

**Project Title: Rolling and Resistance: A Means to Reduced Fungicide Usage on Golf Course Greens**

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**Dr. Joseph Vargas, Nancy Dykema, Adam Palmatier & Ryan Bearss  
Michigan State University**

**Executive Summary**

In this dollar spot study, the combined use of cultural, genetic, and chemical management strategies were tested to determine if they would result in acceptable disease control, lower fungicide usage, and acceptable turfgrass quality. Results of this two year study indicate that a combination of these practices achieves the stated goals. In this research trial, two cultivars of creeping bentgrass including a commonly used dollar spot-susceptible cultivar, Penn A1, and a new dollar spot-resistant cultivar, Flagstick, were compared. For each cultivar, lightweight rolling conducted once or twice daily for five days weekly combined with reduced rate fungicide (boscalid, trade name Emerald) applications at 25% of the label rate was evaluated for dollar spot and turfgrass quality. Data suggests the use of a reduced rate of fungicide (boscalid) results in acceptable management of dollar spot. In addition, the use of a disease-resistant creeping bentgrass cultivar, Flagstick, either alone or combined with rolling reduced dollar spot incidence compared to a susceptible cultivar, Penn A1. By combining cultural, genetic and chemical practices, reduced chemical rates yield dollar spot control similar to full fungicide rates alone.

**Introduction**

Management of golf course turfgrass and surrounding areas often requires expensive and potentially harmful chemical inputs. The most commonly encountered summer disease on Canadian golf courses is dollar spot (*Sclerotinia homoeocarpa* FT Bennet). On average, golf course superintendents may make 10-15 fungicide applications in one growing season to manage dollar spot on putting greens alone, making this disease one of the most costly turfgrass diseases to manage. There are numerous fungicides on the market to treat dollar spot, although new IPM regulations in Ontario and Quebec require a reduction in pesticide usage over time. These regulations will force the turfgrass industry to focus on more sustainable approaches for managing turfgrass pests, including diseases such as dollar spot.

A recent trend among golf courses in Canada is the conversion of annual bluegrass (*Poa annua* L.) putting greens to creeping bentgrass (*Agrostis stolonifera* L.) due to recurring problems associated with ice damage and summer disease complexes on annual bluegrass. Development of disease resistant cultivars has allowed for less devastating outbreaks of diseases like dollar spot on established creeping bentgrass putting greens; however, fungicides are still needed to maintain an acceptable level of quality and playability. Recent research has shown the benefits of frequent lightweight rolling, which reduces dollar spot in creeping bentgrass putting greens. By coupling rolling with a new, highly dollar spot-resistant creeping bentgrass cultivar developed by MSU researchers, there is the realistic possibility that this

costly disease may now be managed under a pesticide-free regimen or with reduced fungicide rates, while still providing the high-quality turfgrass that golfers have come to expect.

### **Project Objectives**

The objectives of this project are to: (1) test and establish a combination of methods for management of creeping bentgrass putting greens by using reduced fungicide rates, disease-resistant cultivars, and optimized lightweight rolling practices, and (2) determine whether acceptable levels of disease, turfgrass quality, and playability are obtainable using the methods described in objective 1.

### **Materials and Methods**

#### **Research Methodology**

To investigate combined management practices for dollar spot reduction, a research study was established in a 2 x 7 split plot design on a creeping bentgrass putting green at the Hancock Turfgrass Research Center, East Lansing, MI. Whole plot factors included two different creeping bentgrass cultivars which were replicated three times and included Penn A1, a commonly used susceptible cultivar, and Flagstick, a newly released, dollar spot-resistant cultivar. Seven subplot treatments were established randomly within cultivar whole plots as listed below.

