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**Utah State University Evaluation of Ring to GREEN
Final Research Report**

Prepared by Kelly Kopp, Ph.D. and Paul Harris



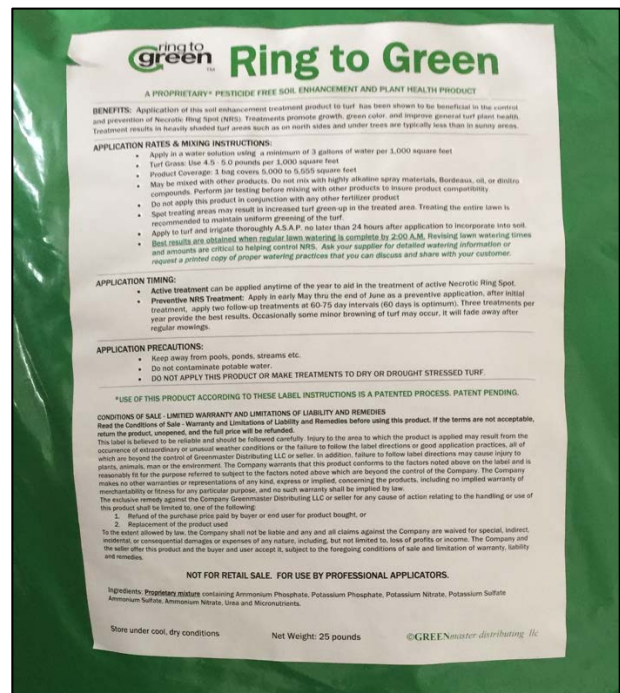
Introduction

Necrotic ring spot (*Ophiosphaerella korrae*) is the most commonly diagnosed fungal turfgrass disease by the Utah State University Plant Pest Diagnostic Laboratory. The disease affects cool-season grasses in the state and region, particularly Kentucky bluegrass. The necrotic ring spot (NRS) disease pathogen infects and kills turfgrass roots and crowns, resulting in the blighted appearance of turf amidst an otherwise healthy area of turf.

Initial symptoms of NRS are small light green spots which coalesce and result in circular brown patches with widely ranging diameters. NRS may occur early in the growing season while temperatures are still cool and soil moisture is high. The disease may also reappear under conditions of heat and/or drought stress during the hottest months of the growing season. In the fall, NRS patches may reappear, and continue through the winter and spring.

In the late summer/fall of 2015, Utah State University (USU) began a research study of the Ring to GREEN product by GreenMaster Distributing, LLC for the control of necrotic ring spot in turfgrass. Prior to USU's involvement, product development had begun in 2010 and the product was patented in 2011. The patent included not only the Ring to Green product, but specific irrigation practices in conjunction with its use.

The Ring to GREEN product aims to promote turfgrass growth and green color, as well as to improve general turf plant health. The product is also suggested as either an annual preventive program, or as an active control program for those areas in which infection has already occurred.



Materials and Methods

Table 1. Manufacturer’s recommendations for use of Ring to GREEN.

Product Applications	Fertilization
<p>3 treatments applied to entire lawn at 5 lbs. per 1000 sq. ft, with 5 lbs. of product mixed in 3 gallons of water per 1000 sq ft. as a PREVENTATIVE, to prevent any fungus developing in <u>non-fungal areas</u> of the lawn.</p>	<p>We do not recommend that fertilizers be applied in conjunction, or simultaneously, with Ring to GREEN applications, but do recommend regular fertilization in between Ring to GREEN treatments that are <u>60 days apart</u> (applied 30 days after Ring to GREEN treatment). For applications 30 days apart, no additional fertilization is needed until the 3 treatments are completed.</p>
<p>3 treatments applied to entire lawn at 10 lbs per 1000 sq ft (double application in affected areas of 5 lbs. per 1000 sq. ft), as a TREATMENT, to effectively treat <u>fungal areas</u> of lawn.</p>	<p>Once the 3 Ring to GREEN treatment have been applied, we recommend normal fertilizing procedures (3 additional fertilizer treatments that year) to continue. Here are a couple of examples:</p> <p>EXAMPLE A: Ring to GREEN treatments in March, May, and July, with fertilizing in April, June and August.</p> <p>EXAMPLE B: Ring to GREEN treatments in March, April and May, with fertilizing in June July and August.</p>
<p>Steps 1 and 2 may be applied simultaneously at the same application.</p>	<p>Once the lawn has received 3 Ring to GREEN treatments, and is fertilized properly the first year, we recommend 6 fertilizations per year to keep the soil healthy, and with proper watering, the lawn may not need any further Ring to GREEN applications. This is because once we bring the soil back to its normal health, and water properly, we should eliminate the ability for fungus to grow. However, proper watering is KEY!</p>
<p>We recommend that there be at least 30 days in between Ring to GREEN applications, but no more than 60 days in between applications. Applications may also be split during the winter with the same, excellent results. For example, one application may be applied in October, with the 2nd and 3rd applications in March and May, or even March and April.</p>	

Study Locations

NRS is a notoriously difficult pathogen to culture and control whether in laboratory, the greenhouse, or field research. Therefore, properties within the state of Utah with positively identified NRS infections were sought out for the purposes of the study. Five properties in the state were identified that had diagnosed NRS infections by the Utah Plant Pest Diagnostic Laboratory. These included two residential properties in Orem (Orem Test Site #1 and Orem Test Site #2), one residential property in Draper (Draper Test Site), a home owner's association in Murray (Murray Test Site), and one residential property in Salt Lake City (Salt Lake City Test Site).

