

CTRF Progress Report for Project **CTRF 2015-2a** (Sept 2018 - February 2019)

RESEARCHER: Dr. Tom Hsiang, University of Guelph

GRADUATE STUDENTS: Kate Stone and Matt Rudland

PROJECT TITLE: Testing lower risk fungicides for activity against turfgrass diseases (Oct 1, 2015 to Dec 31, 2019)

PURPOSE: The purpose of the proposed work is to investigate the use of lower risk fungicides against turfgrass diseases. The specific practical objective is to quantify the extent by which common diseases such as dollar spot, Fusarium patch and snow moulds can be reduced in lab and field tests, using different application regimes of chemicals such as acetic acid (vinegar), borax, citric acid, garlic powder, hydrogen peroxide, iron sulphate, lime sulphur, phosphites, soaps, sodium chloride, and sulphur. These are all products classified by the Ontario Ministry of the Environment (OME) as Class 11, and available for cosmetic use against turfgrass pests in Ontario, and not on the “banned” list for cosmetic use that is found in OME Class 9. This issue should be of concern to turfgrass managers across Canada since most provinces in Canada have some sort of ban on chemicals for cosmetic use on turf. The subsequent scientific objective would be to determine the mode of action with efficacious treatments, since such compounds may possibly affect diseases by directly inhibiting the pathogens, or indirectly through effects on the plant (e.g. activated resistance) or effects on microbial components which affect either the plant or the pathogen or both. The benefits of this type of research would be replacement of “higher risk” synthetic fungicide applications, by ones already deemed to be “lower risk”, via a scientific assessment of how such substances are able to decrease disease. The deliverables from this project is the development of a disease control management regime (application rate, application timing) for important turfgrass diseases using lower risk fungicides that are available for use in Canada.

Results (Sept 2018 - Feb 2019)

Based on previous lab trials from January 2018 until June 2018, ferrous sulfate, para-aminobenzoic acid, Polyoxin-D, humic acid and a registered biocontrol agent (*Chlonostachys rosea*) were selected for outdoor efficacy tests as these compounds showed potential to significantly reduce dollar spot disease on creeping bentgrass in lab tests. Starting in August 2018 and continuing until October 2018, multiple field trials were conducted on creeping bentgrass at the Guelph Turfgrass Institute to determine whether or not these compounds were able to significantly reduce dollar spot disease in a field setting. The first trial was completed over 9 weeks, starting in August 2018, on creeping bentgrass cv. Penncross in order to find out which of these compounds would effectively reduce disease. The results of this trial, as seen in **Table 1 and Figures 1&2**, indicated that two ferrous sulfate compounds at different rates, para-aminobenzoic acid, and Polyoxin-D all significantly reduced dollar spot disease. However, humic acid, at two different rates, as well as *C. rosea* did not significantly reduce dollar spot disease.

Based on these results, another trial was set up using these treatments and rates starting in September 2018 and continuing until November 2018. This trial was conducted in order to determine if there were any significant differences between the efficacy of these treatments against dollar spot disease when comparing different cultivars of creeping bentgrass. In addition, we were looking to see if these treatments significantly differed when compared with each other overall to see which treatments and rates were most effective and if any were similar to the Banner Maxx fungicide standard. Plots were setup on five different creeping bentgrass cultivars including: Focus, 007, Alpha, TTyee, and L93. The results, as seen in **Table 2**, indicated that the ferrous sulfate 5x rate had very similar dollar spot disease suppression to Banner Maxx. The ferrous sulfate 1x rate had significantly less dollar spot disease suppression compared to the ferrous sulfate 5x and Banner Maxx but had significantly more dollar spot disease suppression compared to para-aminobenzoic acid and Polyoxin-D, which had similar levels of disease suppression. When looking at individual cultivars which were inoculated but not treated (Figure 3&4, Table 3), there were no significant differences in disease levels between cultivars up to 55 days after inoculation, although disease did develop up to high levels around 100 spots per 0.25 m². However, there

were some differences between cultivars when looking at individual treatments. For plots treated with Banner (Table 8), Alpha and L93 had significantly more dollar spot disease compared to Tyee, Focus and 007 on most rating dates. For 1x ferrous sulfate (Table 4), Alpha had significantly more dollar spot disease compared to Tyee, L93, Focus and 007 on most rating dates. However, there were very few significant differences between cultivars when looking at the 5x ferrous sulfate (Table 5), Polyoxin-D (Table 6) or para-aminobenzoic acid (Table 7) treatments.

Lastly, we conducted a ferrous sulfate heptahydrate phytotoxicity test starting in August 2018 that ended in October 2018 on 10 creeping bentgrass cultivars including: MacKenzie, penncross, Focus, 007, Alpha, Tyee, L93, V8, T1 and A4. The results of this trial, as seen in [Tables 9-11](#) and [Figures 5&6](#), indicated that the 1x rate resulted in very little blackening of the leaves overall, whereas the 5x rate does at 1 day post treatment application, but is reduced to low levels by 1 week post application. However, the 10x and 15x rates result in fairly severe darkening effects both 1 day and 1 week post treatment application. Due to this observation, we would not suggest a treatment rate of ferrous sulfate heptahydrate over 5x, as it will reduce the overall appearance of the turfgrass significantly.

Based on these Fall 2018 results, we plan on repeating this cultivar based trial in Summer 2019, but will expand it across all 10 cultivars mentioned above to get a better look at if some cultivars respond more to these treatment applications compared to others, in order to potentially be able to recommend cultivar and treatment combinations. In addition, we plan on completing other efficacy trials on creeping bentgrass including treatment interval trials and other trials using various rates for each treatment to determine optimal rates and application timing for each treatment.

In Fall 2018, a field trial with select low risk fungicides was initiated at the Guelph Turfgrass Institute (Figure 7) on creeping bentgrass. As of early February during a short period of snow melt, few symptoms had developed (Tables 12 and 13). We will continue to monitor until spring.

Table 1: Field trial 1 (18/08/09 - 18/10/03) with average dollar spot counts by days post inoculation (DPI) and date with different treatments (applied weekly from 18/08/02 until 18/09/05, twice before inoculation) to reduce dollar spot on creeping bentgrass cv. penncross at fairway height. Plots measured 0.25 m² with four replicates and all plots were inoculated with the dollar spot pathogen (1 g/m²) on 18/08/09, one week after the first treatment. Green shading indicates a significant reduction of disease compared to the inoculated control, while yellow shading indicates a significant increase of disease compared to the inoculated control.