Fungicide applications were made monthly (every 28 days) using a CO<sub>2</sub>-powered backpack sprayer with a double-nozzle boom containing two Tee Jet 8002 E flat fan nozzles at a spray volume of approximately 900 L ha<sup>-1</sup>. Fungicide applications were made with boscalid (Emerald) at 0.055 g m<sup>-2</sup> (full rate) or 0.014 g m<sup>-2</sup> (25% label rate) on 6/29/17, 7/28/17, 8/25/17, and 9/22/17. Rolling treatments were applied 5 days each week beginning on 6/12/17 using a Tru-Turf R52-11T lightweight roller with a 1.3 m width. A single pass (1x) was made rolling from one end of each subplot to the other end. A double pass (2x) was made by rolling down and then immediately back within each subplot. Rolling treatments were applied between 7:00 and 9:00 am each day following morning mowing. Within each Penn A1 and Flagstick replication, seven treatments were tested as listed below.

For each replicate of each creeping bentgrass cultivar (Penn A1 and Flagstick), the following subplot treatments were randomly located and applied:

1. Rolling once per day (single pass, 1x)
2. Rolling twice per day (double pass, 2x)
3. Rolling once per day (1x) with fungicide 0.014 g m<sup>-2</sup> (25% rate monthly)
4. Rolling twice per day (2x) with fungicide 0.014 g m<sup>-2</sup> (25% rate monthly)
5. Fungicide 0.014 g m<sup>-2</sup> (25% rate monthly)
6. Fungicide 0.055 g m<sup>-2</sup> (full rate monthly)
7. Untreated control

#### **General Plot Maintenance**

Plots were mowed 5 days weekly at approximately 3 mm using a Toro Greensmaster 3150-Q triplex mower. Plots were lightly topdressed weekly through June, July, and August, 2017. The entire site was treated with carfentrazone-ethyl (Quicksilver) at 0.49 L ha<sup>-1</sup> on 7/6/17 for moss,

and Revolution at 9.54 L ha<sup>-1</sup> on 5/19/17, 6/2/17, and 8/1/17 for localized dry spots. On 8/31/17, plots were inoculated with a sand-cornmeal topdressing mixture infested with *Sclerotinia homoeocarpa*, the causal agent of dollar spot, to enhance uniform disease development. Foliar fertilizer was applied as needed, at approximately 4.39 kg N ha<sup>-1</sup> weekly.

#### Data Collection

Assessments for dollar spot were made on a 0-100% scale by visually estimating the percentage of each plot exhibiting disease symptoms (Table 1, Figures 1-2). Turfgrass quality was visually measured using a 1-9 scale, where 6 represents acceptable turfgrass quality, 9 is excellent, and 1 is poor (Table 2, Figure 3). Turf color ratings, or greenness, were collected using a FieldScout TCM 500 NDVI Turf Color Meter, and turfgrass chlorophyll measurements were collected using a FieldScout CM 1000 chlorophyll meter (data not shown). For both NDVI and chlorophyll meter data, the mean of six measurements was used. Green speed was assessed weekly using a Pelz meter (Table 3, Figure 4). Measurements consisted of the average six ball roll distance measurements, three in opposite directions. NDVI, chlorophyll meter, and Pelz meter data were collected weekly beginning 6/14/17. Statistical analysis of the above data was performed and means were separated (Least Significant Differences, p=0.05).

#### Results and Discussion

##### **Dollar spot incidence.**

In 2017, dollar spot developed very late in the season compared to historical timings for epidemics. In mid-September, 2017, little to no dollar spot had developed in the plot area, but towards the end of the month, disease increased quickly. By the 9/26/17 rating date, dollar spot averaged 27% in the untreated Penn A1 plots and reached its season maximum on 10/9/17 at 35% dollar spot (Table 1, Figure 1). From 9/26/17 until the end of the trial, Penn A1 treatments without boscalid (i.e. the untreated control, rolled daily 1x and rolled daily 2x) developed significantly more dollar spot than all of the Penn A1 treatments containing boscalid and all Flagstick treatments, depicted graphically in Figure 1. There was significantly less dollar spot in the double rolled Penn A1 plots compared to the untreated control plots. Treatments containing boscalid using either cultivar which exhibited little to no dollar spot on the last three rating dates were not significantly different.