Treatment Dates and Timing

The first site visit and application of Ring to GREEN occurred November 4, 2015 at Orem Test Site #1. This was the first property identified for participation in the study. It was also the only property that received more than 3 applications of the product over the course of the study, and for which treatments began in the fall as opposed to the spring. Subsequent treatment applications were applied on April 15, May 21, and July 15, 2016 at all study sites. A final, evaluative visit to all study sites was conducted on August 25, 2016.

Data Collection

Historically, visual quality ratings of turfgrass color and quality have been used for the purposes of turfgrass evaluation in response to experimental treatments. However, visual quality ratings are subjective in nature and more objective methods of turfgrass evaluation have been developed. In this study, digital image analysis (DIA) was utilized to objectively quantify turfgrass quality. DIA provides an objective method for evaluating turfgrass quality by taking digital images of the study areas under standardized lighting conditions, and evaluating those images with computer software to provide the percentage of green cover.

Following the method described by Bushman et al. (2012), a Canon PowerShot SD1300IS camera (Lake Success, NY) was used to collect the digital imagery from each test site. The camera had 1200 x 1600-pixel resolution with a daylight fluorescent white balance setting. Images were taken for each plot inside a sheet metal box which excluded daylight, but was lighted inside with four 9W IS-09 compact fluorescent light bulbs (UL, Camas, WA).

Images were scanned using SigmaScan Pro v5 (Systat, San Jose, CA) and the Turf Analysis macro developed by Karcher and Richardson (2005) was utilized to develop percent green cover (PGC) of the images. For PGC analysis, the color threshold included pixels with saturation ranging from 0 to 100 and hue ranging from 30-100. PGC was determined by dividing the number of pixels in each image that reached the threshold level by the total number of pixels in each image.

Table 2. Treatment sites and dates including tasks performed on each date.

Location and Date		Ring to GREEN Application	Digital Image Collection
Orem Test Site #1	1-November 4, 2015	X	X
	2-April 15, 2016	X	X
	3-May 12, 2016	X	X
	4-July 15, 2016	X	X
	5-August 25, 2016		X
Orem Test Site #2	1-April 15, 2016	X	X
	2-May 12, 2016	X	X
	3-July 15, 2016	X	X
	4-August 25, 2016		X
Draper Test Site	1-April 15, 2016	X	X
	2-May 12, 2016	X	X
	3-July 15, 2016	X	X
	4-August 25, 2016		X
Murray Test Site	1-April 15, 2016	X	X
	2-May 12, 2016	X	X
	3-July 15, 2016	X	X
	4-August 25, 2016		X
Salt Lake City Test Site	1-April 15, 2016	X	X
	2-May 12, 2016	X	X
	3-July 15, 2016	X	X
	4-August 25, 2016		X

At each of the Ring to GREEN study sites, three or four diseased areas for evaluation and treatment were identified. Each of these areas had existing turfgrass damage due to NRS infection. Subsequent visits to each site included digital imagery collection and Ring to GREEN treatment of the same damaged areas. A final evaluative visit occurred on August 25, 2016.

All Ring to GREEN applications were made following manufacturer's recommendations (Tables 1 and 2). Irrigation instruction was provided by the manufacturer and participants set their own irrigation schedules in response. Mowing height and other management practices, were not controlled in this study.

Results and Discussion

Average PGC changed markedly over the course of the study for all test sites (Figure 1). In the case of Orem Test Site #1, average PGC ranged from a low of 29% to a high of 99%. At Orem Test Site #2, average PGC ranged from a low of 72% to a high of 95%. At the Draper test site, average PGC ranged from a low of 38% to a high of 96%. At the Murray test site, average PGC ranged from a low of 39% to a high of 76%. At the Salt Lake City test site, average PGC ranged from a low of 39% to a high of 76%. At the Salt Lake City test site, average PGC ranged from a low of 51% to a high of 87% (Figure 1).