| Treatment | Rate ^a | Dollar spot counts per 0.25 m ² (by DPI and date) | | | | | | |
|------------------------------------|-------------------|--|------------------|-------------------------------|------------------|------------------|------------------|------------------|
| | | DPI14 (08/23) | DPI21 (08/30) | DPI27 ^b (09/05) | DPI34 (09/12) | DPI40 (09/18) | DPI48 (09/26) | DPI55 (10/03) |
| Inoculated Control | | 17.5 ab | 30.0 bc | 43.8 a | 80.0 a | 91.3 a | 91.3 a | 108.8 a |
| Banner Maxx | 26 ml | 0.0 e | 0.3 e | 1.0 d | 3.5 d | 2.8 c | 4.5 f | 6.3 d |
| Chlonostachys rosea | 300 g | 22.5 a | 41.3 a | 42.5 a | 75.0 a | 82.5 a | 72.3 bc | 105.0 a |
| Ferrous Sulfate Heptahydrate (21%) | 250 g | 8.5 cd | 17.5 d | 22.5 b | 40.0 b | 48.8 b | 45.0 d | 57.5 bc |
| Ferrous Sulfate (100%) | 366 g | 4.3 de | 10.0 de | 11.8 c | 17.5 cd | 23.8 c | 25.0 e | 40.0 c |
| Humic Acid (1%) | 100 ml | 18.3 ab | 35.0 ab | 45.0 a | 78.8 a | 82.5 a | 80.0 ab | 95.0 a |
| Humic Acid (4%) | 400 ml | 18.8 a | 40.0 ab | 45.0 a | 75.0 a | 90.0 a | 81.3 ab | 103.8 a |
| Para-aminobenzoic Acid | 218 g | 11.8 bc | 18.8 d | 23.8 b | 50.0 b | 50.0 b | 55.0 cd | 63.8 b |
| Polyoxin-D | 27 g | 7.8 cd | 20.5 cd | 12.0 c | 33.8 bc | 50.0 b | 47.5 d | 57.5 bc |
| LSD (p=0.05) | | 6.8 | 10.9 | 9.4 | 17.4 | 21.3 | 20.0 | 21.7 |

^a Rates are per 100m² at 100ml/m²

^b Last treatment date

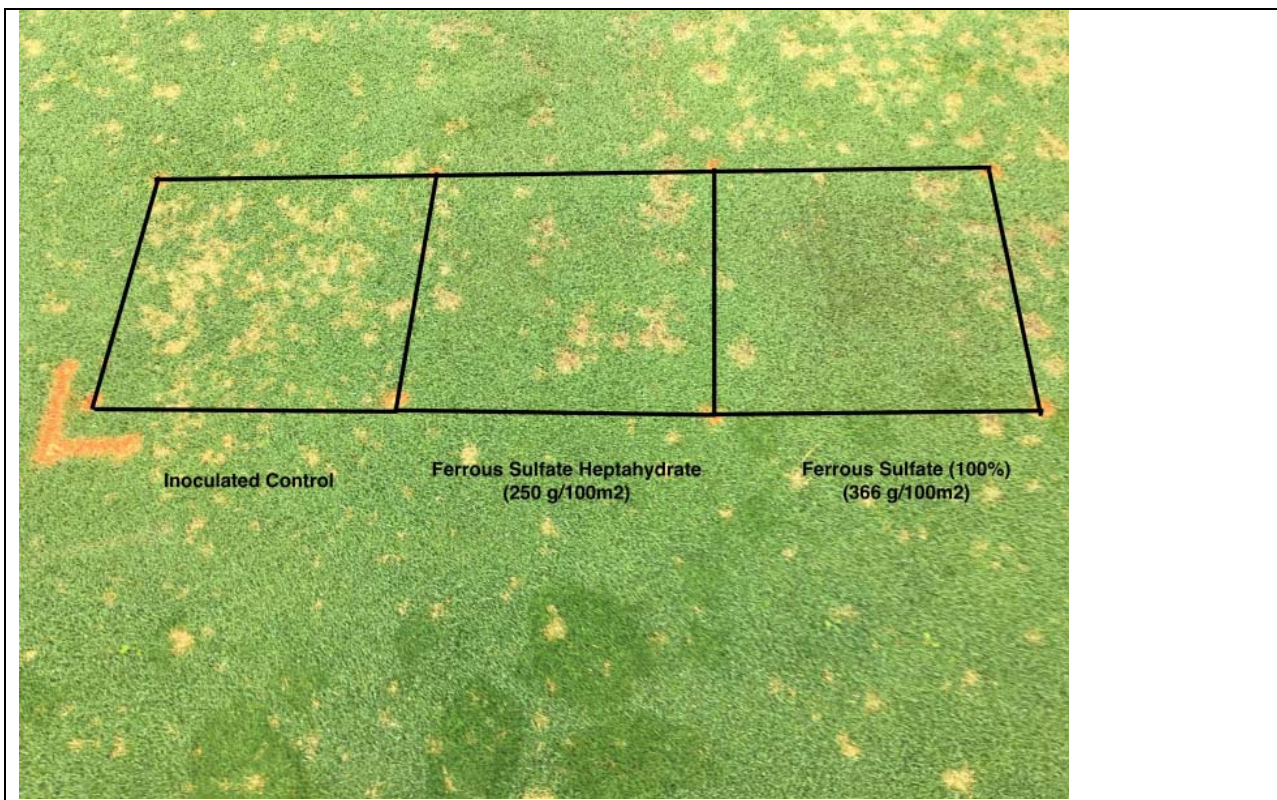


Figure 1: Ferrous sulfate and inoculated control (dollarspot) on creeping bentgrass plots at the Guelph Turfgrass Institute. Plots were first treated 18/08/02, with repeated weekly treatments until 18/09/05. They were inoculated with the dollar spot fungus on 18/08/09. This photo was taken on 18/09/18. Data are shown in Table 1.