##### Fungicide (boscalid) results.

Flagstick. No significant differences occurred between the full rate boscalid treatments and the 25% boscalid treatment on all dates in both years of the study using the resistant cultivar, Flagstick (Table 1).

Penn A1. In 2016, treatments containing boscalid were not significantly different on 8/15 while on 8/1, 8/24, and 9/1, 25% boscalid exhibited significantly more dollar spot than the full label rate (data not shown). In 2017, initially on 9/21 and 9/26, 25% boscalid exhibited significantly more dollar spot than the full label rate boscalid treatment. However, as the season went on the 25% boscalid treatment was not significantly different from the full rate on 9/29, 10/4, and 10/9 (Table 1). Significant reduction in dollar spot was attained using reduced fungicide rates compared to the untreated control. Other than when disease severity was very

high in 2016 (control averaged 75% dollar spot), industry-acceptable levels of dollar spot were reached using 25% of the maximum label rate of fungicide.

#### Rolling results.

Flagstick. Results in 2017 showed no significant differences occurred among rolled Flagstick treatments and the untreated control (Table 1). Findings from 2016 yielded significant differences which were variable among rolled Flagstick treatments and the control (data not shown). At this time, the reduction in dollar spot observed with rolling was not always significant so no conclusive statement can be made regarding the impact of rolling on dollar spot using resistant cultivars.

Penn A1. In 2016 on the Penn A1 plots, the single (1x) and double (2x) rolled plots exhibited significantly less dollar spot than the untreated control on all rating dates except on one early rating date when only the double rolled treatment yielded significantly less dollar spot than the untreated control (data not shown). In 2017, the single rolled treatment in Penn A1 did not significantly differ from the untreated control, but the double rolled treatment resulted in significantly less dollar spot than the control on all except one rating date when disease averaged 1% in the control (Figure 2). These findings indicate that double rolling using a susceptible cultivar may significantly reduce dollar spot incidence.

#### Results combining fungicide (boscalid) with rolling.

Flagstick. When using a dollar spot resistant cultivar, no significant differences occurred among treatments containing any rate of boscalid alone or when combined with rolling on all dates in both years of the study. This indicates that control achieved using the full label rate of boscalid or the 25% rate on a 28 day interval with or without rolling was not different (Table 1).

Penn A1. In both years of the trial, significant differences among all treatments containing boscalid were variable. In 2016, on 8/1, 8/24, and 9/1, full rate boscalid treatments had significantly less dollar spot than the 25% boscalid treatments. By adding rolling to the 25% boscalid plots in Penn A1, no significant differences were seen compared to treatments using the full rate of boscalid (data not shown). In 2017, dollar spot levels in the 25% boscalid with double (2x) rolling plots were not significantly different from those receiving a full rate of boscalid (Table 1).

Other preliminary data indicates the following (data not shown):

- 1.) In 2017, brown patch developed in the Penn A-1 (susceptible) plots but not in the Flagstick (resistant) plots.
- 2.) In Penn A-1 plots, rolled treatments averaged less brown patch than non-rolled treatments in 2017.
- 3.) In 2017, Flagstick treatments exhibited significantly less yellow tufts than Penn A-1 treatments.

### **Turfgrass quality and playability.**

Significant differences in turfgrass quality were observed among treatments, and these trends followed disease levels. Those treatments with higher dollar spot levels had lower turfgrass quality ratings. In general, treatments containing boscalid exhibited better turfgrass quality than those without the fungicide, presumably due to the occurrence of less disease (Table 2, Figure 3.) In both years of the study, Flagstick treatments that contained boscalid, both with and without rolling, were the only treatments that achieved quality ratings averaging 6 or higher.

Few Penn A1 treatments resulted in acceptable turfgrass quality in either year of the study.

NDVI data collected was variable. In both years of the study, when dollar spot was abundant, greenness as indicated by NDVI readings, decreased (data not shown). No significant results were obtained regarding NDVI measurements. Additionally, no significant trend among treatments could be elucidated regarding chlorophyll content (data not shown). As expected, in general, plots that were rolled had the fastest green speeds among all treatments and did not significantly differ based on cultivar or the addition of fungicide (Table 3, Figure 4).