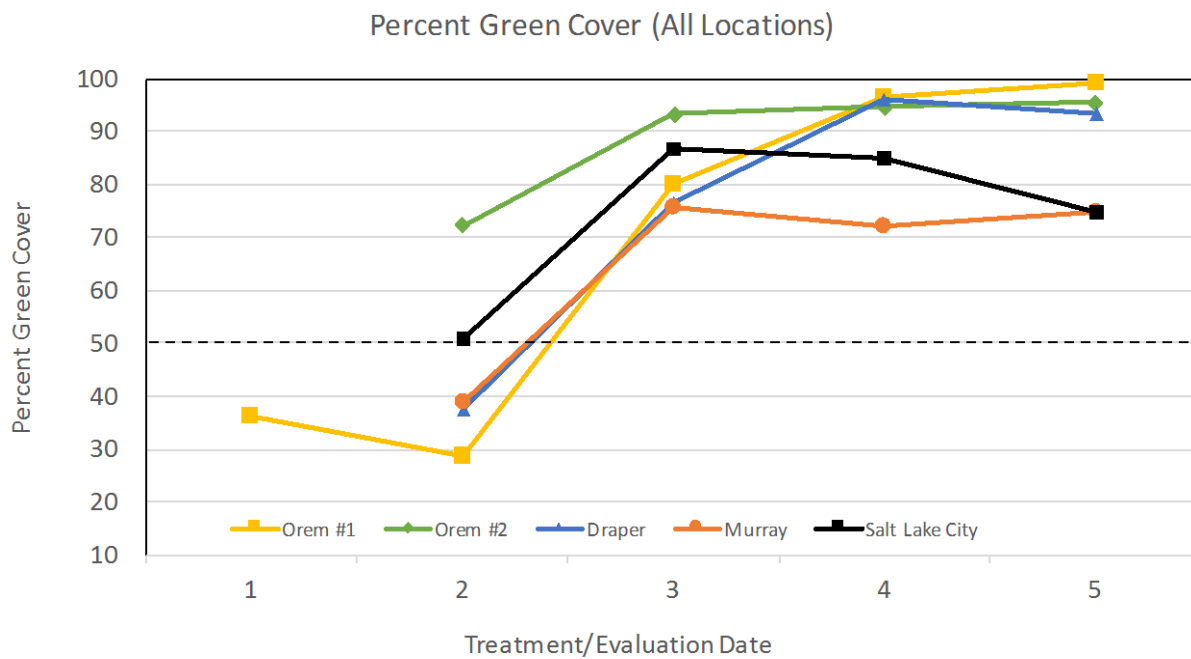


Figure 1. Average percent green cover for all treatment locations, areas, and test sites. The dashed line represents 50% green cover, which is an aesthetically acceptable amount of green cover.

Orem Test Site #1

Orem Test Site #1 was a residential property with southern and western exposures. The owner had been trying to manage and control areas damaged by NRS in his back yard for several years. This site was the only one in the study that received a fall application of Ring to GREEN (Table 2).



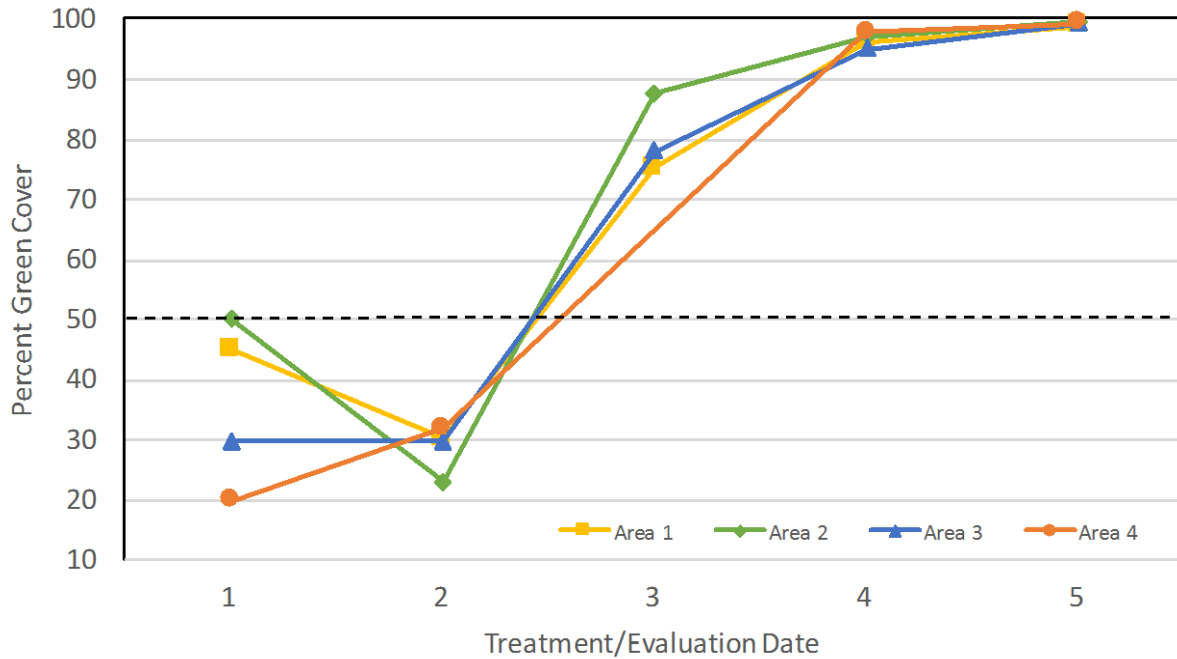


Figure 2. Percent green cover at 4 areas at Orem Test Site #1 across 5 treatment and/or evaluation dates. The dashed line represents 50% green cover, which is an aesthetically acceptable amount of green cover.