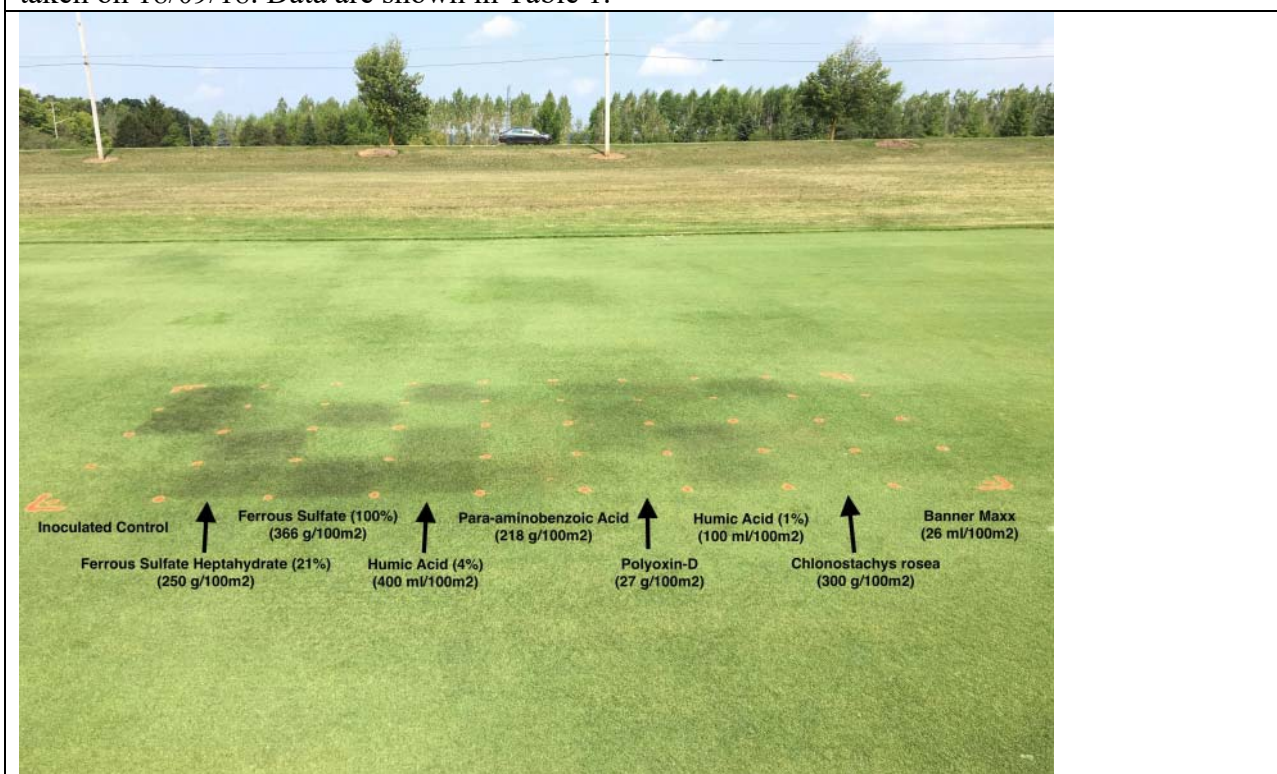


Figure 2: Low risk treatments against dollarspot on creeping bentgrass plots at the Guelph Turfgrass Institute. Plots were first treated 18/08/02, with repeated treatments weekly until 18/09/05. They were inoculated with the dollar spot fungus on 18/08/09. This photo was taken on 18/08/16, one day post treatment application. Data are shown in Table 1.

Table 2: Field trial 2 (18/09/06 - 18/11/07) with average dollar spot counts by days post inoculation (DPI) and date with different treatments (applied weekly from 18/09/06 until 18/10/17, twice before inoculation) to reduce dollar spot on five cultivars of creeping bentgrass at fairway height including: 007, Alpha, Focus, L93 and Tye. Plots measured 0.25 m² with four replicates and all plots were inoculated with the dollar spot pathogen (1 g/m²) on 18/09/13, one week after the first treatment. Green shading indicates a significant reduction of disease compared to the inoculated control, while blue shading indicates significantly less disease compared to the green shaded treatments. The purple shading indicates significantly less disease compared to the blue shaded treatments, while orange shading indicates significantly less disease compared to the purple shaded treatments.

| Treatment | Rate ^a | Dollar spot counts per 0.25 m ² (by DPI and date) | | | | | | | | |
|--|-------------------|--|-----------------|------------------|------------------|------------------|-------------------------------|------------------|------------------|------------------|
| | | Initial (09/12) | DPI6 (09/19) | DPI13 (09/26) | DPI20 (10/03) | DPI27 (10/10) | DPI34 ^b (10/17) | DPI41 (10/24) | DPI48 (10/31) | DPI55 (11/07) |
| Inoculated Control | | 5.2 a | 12.8 a | 17.1 a | 36.8 a | 76.6 a | 97.9 a | 96.1 a | 88.4 a | 90.2 a |
| Banner Maxx | 26 ml | 3.4 bc | 2.1 bc | 0.8 c | 0.8 d | 1.5 d | 1.9 d | 1.3 d | 1.1 e | 1.4 d |
| 1x Ferrous Sulfate Heptahydrate (21%) | 250 g | 3.1 bc | 3.0 bc | 3.7 b | 6.6 c | 25.1 c | 32.0 c | 30.0 c | 26.8 d | 15.0 c |
| 5x Ferrous Sulfate Heptahydrate (21%) | 1250 g | 2.0 c | 0.8 c | 0.9 c | 1.4 cd | 3.8 d | 5.5 d | 5.8 d | 2.9 e | 1.7 d |
| Para-aminobenzoic Acid | 218 g | 4.3 ab | 4.3 b | 3.9 b | 12.8 b | 46.6 b | 64.1 b | 60.2 b | 49.8 b | 51.1 b |
| Polyoxin-D | 27 g | 3.4 bc | 2.4 bc | 2.1 bc | 12.4 b | 30.1 c | 58.6 b | 59.1 b | 39.6 c | 45.7 b |
| LSD (p=0.05) | | 1.7 | 2.5 | 2.6 | 5.5 | 9.1 | 10.6 | 10.7 | 9.3 | 9.4 |

^a Rates are per 100m² at 100ml/m²

^b Last treatment application

Table 3: Field trial 2 (18/09/06 - 18/11/07) with average dollar spot counts by days post inoculation (DPI) and date with no treatments applied, serving as an inoculated control on five cultivars of creeping bentgrass at fairway height including: 007, Alpha, Focus, L93 and Tye. Plots measured 0.25 m² with four replicates and all plots were inoculated with the dollar spot pathogen (1 g/m²) on 18/09/13.

| Cultivar | Dollar spot counts per 0.25 m ² (by DPI and date) | | | | | | | | |
|--------------|--|------------------|------------------|------------------|------------------|-------------------------------|------------------|------------------|------------------|
| | Initial (09/12) | DPI06 (09/19) | DPI13 (09/26) | DPI20 (10/03) | DPI27 (10/10) | DPI34 ^a (10/17) | DPI41 (10/24) | DPI48 (10/31) | DPI55 (11/07) |
| 007 | 7.0 a | 23.0 a | 24.3 a | 51.3 a | 96.3 a | 116.3 a | 96.3 a | 92.5 a | 105.0 a |
| Alpha | 8.0 a | 16.8 a | 20.0 a | 36.3 a | 81.3 a | 95.0 a | 105.0 a | 92.5 a | 92.5 a |
| Focus | 9.5 a | 21.8 a | 25.0 a | 51.3 a | 77.7 a | 97.5 a | 80.0 a | 82.5 a | 91.3 a |
| L93 | 6.5 a | 15.0 a | 18.3 a | 31.8 a | 74.8 a | 83.8 a | 88.9 a | 78.8 a | 81.3 a |
| Tye | 5.3 a | 13.3 a | 21.3 a | 51.3 a | 90.0 a | 103.8 a | 102.5 a | 105.0 a | 102.5 a |
| LSD (p=0.05) | 6.1 | 10.9 | 13.4 | 27.6 | 39.8 | 45.7 | 47.3 | 41.6 | 36.2 |

^a Last treatment application

Table 4: Field trial 2 (18/09/06 - 18/11/07) with average dollar spot counts by days post inoculation (DPI) and date with 1x ferrous sulfate heptahydrate (at a rate of 250 g/100m² applied weekly from 18/09/06 until 18/10/17, twice before inoculation) to reduce dollar spot on five cultivars of creeping bentgrass at fairway height including: 007, Alpha, Focus, L93 and Tyee. Plots measured 0.25 m² with four replicates and all plots were inoculated with the dollar spot pathogen (1 g/m²) on 18/09/13, one week after the first treatment. Green shading indicates cultivars with significantly less dollar spot disease compared to cultivars with no shading, while blue shading indicates cultivars that have significantly less disease than those with green shading. Grey shading indicates cultivars that do not significantly differ from either the green shaded or non shaded cultivars.