### **Conclusions**

Findings from this two year study suggest that acceptable dollar spot control and turfgrass quality can be attained using less fungicide when combined with the use of dollar spot resistant creeping bentgrass and daily rolling. These findings may result in less fungicide being applied to the environment as well as reduced costs to turfgrass managers for disease control. In summary, data from this two year trial suggests:

1. When combined with a dollar spot-resistant cultivar (Flagstick), no significant differences in dollar spot incidence were observed when using full or 25% reduced fungicide rates, and adding rolling to the reduced rate fungicides did not further decrease disease.
2. Under moderate disease pressure using a resistant cultivar, no significant differences in dollar spot were found between double (2x) rolling and those attained using a fungicide.
3. In the absence of fungicide, the use of a resistant cultivar (Flagstick) resulted in significantly less dollar spot than using a susceptible cultivar (Penn A1).
4. Acceptable turfgrass quality was consistently achieved when using a combination of rolling, disease-resistant creeping bentgrass, and reduced fungicide rates.
5. When using a susceptible cultivar (Penn A1), double (2x) rolling significantly reduced the amount of dollar spot without the use of fungicide compared to the untreated control.

Table 1. 2017 Rolling and creeping bentgrass host dollar spot study disease incidence.

Rating Type: Dollar spot incidence.

Rating Scale: Mean percent dollar spot.

Trt No.	Treatment	Boscalid Rate <sup>c</sup>	Creeping Bentgrass Cultivar	9/21/2017		9/26/2017		9/29/2017		10/4/2017		10/9/2017	
				Mean <sup>a</sup>	LSD <sup>b</sup>								
8	Roll daily 2x + Boscalid (25%)	0.014 g m <sup>-2</sup>	Flagstick	0.0	c	0.0	f	0.0	c	0.0	c	0.0	e
6	Roll daily 1x + Boscalid (25%)	0.014 g m <sup>-2</sup>	Flagstick	0.0	c	0.0	f	0.0	c	0.0	c	0.0	e
10	Boscalid (25%)	0.014 g m <sup>-2</sup>	Flagstick	0.0	c	0.0	f	0.0	c	0.0	c	0.0	e
12	Boscalid (full rate)	0.055 g m <sup>-2</sup>	Flagstick	0.0	c	0.0	f	0.0	c	0.0	c	0.0	e
5	Roll daily 1x + Boscalid (25%)	0.014 g m <sup>-2</sup>	Penn A1	0.7	ab	1.3	def	0.3	c	0.0	c	0.0	e
7	Roll daily 2x + Boscalid (25%)	0.014 g m <sup>-2</sup>	Penn A1	0.3	bc	0.3	ef	0.3	c	0.0	c	0.3	de
11	Boscalid (full rate)	0.055 g m <sup>-2</sup>	Penn A1	0.0	c	0.3	ef	0.3	c	0.0	c	0.7	de
9	Boscalid (25%)	0.014 g m <sup>-2</sup>	Penn A1	0.7	ab	3.7	cd	1.3	c	0.0	c	0.7	de
4	Roll daily 2x		Flagstick	0.0	c	2.3	c-f	1.3	c	0.7	c	2.3	cde
2	Roll daily 1x		Flagstick	0.0	c	2.7	cde	3.0	c	2.0	c	3.3	cd
14	Untreated Control		Flagstick	0.0	c	4.0	c	3.7	c	2.0	c	4.0	c
3	Roll daily 2x		Penn A1	0.7	ab	20.0	b	23.3	b	23.3	b	18.3	b
1	Roll daily 1x		Penn A1	1.0	a	26.7	a	26.7	ab	28.3	a	33.3	a
13	Untreated Control		Penn A1	1.0	a	26.7	a	30.0	a	31.7	a	35.0	a

<sup>a</sup> Represents the average of 3 replications.

<sup>b</sup> Means followed by the same letter are not significantly different (LSD, p=0.05).

