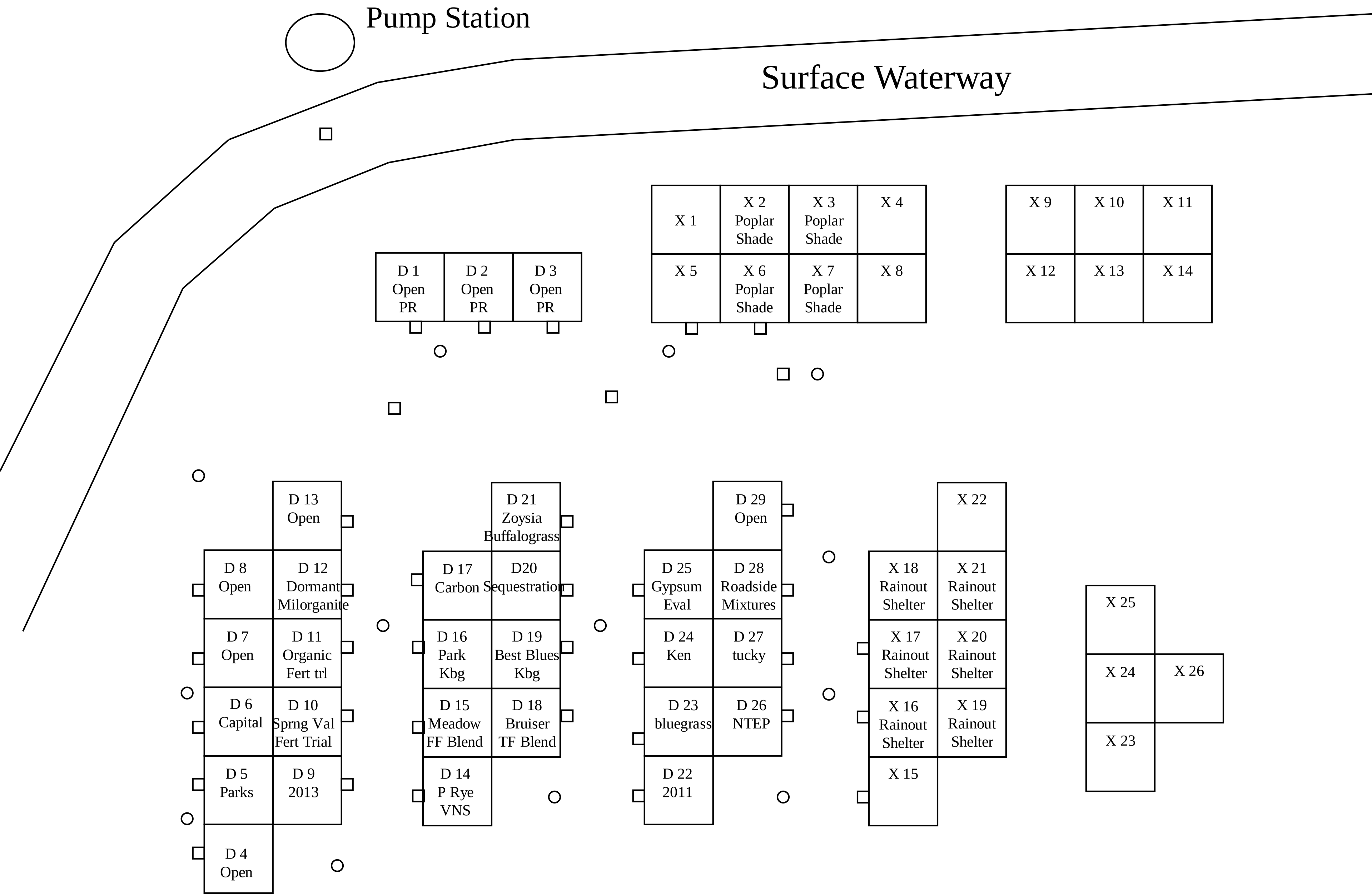
Table 4. Pink snow mold (PSM) and dollar spot disease severity was quantified by counting infection centers and/or visually estimating the percentage of plot area occupied by infection in March and May 2015. Results followed by different letters within each column are statistically different (alpha=0.05).

	17 March 2015		8 May 2015		11 Sept. 2015
Treatment	PSM Centers	PSM Area	PSM Centers	PSM Area	DS Centers
	#/plot	% area	#/plot	% area	#/plot
0.2 lb Ca/M (gypsum)	3.8 B	1.5 BC	3.8 B	3.3 A	209 A
Control (no application)	2.3 B	1.0 C	3.3 B	1.8 A	253 A
0.1 lb K2O/M (K2SO4)	14.3 A	5.5 AB	18.8 AB	6.0 A	281 A
0.2 lb K2O/M (K2SO4)	16.3 A	8.8 A	25.0 A	7.5 A	209 A
0.6 lb K2O/M (K2SO4)	14.8 A	7.5 A	16.3 AB	6.0 A	215 A

2008 NTEP Bentgrass Fairway/Tee Test

7	19	21	15	3	9	10	2	17	12	11	1
14	23	18	16	8	20	6	5	4	13	22	X
1	2	3	4	5	6	7	8	9	10	11	12
13	14	15	16	17	18	19	20	21	22	23	X
5	14	11	12	21	16	15	20	8	18	6	10
7	3	1	13	4	22	23	19	9	17	2	X

Entry No.	Name	Entry No.	Name
1	Penncross	13	A08-TDN2
2	Crystal Bluelinks	14	A08-FT12 (colonial)
3	Benchmark DSR	15	SRP-1WM
4	Declaration	16	007
5	LTP-FEC	17	PST-OJD
6	L-93	18	PST-R9D7 (colonial)
7	T-1	19	Princeville
8	Authority	20	HTM
9	CY-2	21	BCD (colonial)
10	MVS-Ap-101	22	Tiger II (colonial)
11	Memorial	23	Greentime (colonial)
12	A08-EDM (colonial)		



Pump Station
Surface Waterway
X 1
X 2 Poplar Shade
X 3 Poplar Shade
X 4
X 5
X 6 Poplar Shade
X 7 Poplar Shade
X 8
X 9
X 10
X 11
X 12
X 13
X 14
X 15
X 16 Rainout Shelter
X 17 Rainout Shelter
X 18 Rainout Shelter
X 19 Rainout Shelter
X 20 Rainout Shelter
X 21 Rainout Shelter
X 22
X 23
X 24
X 25
X 26
D 1 Open PR
D 2 Open PR
D 3 Open PR
D 4 Open
D 5 Parks
D 6 Capital
D 7 Open
D 8 Open
D 9 2013
D 10 Sprng Val Fert Trial
D 11 Organic Fert trl
D 12 Dormant Milorganite
D 13 Open
D 14 P Rye VNS
D 15 Meadow FF Blend
D 16 Park Kbg
D 17 Carbon Sequestration
D 18 Bruiser TF Blend
D 19 Best Blues Kbg
D20
D 21 Zoysia Buffalograss
D 22 2011
D 23 bluegrass
D 24 Ken
D 25 Gypsum Eval
D 26 NTEP
D 27 tucky
D 28 Roadside Mixtures
D 29 Open

O.J. Noer Turfgrass Research and Education Facility

Large numbers roughly correspond to morning research tour locations