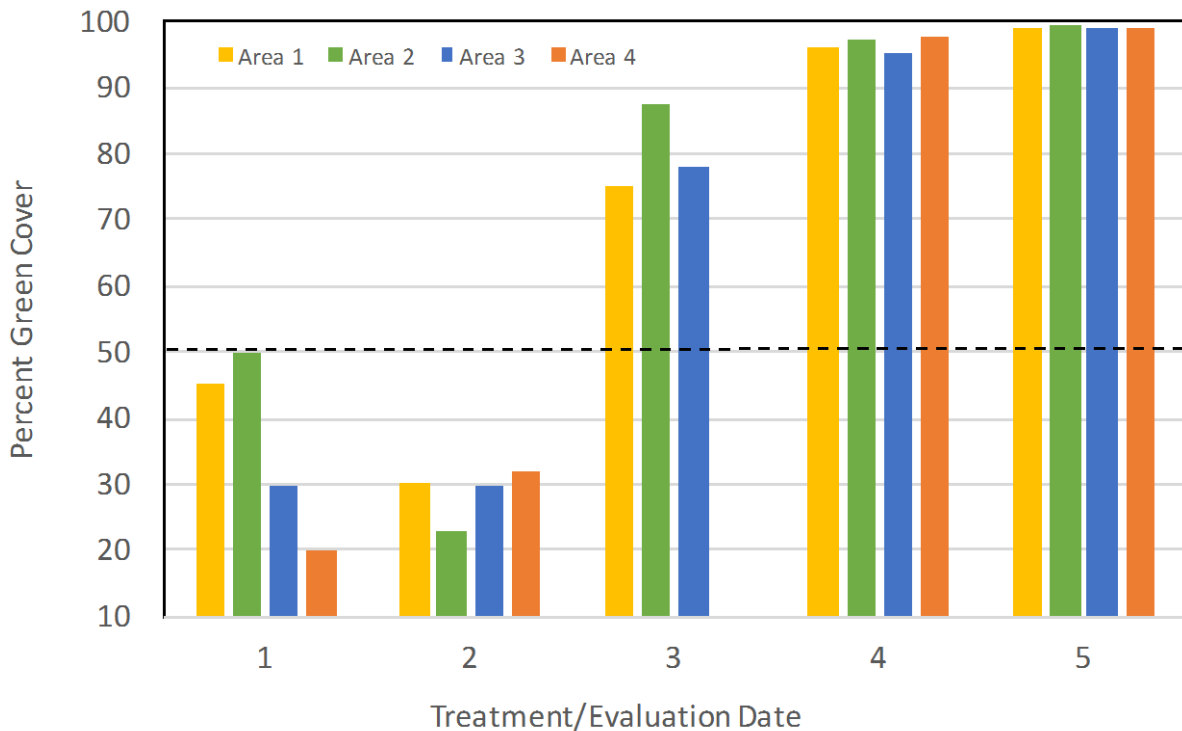


Figure 3. Percent green cover at 4 areas at Orem Test Site #1 across 5 treatment and/or evaluation dates. The dashed line represents 50% green cover, which is an aesthetically acceptable amount of green cover.

Orem Test Site #2

Orem Test Site #2 was a residential property with northern and western exposures. Treatment and evaluation at this site began in the spring of 2016 (Table 2).



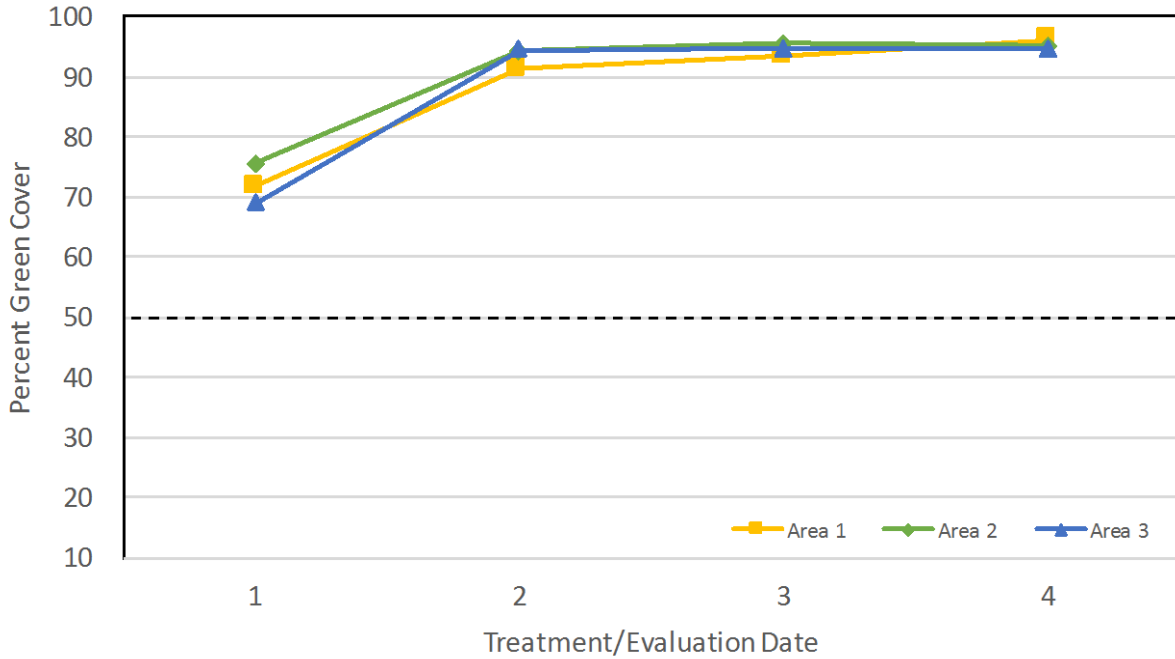


Figure 4. Percent green cover at 3 areas at Orem Test Site #2 across 4 treatment and/or evaluation dates. The dashed line represents 50% green cover, which is an aesthetically acceptable amount of green cover.