| Cultivar | Dollar spot counts per 0.25 m ² (by DPI and date) | | | | | | | | |
|-----------------|--|------------------|------------------|------------------|------------------|-------------------------------|------------------|------------------|------------------|
| | Initial (09/12) | DPI06 (09/19) | DPI13 (09/26) | DPI20 (10/03) | DPI27 (10/10) | DPI34 ^a (10/17) | DPI41 (10/24) | DPI48 (10/31) | DPI55 (11/07) |
| 007 | 5.3 a | 3.5 a | 5.0 a | 9.5 ab | 23.8 b | 27.5 b | 25.0 b | 25.0 c | 15.0 b |
| Alpha | 4.5 a | 3.3 a | 5.0 a | 8.8 ab | 37.5 a | 43.8 a | 46.3 a | 42.5 a | 31.3 a |
| Focus | 4.8 a | 6.5 a | 5.8 a | 11.8 a | 26.3 ab | 27.5 b | 22.5 b | 23.8 c | 13.8 b |
| L93 | 3.5 a | 4.5 a | 4.3 a | 7.5 b | 28.8 ab | 28.8 b | 28.8 b | 33.8 b | 15.0 b |
| Tyee | 3.5 a | 3.3 a | 5.8 a | 7.3 b | 23.8 b | 25.0 b | 23.8 b | 20.0 c | 15.0 b |
| LSD (p=0.05) | 2.8 | 3.5 | 3.5 | 3.9 | 11.4 | 9.8 | 11.2 | 8.4 | 9.8 |

^a Last treatment application

Table 5: Field trial 2 (18/09/06 - 18/11/07) with average dollar spot counts by days post inoculation (DPI) and date with 5x ferrous sulfate heptahydrate (at a rate of 1250 g/100m² applied weekly from 18/09/06 until 18/10/17, twice before inoculation) to reduce dollar spot on five cultivars of creeping bentgrass at fairway height including: 007, Alpha, Focus, L93 and Tyee. Plots measured 0.25 m² with four replicates and all plots were inoculated with the dollar spot pathogen (1 g/m²) on 18/09/13, one week after the first treatment. Green shading indicates cultivars with significantly less dollar spot disease compared to cultivars with no shading. Grey shading indicates cultivars that do not significantly differ from either the green shaded or non shaded cultivars.

| Cultivar | Dollar spot counts per 0.25 m ² (by DPI and date) | | | | | | | | |
|--------------|--|------------------|------------------|------------------|------------------|-------------------------------|------------------|------------------|------------------|
| | Initial (09/12) | DPI06 (09/19) | DPI13 (09/26) | DPI20 (10/03) | DPI27 (10/10) | DPI34 ^a (10/17) | DPI41 (10/24) | DPI48 (10/31) | DPI55 (11/07) |
| 007 | 2.8 ab | 1.3 ab | 1.3 ab | 2.5 a | 4.3 a | 5.0 ab | 3.5 a | 3.8 a | 3.0 a |
| Alpha | 3.0 ab | 1.8 a | 1.3 ab | 1.8 a | 4.5 a | 3.8 ab | 3.8 a | 3.5 a | 3.3 a |
| Focus | 3.8 a | 1.3 ab | 1.0 ab | 1.5 a | 4.0 a | 6.3 a | 2.5 a | 2.3 a | 1.3 a |
| L93 | 1.3 b | 0.5 b | 0.8 b | 1.8 a | 2.8 a | 2.8 b | 2.5 a | 2.5 a | 1.3 a |
| Tyee | 3.0 ab | 1.0 ab | 2.0 a | 1.8 a | 3.0 a | 3.3 ab | 4.3 a | 3.0 a | 1.3 a |
| LSD (p=0.05) | 2.3 | 0.9 | 1.3 | 1.6 | 2.5 | 3.4 | 2.5 | 2.2 | 2.2 |

^a Last treatment application

Table 6: Field trial 2 (18/09/06 - 18/11/07) with average dollar spot counts by days post inoculation (DPI) and date with para-aminobenzoic acid (at a rate of 218 g/100m² applied weekly from 18/09/06 until 18/10/17, twice before inoculation) to reduce dollar spot on five cultivars of creeping bentgrass at fairway height including: 007, Alpha, Focus, L93 and Tye. Plots measured 0.25 m² with four replicates and all plots were inoculated with the dollar spot pathogen (1 g/m²) on 18/09/13, one week after the first treatment. Green shading indicates cultivars with significantly less dollar spot disease compared to cultivars with no shading. Grey shading indicates cultivars that do not significantly differ from either the green shaded or non shaded cultivars.

| Cultivar | Dollar spot counts per 0.25 m ² (by DPI and date) | | | | | | | | |
|--------------|--|------------------|------------------|------------------|------------------|-------------------------------|------------------|------------------|------------------|
| | Initial (09/12) | DPI06 (09/19) | DPI13 (09/26) | DPI20 (10/03) | DPI27 (10/10) | DPI34 ^a (10/17) | DPI41 (10/24) | DPI48 (10/31) | DPI55 (11/07) |
| 007 | 6.0 ab | 6.3 a | 5.5 a | 21.3 a | 61.3 a | 78.8 a | 63.8 a | 58.8 a | 72.5 a |
| Alpha | 7.8 a | 7.5 a | 5.0 a | 17.5 ab | 53.8 a | 66.3 a | 71.3 a | 60.0 a | 61.3 ab |
| Focus | 7.5 a | 5.3 a | 5.5 a | 22.5 a | 46.3 a | 60.0 a | 43.8 a | 42.5 a | 47.5 ab |
| L93 | 4.3 b | 5.5 a | 4.3 a | 11.3 b | 41.3 a | 52.5 a | 46.3 a | 36.3 a | 35.0 b |
| Tye | 4.5 b | 5.5 a | 6.0 a | 11.3 b | 62.5 a | 68.8 a | 71.3 a | 62.5 a | 63.8 a |
| LSD (p=0.05) | 2.7 | 3.6 | 3.2 | 9.6 | 26.4 | 33.0 | 32.3 | 30.1 | 27.5 |

^a Last treatment application

Table 7: Field trial 2 (18/09/06 - 18/11/07) with average dollar spot counts by days post inoculation (DPI) and date with Polyoxin-D (at a rate of 27 g/100m² applied weekly from 18/09/06 until 18/10/17, twice before inoculation) to reduce dollar spot on five cultivars of creeping bentgrass at fairway height including: 007, Alpha, Focus, L93 and Tye. Plots measured 0.25 m² with four replicates and all plots were inoculated with the dollar spot pathogen (1 g/m²) on 18/09/13, one week after the first treatment. Green shading indicates cultivars with significantly less dollar spot disease compared to cultivars with no shading. Grey shading indicates cultivars that do not significantly differ from either the green shaded or non shaded cultivars.