<sup>c</sup> All boscalid applications made on a 28 day interval on 6/29/17, 7/28/17, 8/25/17 and 9/22/17.

Figure 1. 2017 average percent dollar spot incidence ratings for each treatment as listed in the figure legend.

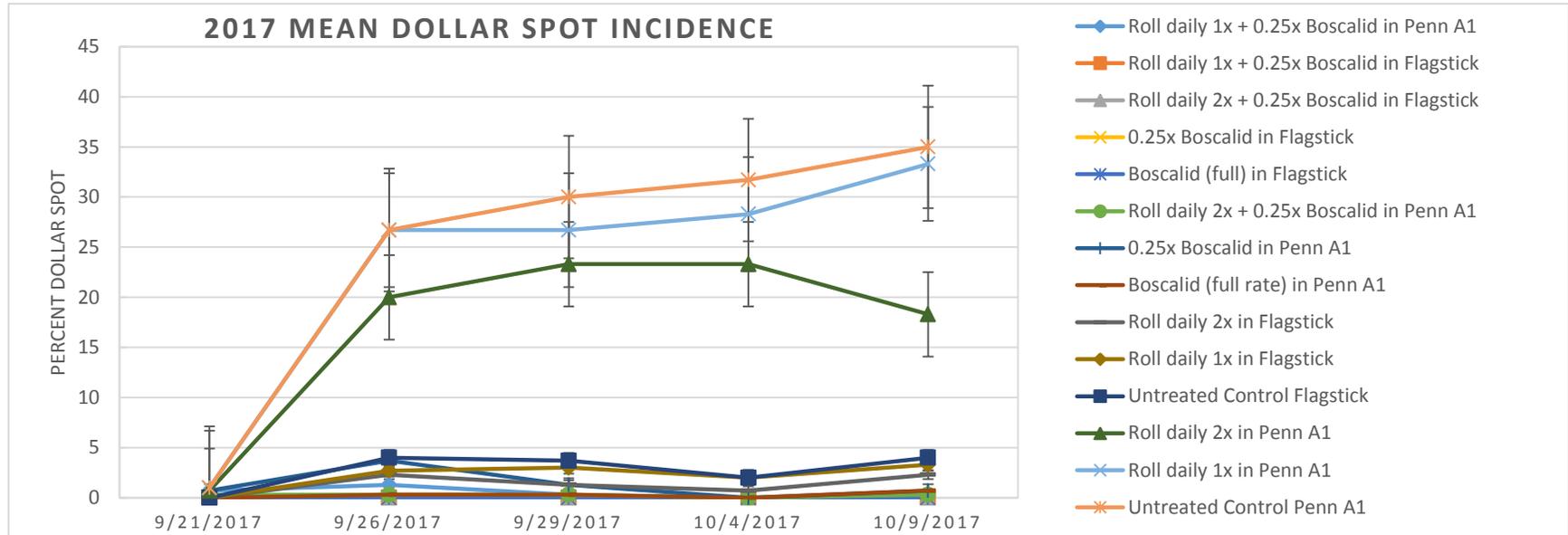


Figure 2. 2017 average percent dollar spot incidence among rolling only treatments.