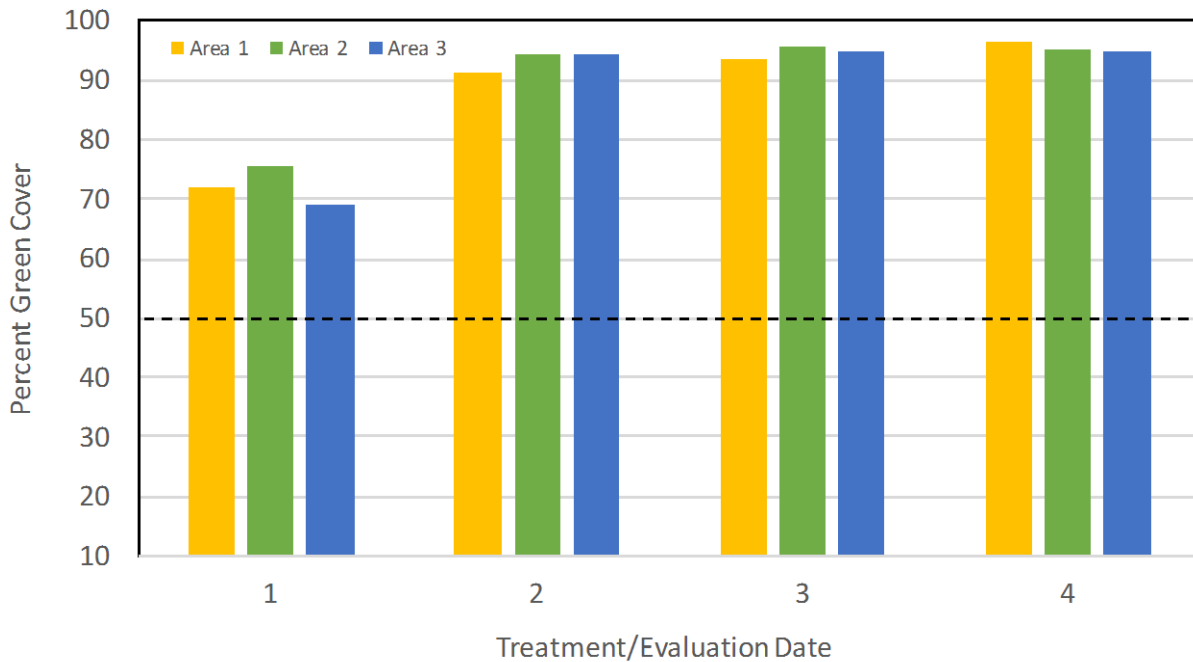


Figure 5. Percent green cover at 3 areas at Orem Test Site #2 across 4 treatment and/or evaluation dates. The dashed line represents 50% green cover, which is an aesthetically acceptable amount of green cover.

Draper Test Site

The Draper Test Site was a residential property with eastern and southern exposures. This location had heavy shade in two of the three treatment areas. In addition, the homeowner was actively pursuing additional options for controlling NRS on the site, including the application of compost and over-seeding in Areas 1 and 2. Treatment and evaluation at this site began in the spring of 2016 (Table 2).



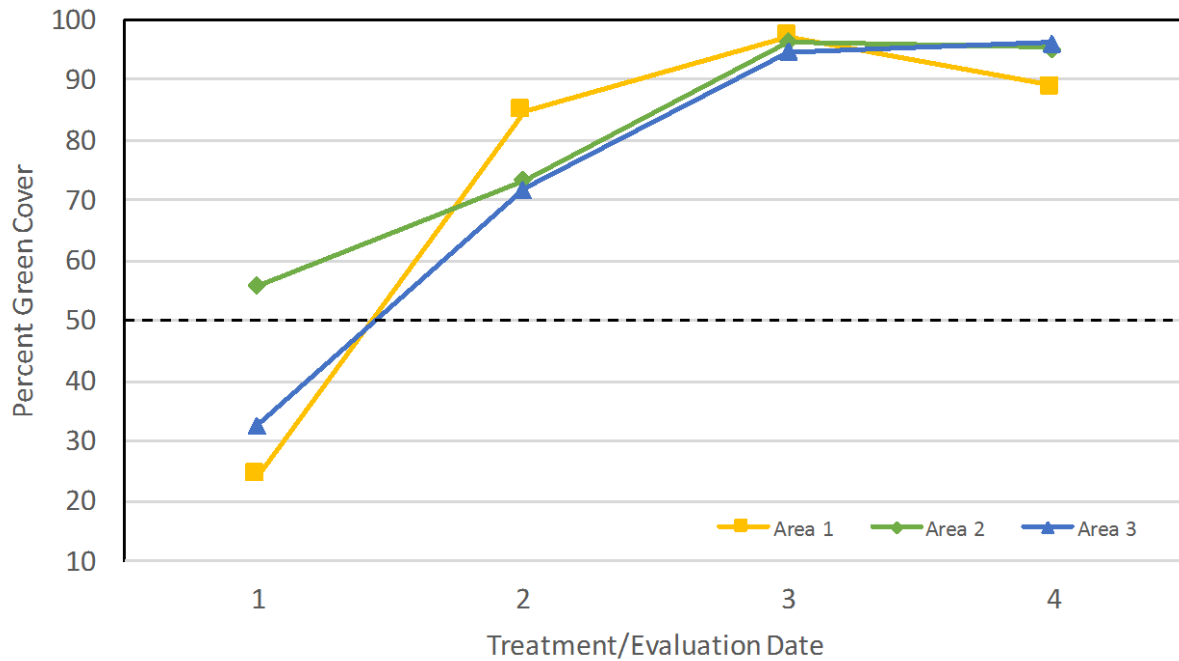


Figure 6. Percent green cover at 3 areas at Draper Test Site across 4 treatment and/or evaluation dates. The dashed line represents 50% green cover, which is an aesthetically acceptable amount of green cover.