| Cultivar | Dollar spot counts per 0.25 m ² (by DPI and date) | | | | | | | | |
|--------------|--|------------------|------------------|------------------|------------------|-------------------------------|------------------|------------------|------------------|
| | Initial (09/12) | DPI06 (09/19) | DPI13 (09/26) | DPI20 (10/03) | DPI27 (10/10) | DPI34 ^a (10/17) | DPI41 (10/24) | DPI48 (10/31) | DPI55 (11/07) |
| 007 | 6.8 a | 3.5 a | 2.0 b | 15.0 a | 37.5 a | 72.5 a | 56.3 a | 42.5 a | 61.3 ab |
| Alpha | 5.8 ab | 5.0 a | 4.5 a | 16.8 a | 41.3 a | 58.8 a | 75.0 a | 56.3 a | 68.8 a |
| Focus | 5.8 ab | 2.8 a | 2.3 b | 15.3 a | 32.3 a | 55.0 a | 43.8 a | 27.5 a | 32.5 b |
| L93 | 1.8 b | 1.8 a | 1.8 b | 15.5 a | 33.8 a | 48.8 a | 62.5 a | 36.3 a | 38.8 b |
| Tye | 3.8 ab | 3.8 a | 3.3 ab | 17.5 a | 41.3 a | 60.0 a | 57.5 a | 48.8 a | 47.5 ab |
| LSD (p=0.05) | 4.6 | 3.6 | 2.0 | 20.2 | 35.4 | 44.7 | 45.6 | 34.2 | 29.4 |

^a Last treatment application

Table 8: Field trial 2 (09/06 -11/07) with average dollar spot counts by days post inoculation (DPI) and date with **Banner Maxx** (at a rate of 26 ml/100m² applied weekly from 18/09/06 until 18/10/17, twice before inoculation) to reduce dollar spot on five cultivars of creeping bentgrass at fairway height including: 007, Alpha, Focus, L93 and Tye. Plots measured 0.25 m² with four replicates and all plots were inoculated with the dollar spot pathogen (1 g/m²) on 18/09/13, one week after the first treatment. Green shading indicates cultivars with significantly less dollar spot disease compared to cultivars with no shading. Grey shading indicates cultivars that do not significantly differ from either the green shaded or non shaded cultivars.

| Cultivar | Dollar spot counts per 0.25 m ² (by DPI and date) | | | | | | | | |
|--------------|--|------------------|------------------|------------------|------------------|-------------------------------|------------------|------------------|------------------|
| | Initial (09/12) | DPI06 (09/19) | DPI13 (09/26) | DPI20 (10/03) | DPI27 (10/10) | DPI34 ^a (10/17) | DPI41 (10/24) | DPI48 (10/31) | DPI55 (11/07) |
| 007 | 3.8 b | 1.8 b | 0.5 b | 0.0 b | 1.0 bc | 0.8 c | 0.5 b | 0.5 b | 0.3 b |
| Alpha | 5.0 b | 5.0 a | 2.0 a | 1.8 a | 3.3 a | 5.0 a | 3.8 a | 3.5 a | 6.5 a |
| Focus | 8.5 a | 3.0 ab | 0.8 b | 0.5 ab | 0.8 c | 1.3 bc | 0.5 b | 0.8 b | 0.5 b |
| L93 | 3.5 b | 3.0 ab | 1.0 ab | 1.5 ab | 2.5 ab | 3.0 ab | 2.3 ab | 1.5 b | 1.3 b |
| Tye | 3.3 b | 2.3 b | 1.5 ab | 1.8 a | 1.8 abc | 2.5 bc | 1.8 b | 1.5 b | 1.0 b |
| LSD (p=0.05) | 3.2 | 2.5 | 1.01 | 1.5 | 1.7 | 2.0 | 1.9 | 1.2 | 4.0 |

^a Last treatment application

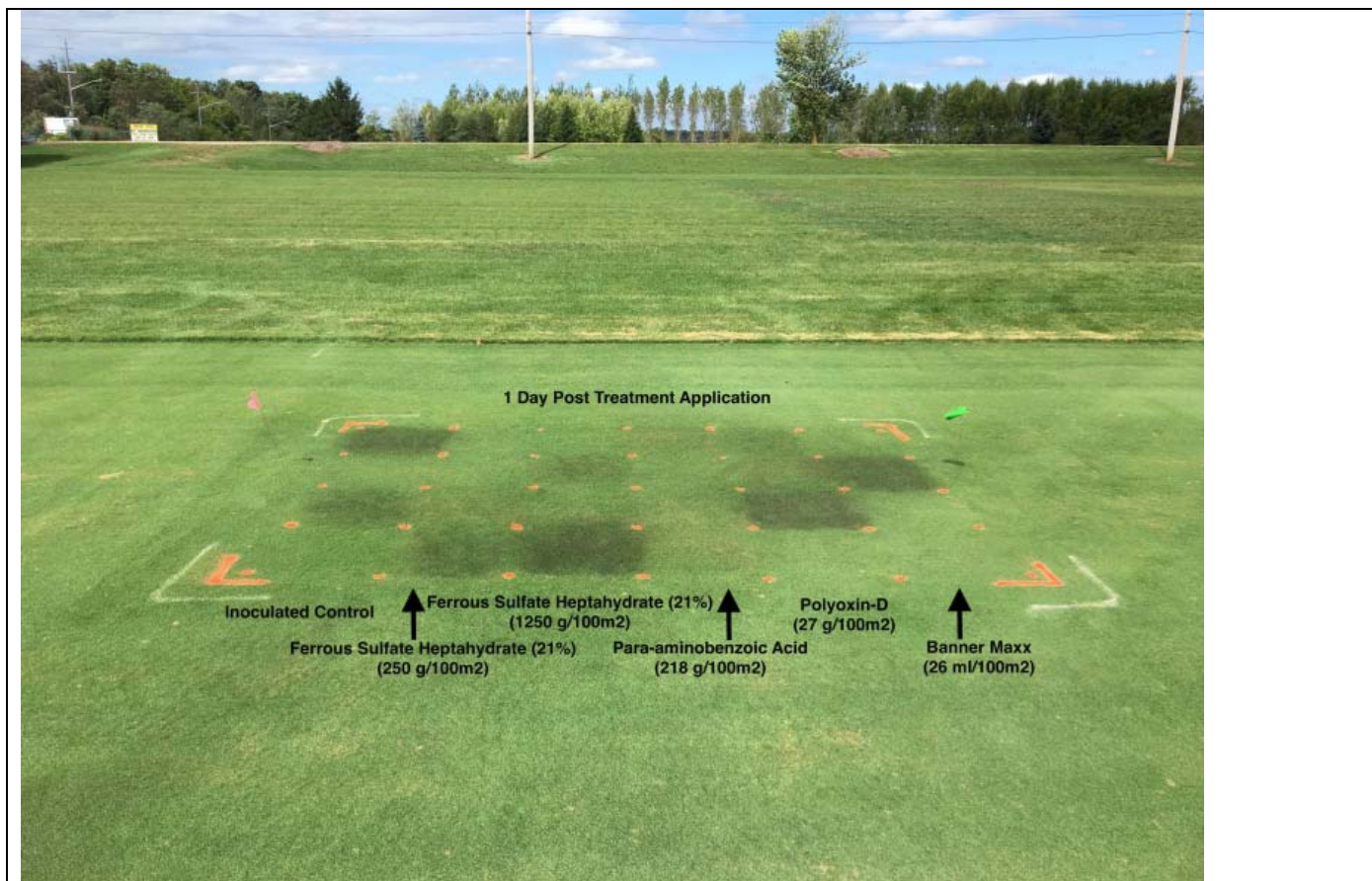


Figure 3: Low risk treatments against dollarspot on creeping bentgrass plots at the Guelph Turfgrass Institute. Plots were first treated 18/09/06, with repeated treatments weekly until 18/10/17. They were inoculated with the dollar spot fungus on 18/09/13. This photo was taken on 18/09/13, one day post treatment application. Data are shown in Table 2.