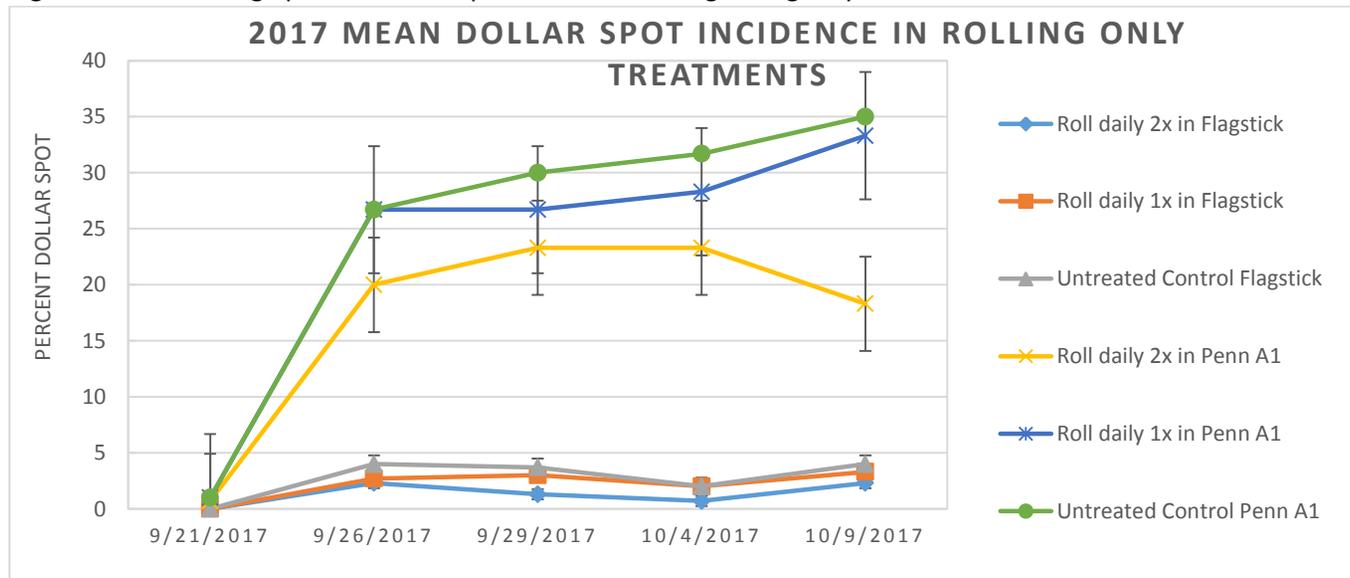


Table 2. 2017 Rolling and creeping bentgrass host dollar spot study quality results.

Rating Type: Turfgrass quality.

Rating Scale: 1-9, where 1 = poor, 6 = acceptable, and 9 = excellent.

Trt No.	Treatment Name	Boscalid Rate <sup>c</sup>	Creeping Bentgrass Cultivar	9/21/2017		9/26/2017		9/29/2017		10/4/2017		10/9/2017	
				Mean <sup>a</sup>	LSD <sup>b</sup>								
8	Roll daily 2x + Boscalid (25%)	0.014 g m <sup>-2</sup>	Flagstick	7.0	a	7.0	a	7.5	a	7.5	a	7.5	a
6	Roll daily 1x + Boscalid (25%)	0.014 g m <sup>-2</sup>	Flagstick	6.5	abc	6.7	ab	7.2	ab	7.2	a	7.2	a
10	Boscalid (25%)	0.014 g m <sup>-2</sup>	Flagstick	6.0	cde	6.5	bc	7.0	b	7.0	a	7.0	ab
12	Boscalid (full rate)	0.055 g m <sup>-2</sup>	Flagstick	6.3	a-d	6.8	ab	7.0	b	7.0	a	7.0	ab
4	Roll daily 2x		Flagstick	6.2	bcd	5.8	de	6.3	c	6.3	b	6.3	bc
5	Roll daily 1x + Boscalid (25%)	0.014 g m <sup>-2</sup>	Penn A1	5.7	d-g	5.3	fg	6.0	cd	6.0	bc	6.2	cd
7	Roll daily 2x + Boscalid (25%)	0.014 g m <sup>-2</sup>	Penn A1	5.3	efg	5.5	ef	5.8	d	5.8	bcd	5.8	cde
11	Boscalid (full rate)	0.055 g m <sup>-2</sup>	Penn A1	5.8	c-f	6.2	cd	5.8	d	5.8	bcd	5.7	cde
9	Boscalid (25%)	0.014 g m <sup>-2</sup>	Penn A1	5.0	g	5.3	fg	5.8	d	5.8	bcd	5.5	de
2	Roll daily 1x		Flagstick	6.8	ab	5.2	fg	5.3	e	5.5	cd	5.3	e
14	Untreated Control		Flagstick	6.8	ab	5.0	g	5.0	e	5.3	d	5.3	e
3	Roll daily 2x		Penn A1	5.2	fg	3.5	h	3.5	f	3.2	e	3.3	f
1	Roll daily 1x		Penn A1	5.3	efg	3.3	h	3.3	f	3.5	e	3.2	f
13	Untreated Control		Penn A1	5.3	efg	3.2	h	3.2	f	3.3	e	3.0	f

<sup>a</sup> Represents the average of 3 replications.