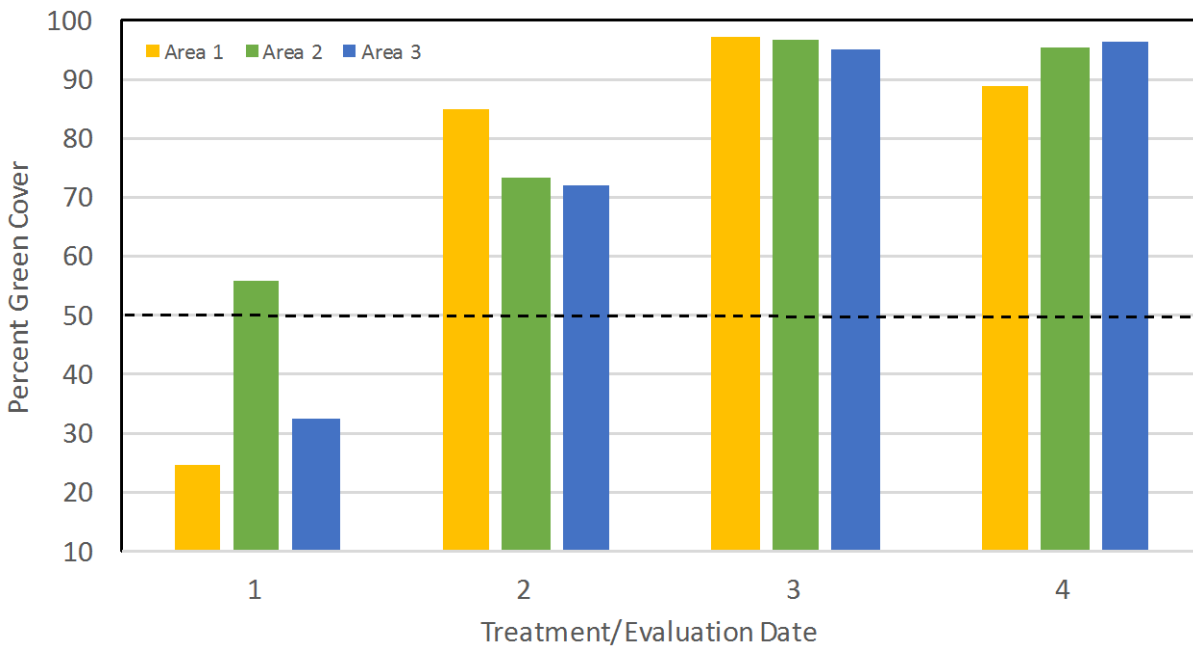


Figure 7. Percent green cover at 3 areas at Draper Test Site across 4 treatment and/or evaluation dates. The dashed line represents 50% green cover, which is an aesthetically acceptable amount of green cover.

Murray Test Site

The Murray Test Site was located at a homeowner's association with 29 homes, each having a small landscape, and a larger, landscaped common area. Treatment and evaluation at this site began in the spring of 2016 (Table 2).



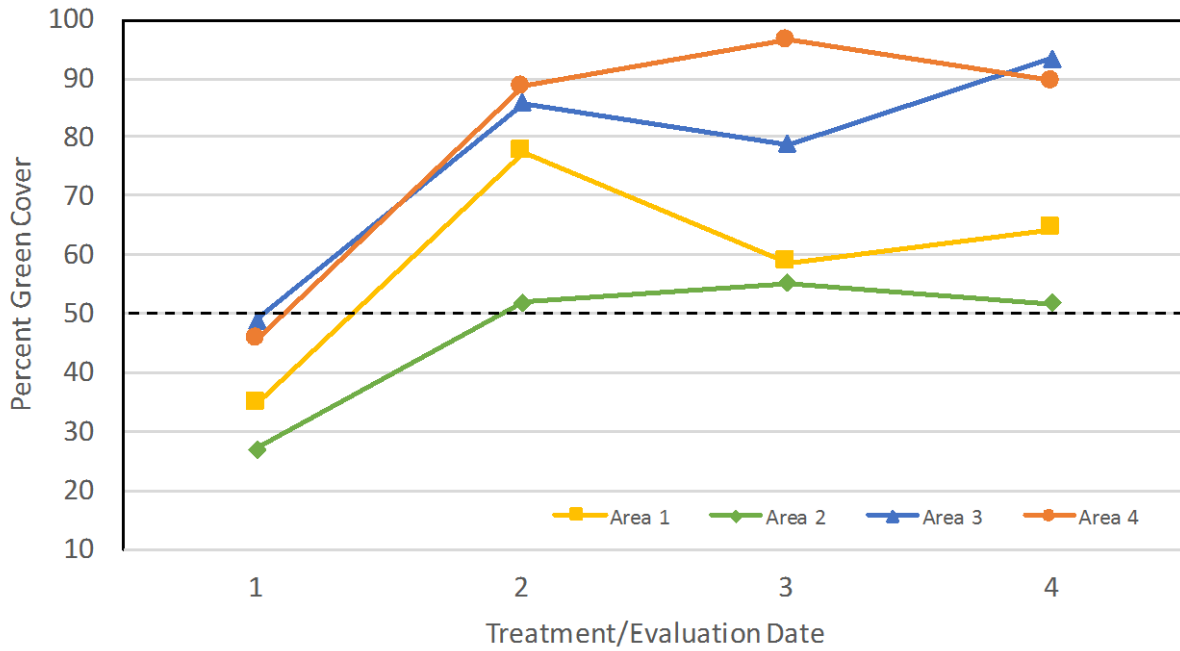


Figure 8. Percent green cover at 4 areas at Murray Test Site across 4 treatment and/or evaluation dates. The dashed line represents 50% green cover, which is an aesthetically acceptable amount of green cover.