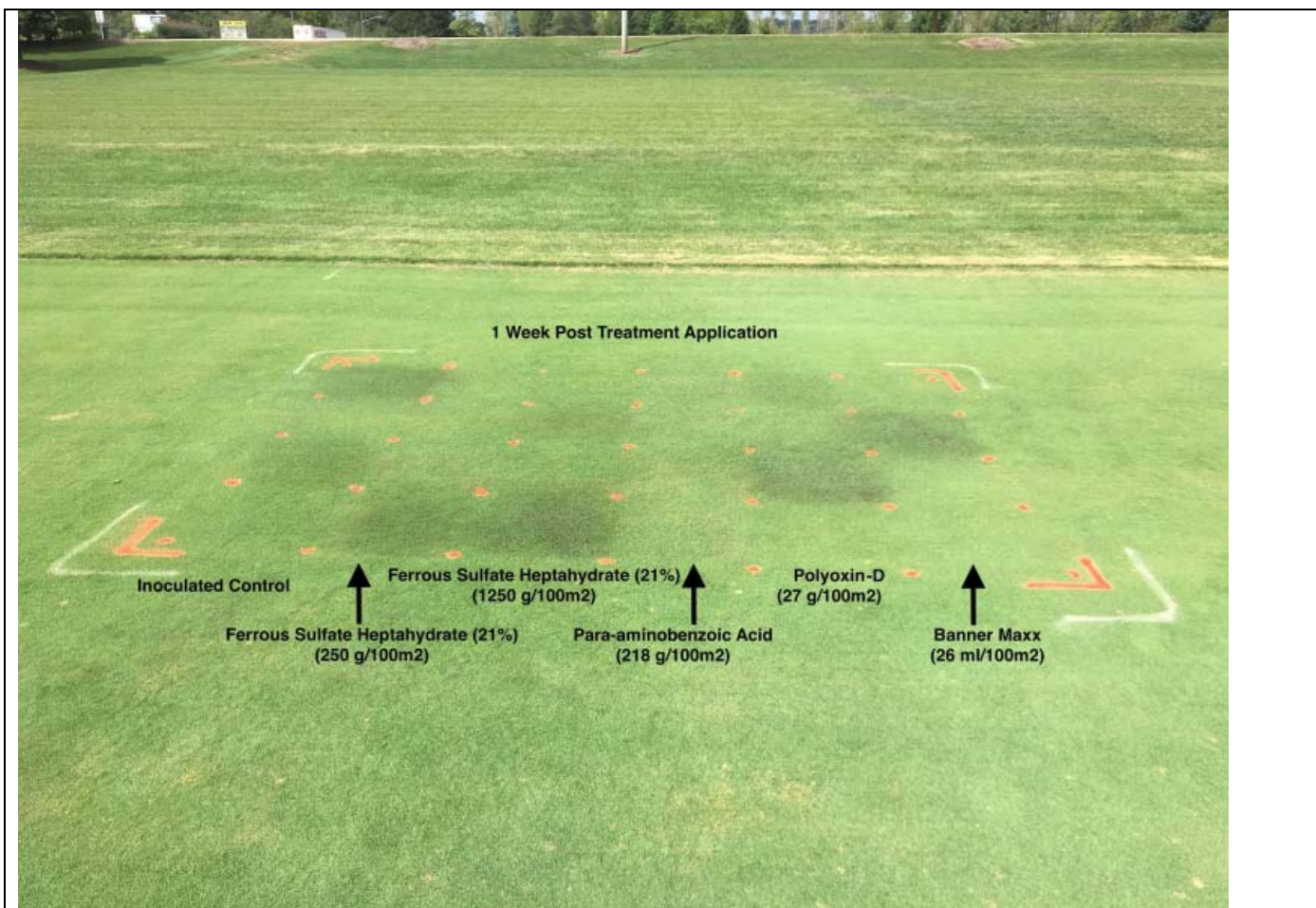


Figure 4: Low risk treatments against dollarspot on creeping bentgrass plots at the Guelph Turfgrass Institute. Plots were first treated 18/09/06, with repeated treatments weekly until 18/10/17. They were inoculated with the dollar spot fungus on 18/09/13. This photo was taken on 18/09/12, one week post treatment application. Data are shown in Table 2.

Table 9: Phytotoxicity trial (18/08/14 - 18/10/05) with average % leaf blade blackening across 10 creeping bentgrass cultivars at fairway height by rating date with different rates of ferrous sulfate heptahydrate (21%) (applied weekly from 18/08/15 until 18/09/06, with ratings taken **1 day post** treatment application [DPT]). Plots measured 0.0625 m² with four replicates for each treatment level.

| Treatment | Rate ^a | % leaf blade blackening (by date) | | |
|--|-------------------|-----------------------------------|------------------|------------------|
| | | 1 DPT (08/16) | 1 DPT (08/24) | 1 DPT (08/31) |
| Untreated | | 0.0 e | 0.0 e | 0.0 e |
| 1x Ferrous Sulfate Heptahydrate (21%) | 250 g | 15.7 d | 21.8 d | 10.5 d |
| 5x Ferrous Sulfate Heptahydrate (21%) | 1250 g | 31.6 c | 46.0 c | 22.9 c |
| 10x Ferrous Sulfate Heptahydrate (21%) | 2500 g | 53.0 b | 66.9 b | 53.4 b |
| 15x Ferrous Sulfate Heptahydrate (21%) | 3750 g | 62.9 a | 78.0 a | 65.9 a |
| | LSD (p=0.05) | 4 | 3.4 | 5.1 |

^a Rates are per 100m² at 100ml/m²

Table 10: Phytotoxicity trial (18/08/15 - 18/10/05) with average % leaf blade blackening across 10 creeping bentgrass cultivars at fairway height by rating date with different rates of ferrous sulfate heptahydrate (21%) (applied weekly from 18/08/14 until 18/09/06, with ratings taken **7 days post treatment** application [DPT]). Plots measured 0.0625 m² with four replicates for each treatment level.

| Treatment | Rate ^a | % leaf blade blackening (by date) | | | |
|--|-------------------|-----------------------------------|------------------|------------------|------------------|
| | | 7 DPT (08/22) | 7 DPT (08/30) | 7 DPT (09/06) | 7 DPT (09/14) |
| Untreated | | 0.0 d | 0.0 e | 0.0 d | 0.0 e |
| 1x Ferrous Sulfate Heptahydrate (21%) | 250 g | 3.2 c | 5.1 d | 3.2 d | 4.5 d |
| 5x Ferrous Sulfate Heptahydrate (21%) | 1250 g | 5.5 c | 10.8 c | 9.4 c | 14.3 c |
| 10x Ferrous Sulfate Heptahydrate (21%) | 2500 g | 11.2 b | 22.8 b | 27.6 b | 45.5 b |
| 15x Ferrous Sulfate Heptahydrate (21%) | 3750 g | 15.1 a | 32.5 a | 40.0 a | 58.3 a |
| | LSD (p=0.05) | 2.5 | 2.8 | 4.3 | 4 |