<sup>b</sup> Means followed by the same letter are not significantly different (LSD, p=0.05).

<sup>c</sup> All boscalid applications made on a 28 day interval on 6/29/17, 7/28/17, 8/25/17 and 9/22/17.

Figure 3. 2017 mean turfgrass quality ratings. Ratings are based on a 1-9 scale where 1=poor, 6=acceptable, and 9=excellent.

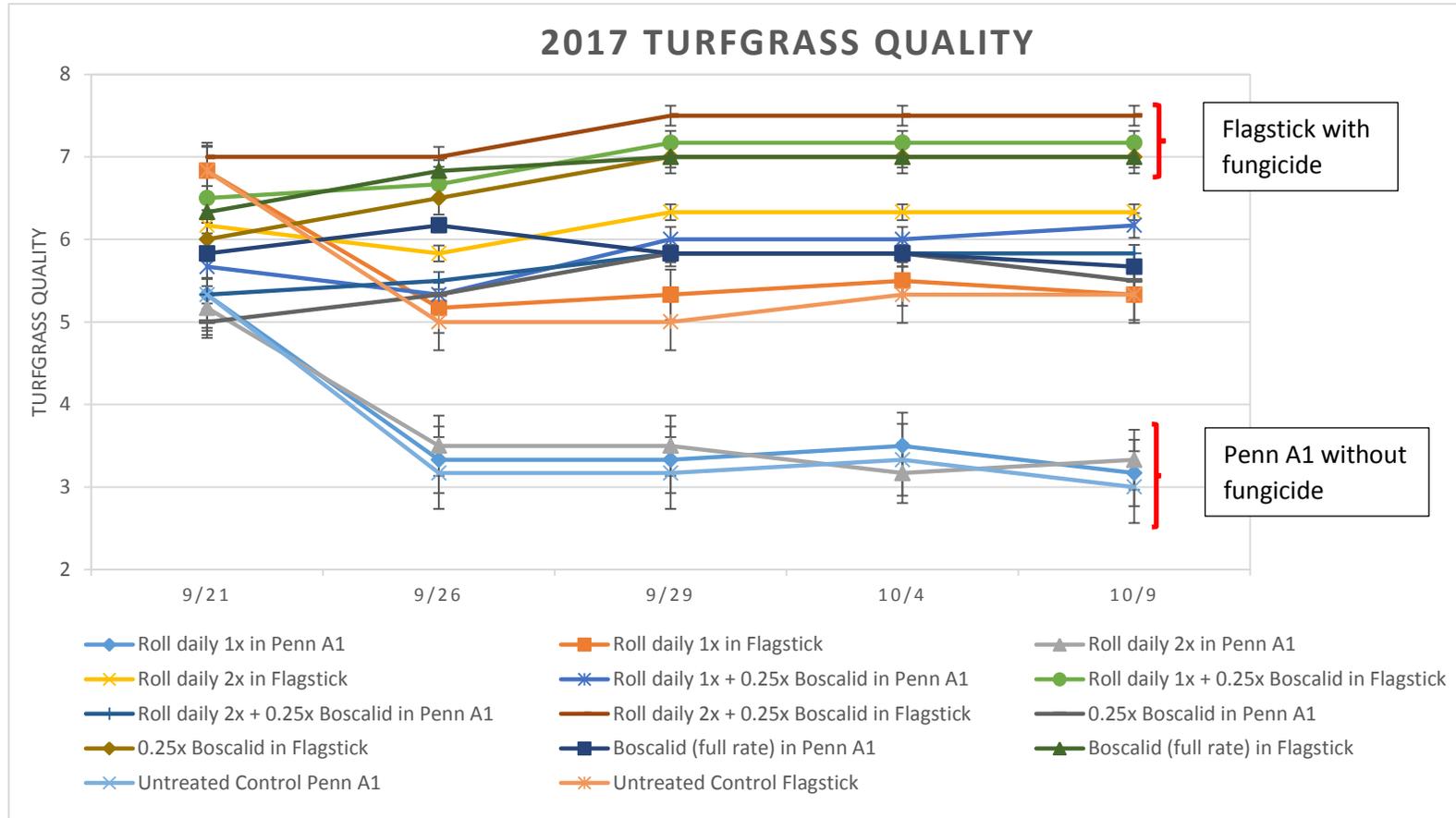


Table 3. 2017 Rolling and creeping bentgrass host dollar spot study green speed ratings.

Rating Type: Ball roll distance (green speed) measured using a Pelz Meter.

Rating scale: Distance in meters (m).

Trt No	Treatment Name	Boscalid Rate <sup>c</sup>	Creeping Bentgrass Cultivar	8/10/2017		8/18/2017		8/30/2017		9/6/2017		9/13/2017		9/21/2017	
				Mean <sup>a</sup>	LSD <sup>b</sup>										
3	Roll daily 2x		Penn A1	3.0	a	2.9	ab	2.8	ab	3.1	a	3.3	abc	3.2	a
7	Roll daily 2x + Boscalid (25%)	0.014 g m <sup>-2</sup>	Penn A1	2.8	abc	3.1	a	2.8	ab	3.1	a	3.3	a	3.1	a
8	Roll daily 2x + Boscalid (25%)	0.014 g m <sup>-2</sup>	Flagstick	2.8	bc	2.9	ab	2.8	ab	2.9	ab	3.3	a	3.0	a
4	Roll daily 2x		Flagstick	2.8	bc	2.9	ab	2.8	a	2.9	ab	3.3	ab	3.0	a
6	Roll daily 1x + Boscalid (25%)	0.014 g m <sup>-2</sup>	Flagstick	2.7	bc	2.7	bc	2.7	ab	2.8	b	3.0	d	2.9	a