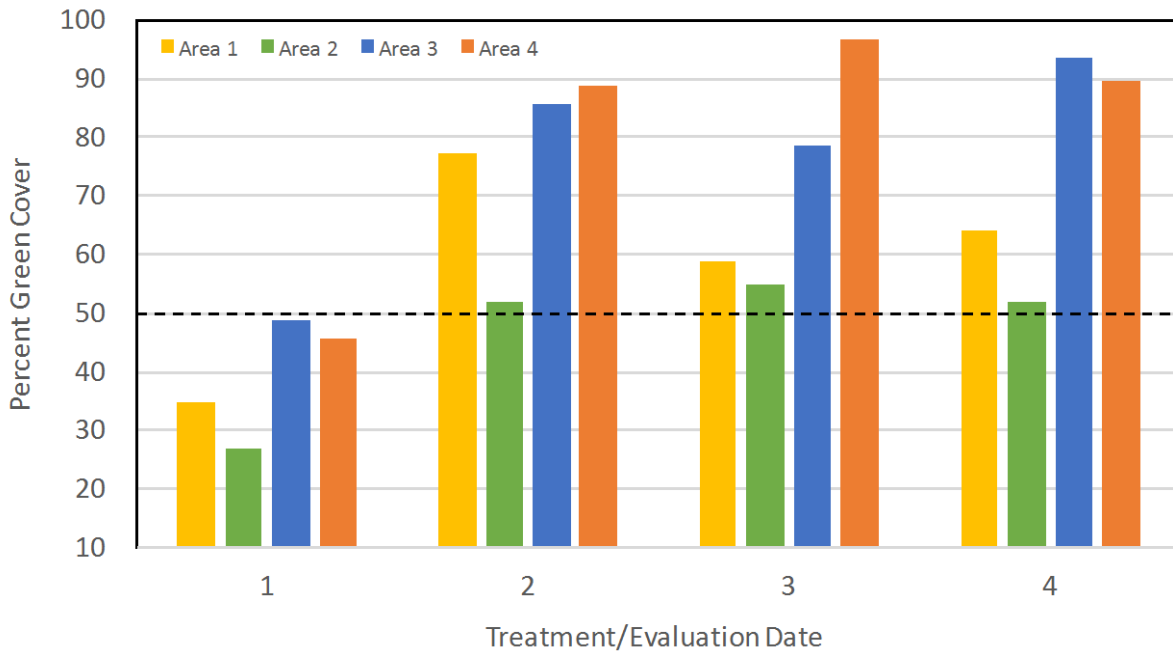


Figure 9. Percent green cover at 4 areas at Murray Test Site across 4 treatment and/or evaluation dates. The dashed line represents 50% green cover, which is an aesthetically acceptable amount of green cover.

Salt Lake City Test Site

The Salt Lake City Test Site was a residential property with northern and eastern exposures. The homeowner had been dealing with an increasingly worse case of NRS for several years. Treatment and evaluation at this site began in the spring of 2016 (Table 2).



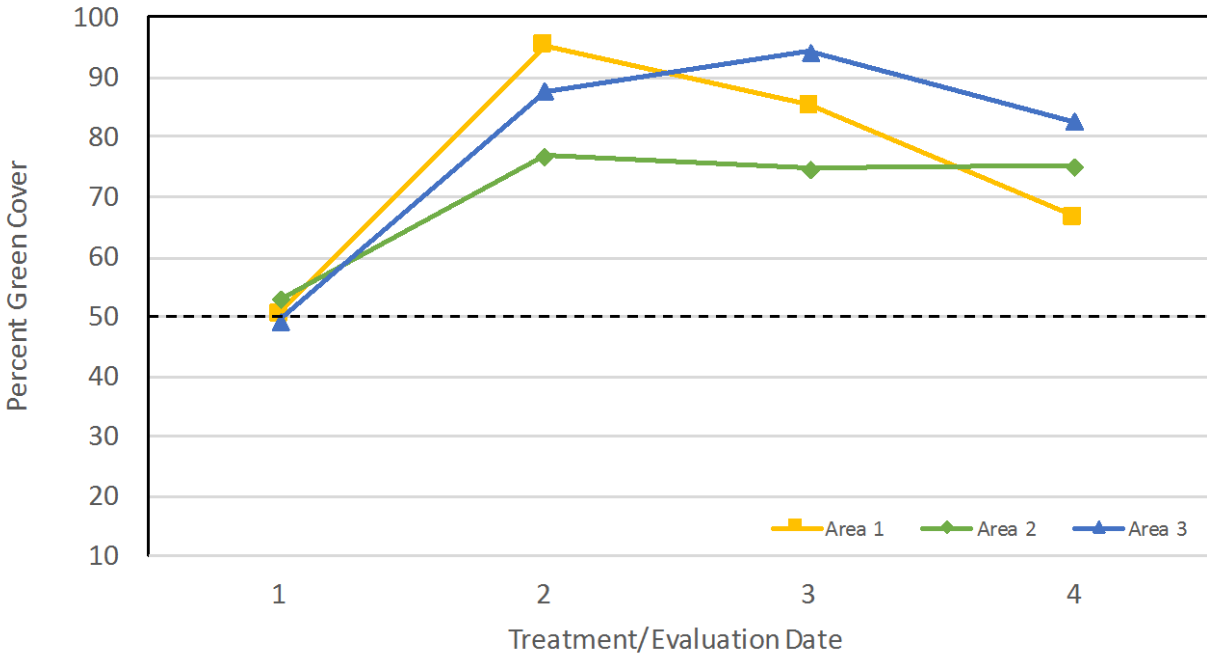


Figure 10. Percent green cover at 3 areas at Salt Lake City Test Site across 4 treatment and/or evaluation dates. The dashed line represents 50% green cover, which is an aesthetically acceptable amount of green cover.