^a Rates are per 100m² at 100ml/m²

Table 11: Phytotoxicity trial (18/08/15 - 18/10/05) with average % leaf blade blackening across 10 creeping bentgrass cultivars at fairway height by rating date with different rates of ferrous sulfate heptahydrate (21%) (applied weekly from 18/08/14 until 18/09/06, with ratings taken **14 days, 21 days and 28 days** post treatment application [DPT] to see residual effects). Plots measured 0.0625 m² with four replicates for each treatment level.

| Treatment | Rate ^a | % leaf blade blackening (by date) | | |
|--|-------------------|-----------------------------------|-------------------|-------------------|
| | | 14 DPT (09/21) | 21 DPT (09/28) | 28 DPT (10/05) |
| Untreated | | 0.0 c | 0.0 c | 0.0 c |
| 1x Ferrous Sulfate Heptahydrate (21%) | 250 g | 2.8 c | 1.9 c | 0.1 c |
| 5x Ferrous Sulfate Heptahydrate (21%) | 1250 g | 16.8 b | 8.0 b | 4.2 b |
| 10x Ferrous Sulfate Heptahydrate (21%) | 2500 g | 13.4 b | 8.7 b | 4.2 b |
| 15x Ferrous Sulfate Heptahydrate (21%) | 3750 g | 22.1 a | 12.7 a | 7.9 a |
| | LSD (p=0.05) | 4 | 2.3 | 1.8 |

^a Rates are per 100m² at 100ml/m²

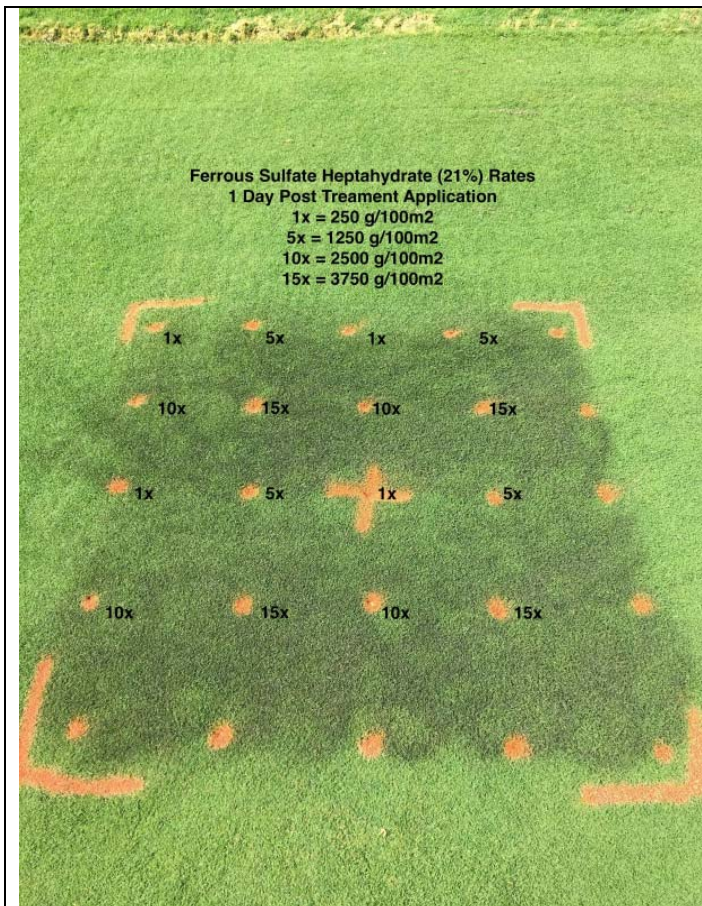


Figure 5: Phytotoxicity trial with various ferrous sulfate treatments on creeping bentgrass plots at the Guelph Turfgrass Institute. Plots were first treated 18/08/15, with repeated treatments weekly until 18/09/06. This photo taken on 18/08/23, one day post treatment application. Data are shown in Tables 9 - 11.

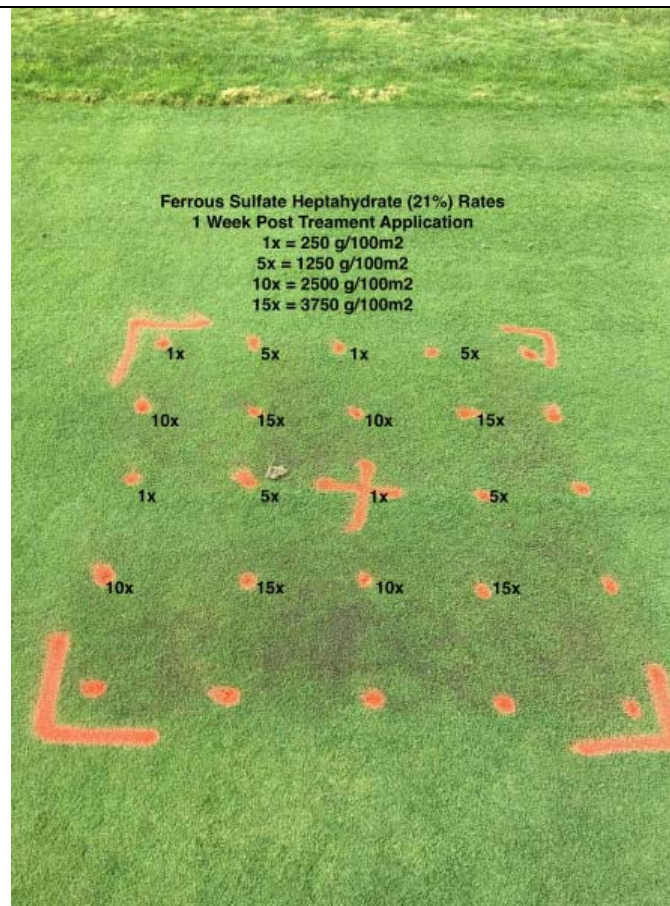


Figure 6: Phytotoxicity trial with various ferrous sulfate treatments on creeping bentgrass plots at the Guelph Turfgrass Institute. Plots were first treated 18/08/15, with repeated treatments weekly until 18/09/06. This photo taken on 18/08/30, one week post treatment application. Data are shown in Tables 9 - 11.