2	Roll daily 1x		Flagstick	2.7	c	2.7	bc	2.7	ab	2.8	b	3.0	cd	2.9	ab
5	Roll daily 1x + Boscalid (25%)	0.014 g m <sup>-2</sup>	Penn A1	2.8	abc	2.8	bc	2.7	ab	2.9	b	3.1	bcd	2.9	ab
1	Roll daily 1x		Penn A1	2.9	ab	2.8	bc	2.7	b	2.9	ab	3.2	abc	2.9	abc
9	Boscalid (25%)	0.014 g m <sup>-2</sup>	Penn A1	2.5	d	2.6	cd	2.4	c	2.5	c	2.7	e	2.6	bcd
14	Untreated Control		Flagstick	2.4	de	2.4	de	2.3	c	2.4	cd	2.5	e	2.6	bcd
12	Boscalid (full rate)	0.055 g m <sup>-2</sup>	Flagstick	2.4	de	2.3	e	2.3	c	2.4	cd	2.6	e	2.6	bcd
11	Boscalid (full rate)	0.055 g m <sup>-2</sup>	Penn A1	2.4	de	2.4	de	2.3	c	2.5	cd	2.7	e	2.6	bcd
10	Boscalid (25%)	0.014 g m <sup>-2</sup>	Flagstick	2.4	de	2.4	de	2.4	c	2.4	cd	2.6	e	2.6	cd
13	Untreated Control		Penn A1	2.3	e	2.2	e	2.3	c	2.3	d	2.7	e	2.5	d

<sup>a</sup> Represents the average of 3 replications.

<sup>b</sup> Means followed by the same letter are not significantly different (LSD, p=0.05).

<sup>c</sup> All boscalid applications made on a 28 day interval on 6/29/17, 7/28/17, 8/25/17 and 9/22/17.

Figure 4. 2017 green speed represented by the measurement of ball roll distance using a Pelz meter (meters).