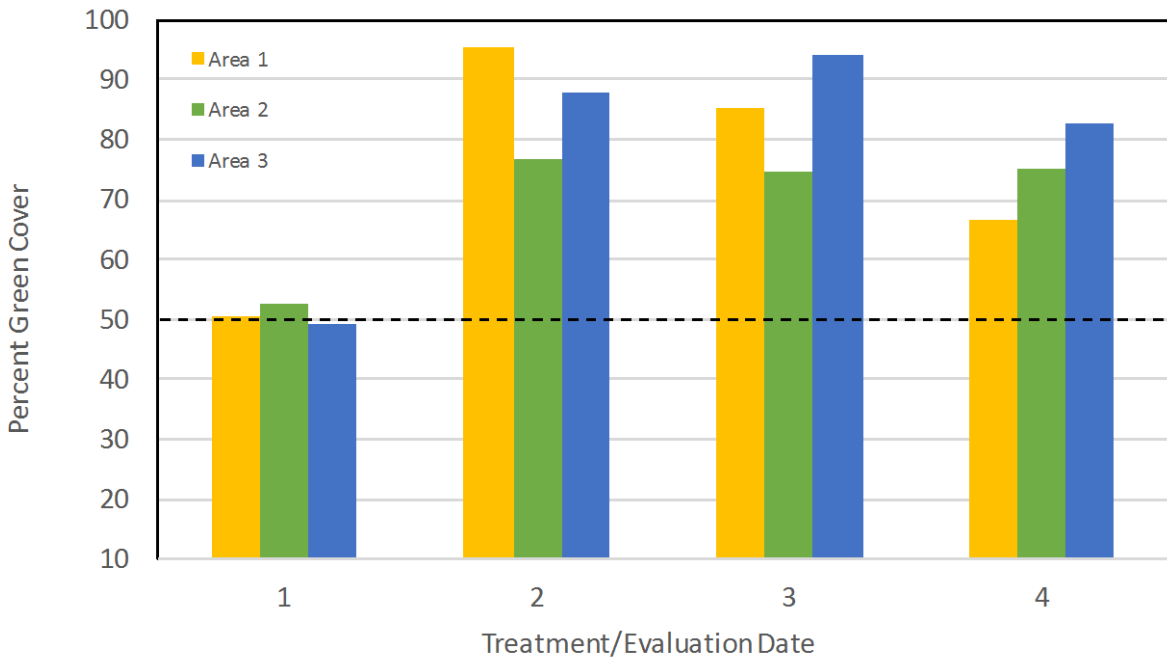


Figure 11. Percent green cover at 3 areas at Salt Lake City Test Site across 4 treatment and/or evaluation dates. The dashed line represents 50% green cover, which is an aesthetically acceptable amount of green cover.

With one exception, all test sites and areas had percent green cover that improved, on average, at every evaluation date once treatment began (Figure 1). In the case of Orem Test Site #1, the second evaluation date had declining PGC. This was not unexpected, however, since the Orem Test Site #1 treatments began in the fall of 2015 and the second treatment was applied in the early spring of 2016. As treatments continued at Orem Test Site #1 through 2016, PGC improved to an average level of 99% (Figures 2 and 3).

At Orem Test Site #2, initial PGC averaged above acceptable levels (72%) and continued to improve over the course of the study with final PGC's averaging 95% (Figures 4 and 5). At the Draper Test Site, initial PGC's averaged lower than acceptable levels (38%), but improved steadily over the course of the study to an average level of 94% (Figure 6 and 7). At the Murray Test Site, initial PGC's averaged 39%, and did exhibit some improvement over the course of the study to an average level of 75% (Figure 8 and 9). There were, however, two areas evaluated at the Murray Test Site that ended the study at 90 and 93% green cover, so the results at this site were mixed, depending on the area evaluated. At the Salt Lake City Test Site, initial PGC's averaged 51%, improved to 87%, and then declined to an average of 75% at the final evaluation (Figure 10 and 11).

At every test site and area tested, the trend was for PGC to improve over the course of the study. On average, final PGC's were above the aesthetically acceptable level of 50% at every test site.

Considerations

Management practices such as mowing height and frequency were not controlled in this study. Additional fertilization, over-seeding, application of compost, and aeration were also not controlled. However, Ring to GREEN applications were applied exactly as specified by the manufacturer.

This study was conducted over one growing season. Ongoing effects of Ring to GREEN applications or lack of application beyond one growing season are not known or implied.

References

Bushman, S., B.L. Waldron, J. Robins, K. Bhattarai, and P.G. Johnson. 2012. Summer percent green cover among Kentucky bluegrass (*Poa pratensis* L.) cultivars, accessions, and other *Poa* species managed under deficit irrigation. *Crop Science* 52:400-407.

Karcher, D. and M. Richardson. 2005. Batch analysis of digital images to evaluate turfgrass characteristics. *Crop Science* 45:1536-1539.