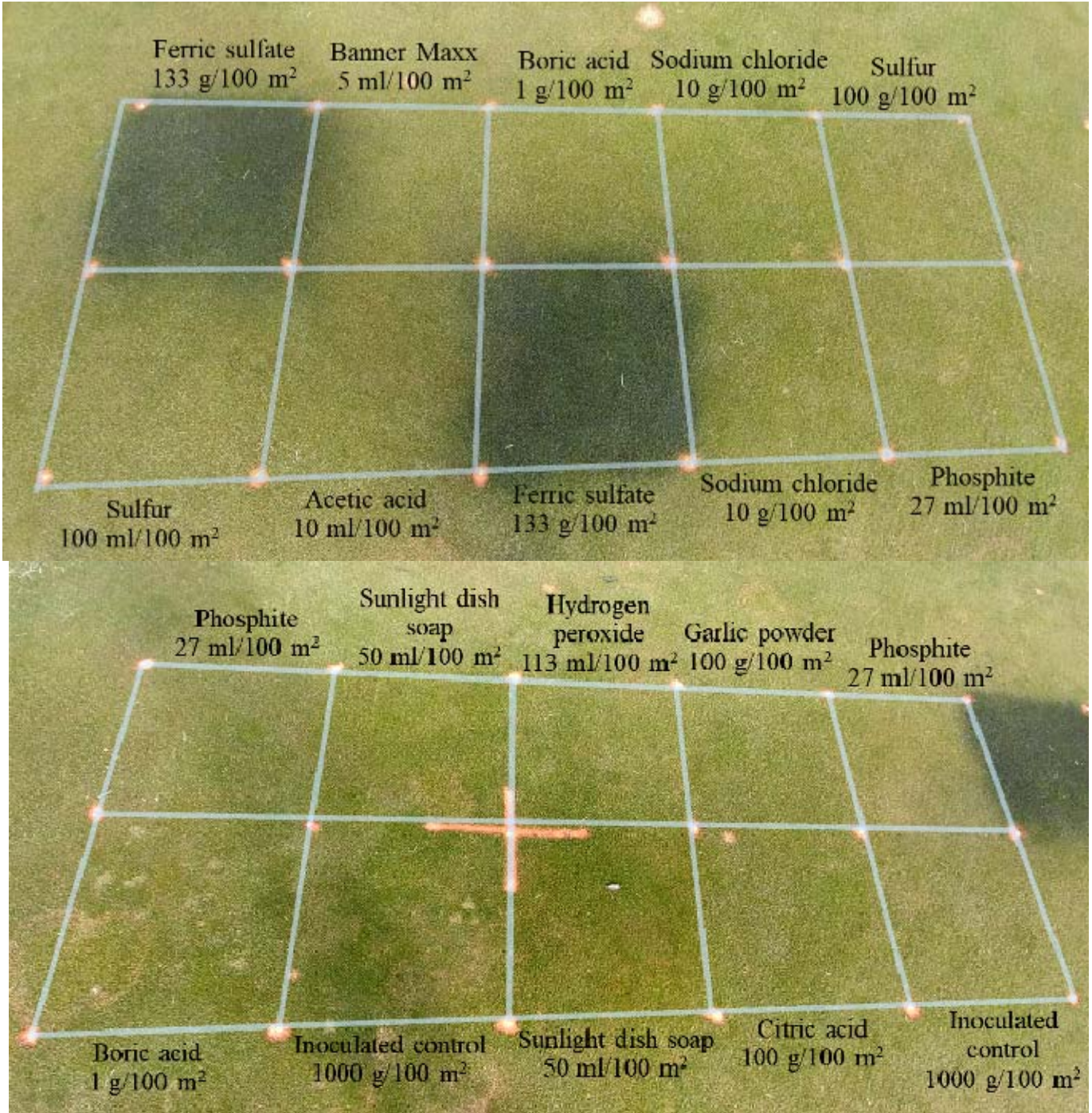


Figure 7: Creeping bentgrass plots at GTI treated twice with each compound in October 2018. They were then inoculated with *M. nivale* in late October and late November, 2018. Pictures were taken in November 2018.

Table 12: Field trial 1 percent yellowing by date post inoculation (DPI) with different low risk treatments (applied weekly, twice before inoculation at a liquid rate of 2.5 L/100 m²) to reduce Microdochium patch on creeping bentgrass. Plots measure 0.25 m² with four replicates. Plots were inoculated with the Microdochium patch pathogen on 181010, 181031, and 181127. Green shading shows significant reduction of disease compared to inoculated control. Red shading shows significant increases.

| Treatment | Concentration | Rate/100 m ² | Percent Yellowing | | |
|--------------------|---------------|-------------------------|-------------------|-------------------|--------------------|
| | | | 181107 (DPI28) | 181217 (DPI70) | 190205 (DPI119) |
| Inoculated Control | 100% | 1000 g | 0.0 | 0.8 | 5.0 |
| Banner Maxx | 0.26% | 26 ml | 0.0 | 0.0 | 0.0 |
| Acetic Acid | 0.1% | 10 ml | 0.5 | 0.8 | 1.5 |
| Boric Acid | 0.01% | 1 g | 0.5 | 0.8 | 2.8 |
| Citric Acid | 1% | 100 g | 0.0 | 0.3 | 1.0 |
| Ferric Sulfate | 1.3% | 133 g | 0.0 | 0.0 | 0.0 |
| Garlic Powder | 1% | 100 g | 0.0 | 0.0 | 0.0 |
| Hydrogen peroxide | 0.03% | 113 ml | 0.0 | 0.3 | 1.3 |
| Phosphite | 0.05% | 27 ml | 0.0 | 0.0 | 0.3 |
| Sodium Chloride | 0.1% | 10 g | 0.0 | 0.0 | 0.8 |
| Sulfur | 1% | 100 g | 0.0 | 0.3 | 0.0 |
| Sunlight Soap | 0.5% | 50 ml | 0.3 | 0.5 | 5.5 |
| LSD (p=0.05) | | | 0.3 | 1.0 | 4.9 |

Table 13: Field trial 2 percent yellowing by date post inoculation (DPI) with different low risk treatments (applied weekly, twice before inoculation at a liquid rate of 2.5 L/100 m²) to reduce Microdochium patch on creeping bentgrass. Plots measure 0.25 m² with four replicates. Plots were inoculated with the Microdochium patch pathogen on 181031, and 181127. Green shading shows significant reduction of disease compared to inoculated control. Red shading shows significant increases.

| Treatment | Concentration | Rate/100 m ² | Percent Yellowing | |
|--------------------|---------------|-------------------------|-------------------|-------------------|
| | | | 181217 (DPI20) | 190205 (DPI98) |
| Inoculated Control | 100% | 1000 g | 0.3 | 1.5 |
| Banner Maxx | 0.26% | 26 ml | 0.0 | 0.3 |
| Acetic Acid | 0.1% | 10 ml | 1.0 | 1.8 |
| Boric Acid | 0.01% | 1 g | 0.0 | 0.5 |
| Citric Acid | 1% | 100 g | 0.0 | 2.5 |
| Ferric Sulfate | 1.3% | 133 g | 0.0 | 0.0 |
| Garlic Powder | 1% | 100 g | 0.3 | 3.0 |
| Hydrogen peroxide | 0.03% | 113 ml | 0.3 | 1.0 |
| Phosphite | 0.05% | 27 ml | 0.3 | 0.3 |
| Sodium Chloride | 0.1% | 10 g | 0.3 | 0.5 |
| Sulfur | 1% | 100 g | 0.3 | 1.5 |
| Sunlight Soap | 0.5% | 50 ml | 0.5 | 6.8 |
| LSD (p=0.05) | | | 0.8 | 5.9 |